International Conference on Unmanned Aircraft Systems ICUAS 2025

May 14 - 17
University of North Carolina at Charlotte
Charlotte, NC 28223 - USA

Technical Program and Book of Abstracts

ICUAS

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THE 2025 INT'L CONFERENCE ON UNMANNED AIRCRAFT SYSTEMS
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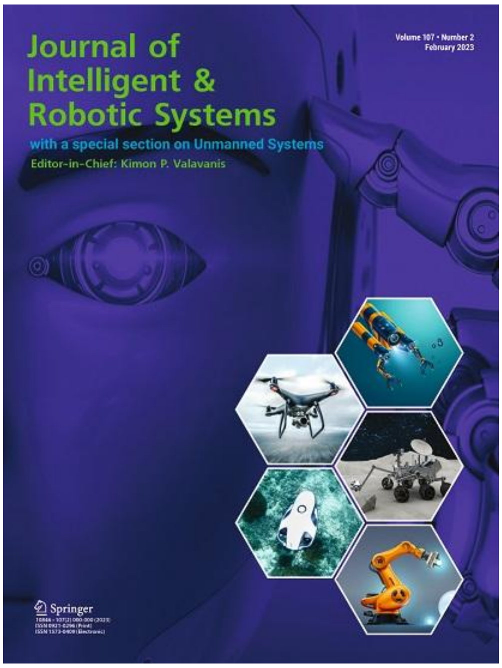

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Welcome Message from the ICUAS Association

Dear authors, colleagues, participants, and attendees:

On behalf of the ICUAS Association Inc., and in my capacity as the President of the Association, it is a privilege, a great pleasure and an honor to welcome you to the *2025 International Conference on Unmanned Aircraft Systems* (ICUAS'25). ICUAS'25 takes place on the campus of the University of North Carolina at Charlotte (UNCC), and it is sponsored by UNCC. The other three Academic Sponsors are the University of South Carolina (SC), the University of Denver (DU), and the University of Zagreb (UZ). The Conference has returned to the US after a five-year period, 2020-2024, during which it took place in Athens and Chania (Greece), Dubrovnik (Croatia) and Warsaw (Poland). ICUAS'25 is a 'physical presence only' Conference.

We look forward to your active involvement in the Association and in the Conference, and to your contributions and feedback. We welcome your participation, and we are open to your ideas and suggestions.

I offer my best wishes for a successful and productive event. I look forward to seeing all of you at the Conference, and I also look forward to continuing working with you.

Kimon P. Valavanis

Welcome Message from the ICUAS'25 General Chairs

Dear authors, colleagues, participants and attendees:

On behalf of the 2025 ICUAS Organizing Committee, it is a privilege and a great pleasure to welcome you to this year's Conference, which is organized on the campus of the University of North Carolina at Charlotte (UNCC). The Conference is a four-day event. The three-day technical Conference is on May 14-16, while the last day, May 17, is reserved for Tutorials and Workshops.

Conference participants represent academia, industry, government agencies, lawyers, policy makers, manufacturers, students, and end-users, all having deep interest in the state-of-the-art and future directions in UAS/RPAS, and in unmanned aviation. In response to the Call for Papers, we received 207 contributed and invited session papers. The Technical Program includes 158 contributed and invited session papers, which have been accepted for presentation and inclusion in the Conference Proceedings after a very thorough review process. As in previous years, all papers were also checked following the *iThenticate Document Viewer Guide* before the final decision was made.

We have assembled a three-day top-quality Technical Program. We also have three Plenary Lectures in which the keynote speakers address pressing and important issues related to several aspects of unmanned aviation. ICUAS'25 also includes the UAV Competition, which is student focused, offering unique opportunities for students to test and compare their skills with those of their peers, worldwide.

The Organizing Committee members, the Associate Editors and the reviewers have devoted an enormous amount of time and effort to assemble an exciting, informative, and educational Conference. We are thankful to all for their dedication and professionalism.

As already mentioned, the paper peer review process was very thorough and in-depth. It was coordinated by the Program Chairs, who assign groups of papers to the Associate Editors, and the Associate Editors choose qualified reviewers to review all papers. We thank all of them for their extremely valuable contributions and dedication. All papers were submitted through the PaperCept Conference Management System. Dr. Pradeep Misra is the 'glue' who keeps all Conference components together. We would not have been able to complete the paper review process without his help, and for this, we thank him wholeheartedly.

We thank all the authors for your participation and contributions. We hope you enjoy the Conference, as well as Charlotte. Take this opportunity to mix business and pleasure; Charlotte is a very nice city with a lot to offer.

With our warmest regards,

Nikos Vitzilaios and Giuseppe Loianno

Welcome Message from the ICUAS'25 Program Chairs

Dear authors, colleagues, participants and attendees:

Welcome to ICUAS'25. This year we received 207 contributed, invited session papers, and workshop and tutorial proposals from 36 different countries. 203 contributed and invited session papers went through a very detailed and rigorous review process. All papers were also checked for originality using the *iThenticate Document Viewer Guide*. Our goal was for each paper to have three reviews, in addition to the review by the corresponding Associate Editors and the Program Chairs. We met and achieved this goal; the aim was simply to make just and informed decisions and select the best papers for presentation and inclusion in the Conference Proceedings.

The Technical Program includes 158 contributed and invited session peer reviewed papers, which have been uploaded in final form. The acceptance ratio is about 77%, however, this percentage is justified because of the high quality of the submitted papers. The Table below shows the number of submitted and accepted papers per country.

Country	Submitted	Accepted
Argentina	2	2
Australia	1	1
Austria	1	1
Bangladesh	1	0
Brazil	17	13
Canada	7	5
China	3	1
Colombia	1	1
Croatia	4	4
Cyprus	4	4
Czech Republic	1	0
Denmark	6	4
France	7	5
Germany	7	6
Greece	2	2
India	7	4
Israel	2	1
Italy	8	8
Korea, South	1	1
Mexico	3	2
Netherlands	5	5
New Zealand	4	3
Norway	1	1
Poland	3	2
Portugal	1	1
Qatar	1	1
Russia	2	2
Saudi Arabia	1	0
Singapore	3	3
Spain	16	14

Sweden	1	1
Switzerland	1	1
Turkey	2	2
United Arab Emirates	1	1
United Kingdom	3	2
USA	73	56

We would like to thank all the authors for their contributions. The rigorous review process would not have been possible if we did not have such a strong community of expert reviewers. We thank all reviewers for their professional service. Dr. Pradeep Misra helped us in working and effectively using the online paper submission and review system. This system is very sophisticated and yet very practical to use for both small- and large- scale Conferences. It is very hard to imagine how things would have been done without this excellent tool!

Last, but not least, we also thank all Associate Editors and reviewers for their professionalism and services in handling and reviewing all submitted papers.

We hope you enjoy the technical aspects of the Conference and the city of Charlotte.

We are looking forward to meeting all of you at the Conference!

Marco Tognon, Salua Hamaza, and Nitin Sanket

ICUAS’25 General Information

The Venue

The Conference Venue is the ***Popp-Martin Student Union*** at the University of North Carolina at Charlotte (UNCC). The UNCC Student Union originally opened its doors in 2009 as the community center of the University. It serves students, faculty, staff, alumni, and visitors. It offers a plethora of alternatives that facilitate student life, and it includes outstanding facilities to host a Conference.

The main entrance of the Student Union building.

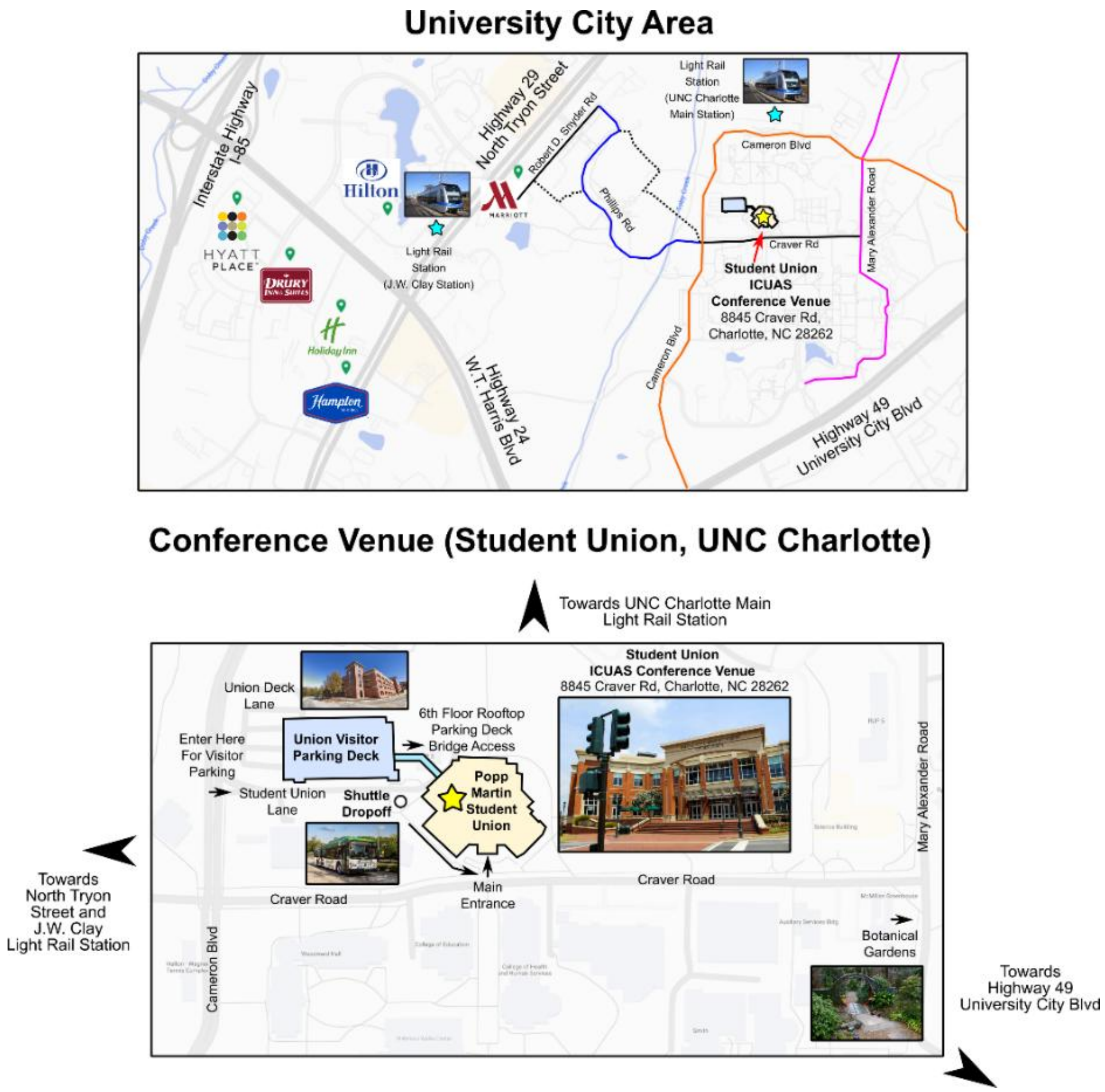
Recommended Hotels

The following hotels are conveniently located close to the University Campus.

- *UNC Charlotte Marriott Hotel & Conference Center*
  9041 Robert D. Snyder Rd, Charlotte, NC 28262
- *Hilton Charlotte University Place*
  8629 J M Keynes Dr, Charlotte, NC 28262
- *Holiday Inn Charlotte University, an IHG Hotel*
  8520 University Executive Park Dr, Charlotte, NC 28262
- *Drury Inn & Suites Charlotte University Place*
  415 West W. T. Harris Blvd, Charlotte, NC 28262
- *Hampton Inn Charlotte-University Place*
  8419 N Tryon St, Charlotte, NC 28262

Each participant is responsible for making their own accommodation reservations.

The University City Area map, shown below, includes the list of recommended hotels with their logos.



University City Area and the Conference Venue (Student Union).

To accommodate registered participants, a Shuttle Service will provide transportation from the nearby hotels to the Student Union, that is, to the Conference venue. The Shuttle Bus will provide transportation during May 14-16. The Shuttle Bus will stop at the previously listed hotels. The time schedule and the pick-up locations for conference participants are shown in the table below (next page).

Note that participants staying at the UNC Charlotte Mariott Hotel and Conference Center may also use the Silver Line Niner Transit Bus.

	Vehicle					
Event Dates	Type	Quantity	Pick-up Location(s)	Shuttle Start Time	Dropoff Location(s)	Shuttle End Time
Wednesday, May 14	Niner Transit	2	UNC Charlotte Marriott Hilton University Hampton Inn Holiday Inn Drury Inn	7:00 AM	Student Union Rear	9:30 AM
	Niner Transit	2	Student Union Rear	3:30 PM	UNC Charlotte Marriott Hilton University Hampton Inn Holiday Inn Drury Inn	6:00 PM
Thursday, May 15	Niner Transit	2	UNC Charlotte Marriott Hilton University Hampton Inn Holiday Inn Drury Inn	7:30 AM	Student Union Rear	10:00 AM
	Niner Transit	2	Student Union Rear	5:00 PM	UNC Charlotte Marriott Hilton University Hampton Inn Holiday Inn Drury Inn	7:30 PM
Friday, May 16	Niner Transit	1	UNC Charlotte Marriott Hilton University Hampton Inn Holiday Inn Drury Inn	7:30 AM	Student Union Rear	10:00 AM
	Niner Transit	1	Student Union Rear	3:00 PM	UNC Charlotte Marriott Hilton University Hampton Inn Holiday Inn Drury Inn	5:30 PM

Shuttle Bus Schedule

Traveling to Charlotte

The Charlotte Douglas International Airport (CLT, https://www.cltairport.com) is the closest airport to the Conference venue. It services major international flights. A list of available connections is provided at https://www.flightconnections.com/flights-from-charlotte-clt, however, check for the most recent list of connections and direct flights.

Recommended options for ground transportation from CLT to your lodging accommodation include Uber/Lyft and taxi services. A bus is also available (the "CATS Sprinter"), which connects the Airport and uptown Charlotte, check https://www.cltairport.com/to-and-from/.

If you decide to rent a car, upon arrival, go to the Arrivals/Baggage Claim Level, and proceed to the Lower-Level Walkway via the escalator or elevator. Proceed through the Lower-Level Walkway and take the elevator to the Level 2 Lobby. Once inside the lobby, proceed to the counter of the rental company from which you are picking up a car, A representative will assist you. For details, visit https://www.cltairport.com/to-and-from/rental-cars/.

Note that the Transportation Security Administration (TSA) recommends arriving at Charlotte Douglas International Airport (CLT) at least three hours before an international flight.

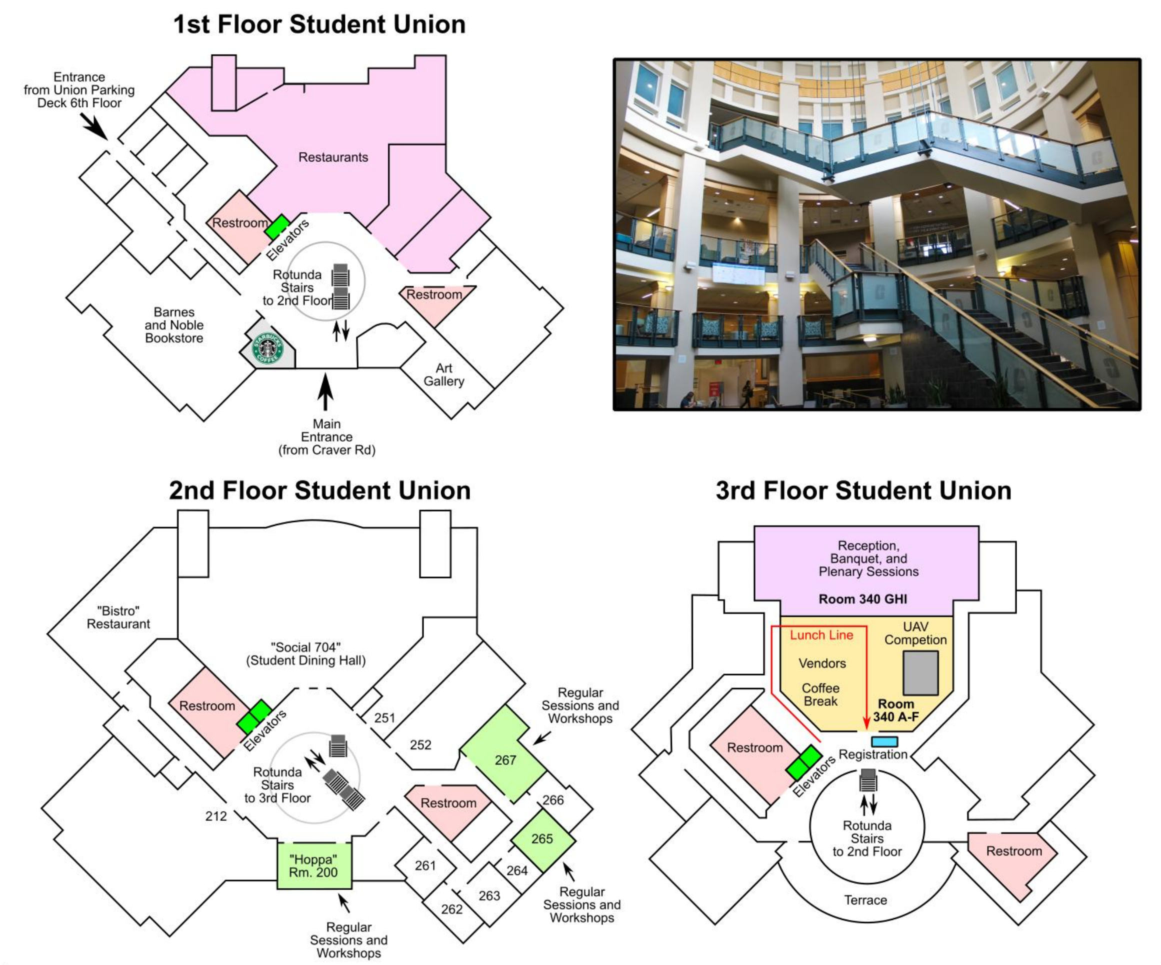
Train Service: A train provides services to Charlotte along a route connecting New York, Atlanta, and New Orleans (https://www.amtrak.com/).

Bus Service: Various bus options connecting to nearby cities are also available (https://www.greyhound.com/).

Local Transportation: Once in Charlotte, public transportation to reach the Campus includes the Lynx Blue Line Light Rail (https://www.charlottenc.gov/CATS/Rail). There are two stops on Campus, UNC Charlotte Main Station, and J. W. Clay Station, which are both within walking distance of the Student Union.

Conference Activities

All Conference activities will take place on the 2nd and 3rd floors of the Student Union building, see the layout below. The four parallel sessions, and Workshops/Tutorials will be in Rooms 340GHI, 200, 265, and 267. The Keynote Lectures will be on the 3rd floor, in Room 340 GHI. The UAV Competition, coffee breaks, lunches, the welcome reception and the banquets will also be on the 3rd floor.



Conference Activities location.

Sightseeing / About Charlotte

The location of the Official Tourism Bureau is:

Charlotte Regional Visitors Authority
https://www.charlottesgotalot.com/
501 South College Street
Charlotte, NC 28202
(704) 339-6040

Local attractions include, among others:

- Sullenberger Aviation Museum, https://www.sullenbergeraviation.org/
- Discovery Place Science, https://my.discoveryplace.org/
- Carowinds Amusement Park, carowinds.com
- Charlotte Motor Speedway, https://www.charlottemotorspeedway.com/
- U.S. National Whitewater Center, https://center.whitewater.org/
- Bechtler Museum of Modern Art, https://www.bechtler.org/
- Mint Museum, https://www.mintmuseum.org/
- NASCAR Hall of Fame, https://www.nascarhall.com

Visa Requirements

Citizens of some countries need an entry visa to the US. Please check the list of Countries from which an entry visa is required before you finalize your trip.

CONFERENCE REGISTRATION

All Conference attendees must register by using the online registration when they upload the final version of their papers. This is the preferred option. Late and onsite registration is also available for non-authors who want to attend the Conference. It is not required to present a paper in the Conference program to register and to attend the Conference. All registered participants must check in at the Registration Desk to pick up their registration packages. Personal badges will be provided for all registered participants. Attendees must always wear their badges when attending any ICUAS'25 event (workshops, tutorials, technical sessions, and social functions). Conference details will be posted and updated daily in the registration area. To register, follow the steps:

- ✓ Go to https://controls.papercept.net
- ✓ Scroll down the list until you find ICUAS 2025 - Choose ICUAS 2025 (from the list of Conferences)
- ✓ Click on Register for ICUAS'25
- ✓ Login with your PIN and Password. *First time users must create a 'profile', to get a PIN and Password.*
- ✓ After you Log in, choose **Registree**.
- ✓ Follow the self-explained screens to register.

Alternatively, and especially if you have not authored a paper, you may register through www.icuas.com. The registration desk will be open during the following hours:

TUESDAY, MAY 13:	5:00 PM – 7:00 PM
WEDNESDAY, MAY 14:	8:15 AM – 4:00 PM
THURSDAY, MAY 15:	8:30 AM – 2:30 PM
FRIDAY, MAY 16:	8:30 AM – 11:00 AM
SATURDAY, MAY 17:	8:00 AM – 9:00 AM

Onsite Conference registration policy & fees

Attendees can register for the Conference under the following registration categories/rates:

Attendee Status	Onsite Registration
Regular Registration	$700
Student Registration	$400
Retiree Registration	$200

Life Member	$0
T1: Modeling, Autonomous Navigation and Control of Multirotor UAVs: *Merging Conventional and Proposed New Methodologies*	$180
T2: Embodied-AI for Aerial Robots: What do we need for full autonomy?	$180
Spouse Registration (Social Events)	$200
Extra Welcome Reception Ticket	$50
Extra Banquet Ticket	$100

Internet Access
All registered attendees will have complementary internet access.

Lunch for Registered Participants
Lunch will be served to registered Conference participants. Lunch tickets will be provided for Wednesday, Thursday and Friday, May 14-16.

Coffee Breaks with Snacks
There will be two coffee breaks per day for all registered participants, one in the morning and one in the afternoon.

Events and Receptions
The ICUAS'25 social agenda includes a *Welcome Reception* on Tuesday, May 13, and a *Banquet*, on Thursday, May 15.

ICUAS'25 Tutorials and Workshops

ICUAS'25 offers two half-day Workshops/Tutorials addressing current and future topics in unmanned aircraft systems from experts in academia, national laboratories, and industry. Interested participants may find details on www.uasconferences.com, and they may use the online system for registration. Tutorials/Workshops will take place on Saturday, May 17 from 09:00 AM - 1:00 PM.

TUTORIALS / WORKSHOPS – Saturday, May 17		
Location	**Time**	**Title**
Room 200	Half Day 9:00 – 13:00	***Modeling, Autonomous Navigation and Control of Multirotor UAVs:*** Merging Conventional and Proposed New Methodologies
Room 267	Half-Day 9:00 – 13:00	***Embodied-AI for Aerial Robots: What do we need for full autonomy***?

ICUAS'25 Plenary Lectures

ICUAS'25 includes three Plenary Lectures given by leading authorities in their fields. We are proud to include them in the Technical Program. The schedule for the lectures is shown next.

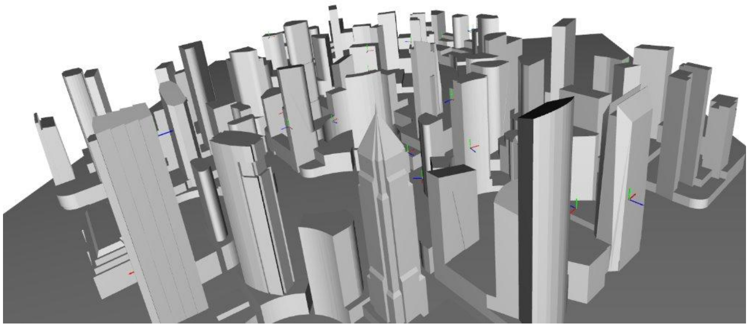
PLENARY LECTURES		
Day	**Time**	**Room 340 GHI**
Wednesday May 14	09:00 – 10:00	***Shields up: Building Defense Minded UAVs***, *Dr. David Casbeer, Air Force Research Laboratory–Aerospace Systems Directorate*
Thursday May 15	09:00 - 10:00	***Fast, Efficient, and Robust Autonomy for Unmanned Aerial Systems***, *Dr. Jonathan How, Massachusetts Institute of Technology*
Friday May 16	09:00 – 10:00	***What's the Problem? Challenges in Multirotor Research***, *Dr. Pauline Pounds, University of Queensland*

ICUAS 2025 UAV Competition

This year, the UAV Competition focuses on deploying a team of UAVs in an urban environment to locate and identify (potential) threats. UAVs deploy from a base, and they need to find and identify several targets in a known environment. Since some of the threats may interfere with communication links between agents, the UAV team is required to keep constant communication between the base and all agents in the system.

Involved teams submitted their solutions, which were evaluated following a two-phase process. That is, each solution was evaluated considering two different 'worlds', i.e., two working environments. One that was shared with each team during the simulation phase, and one that was not seen by the teams. Both world models were made available to teams at runtime as *Octomaps*. Throughout the world, multiple *ArUco* tags were scattered on vertical surfaces in the world, as shown below.

Following a rigorous evaluation procedure, the following teams emerged as top contenders, thus qualifying for the finals, which will take place during the Conference.



Coordinate frames denoting ArUco tag locations in a model of urban environment.

1st Place: ***AIRo Lab,*** *The Hong Kong Polytechnic University*, China
Team Advisor: Prof. Chih-Yung Wen
Team Leader: Zheng Tan
Members: Li-Yu Lo, Yifei Zhang, Yuzhou Li, Wenyu Yang

2nd Place: ***Center for Scientific Innovation and Education - CSIE***, Armenia
Team Advisor: Prof. Astghik Hakobyan, *National Polytechnic University of Armenia*
Team leader: Gor Arzanyan, *American University of Armenia*
Members: Nane Hakhverdyan, *Yerevan State University*
Anna Manucharyan, *American University of Armenia*
Artak Mnatsakanyan, *National Polytechnic University of Armenia*
Rafik Simonyan, *National Polytechnic University of Armenia*

3rd Place: ***Aerial Robotics IITK***, *Indian Institute of Technology, Kanpur*, India
Team advisor: Prof. Ketan Rajawat
Team leader: Pulak Gautam
Members: Varun Sappa, Vihaan Sapra, Akshat Jain, Shvetang Rao, Ayyappan Atulya Sundaram, Shruti Dalvi, Aman Singh Gill, Anmoldeep Singh Dhillon, Sanskar Yaduka

4th Place: ***AGH AVADER***, ***AGH University of Krakow***, Poland
Team advisor: Dr. Tomasz Kryjak, AGH University of Krakow
Team leader: Remigiusz Mietła
Members: Hubert Szolc, Mateusz Wąsala, Mateusz Gołąbek, Tymoteusz Domagała, Jan Jagodziński, Kacper Iwicki, Kamil Jędrzejko

5th Place: ***KNU ARRF***, *Kyungpook National University (KNU)*, South Korea
Team advisor: Prof. Kyuman Lee
Team leader: Joohyuk Lee
Members: Hojun Lee, Jeonghoon Song, Mohomad Aqeel Abdhul Rahuman, Seong-jin Oh, Yonggyun Moon, Kangmin Kim

The UAV Competition Chair, and the Organizing Committee members extend their sincere gratitude towards the two Platinum Sponsors whose equipment will enable and allow for the deployment of the teams' solutions in the competition arena during ICUAS 2025. *Bitcraze* supplies a fleet of Crazyflies, spare parts, their Loco motion tracking system, and *NaturalPoint* installs their Optitrack motion capture system. Each team will fly Crazyflies and will showcase their approach to solving the challenging problem posed.

ICUAS' 25 TECHNICAL PROGRAM AT A GLANCE

Wednesday, May 14

Room 340 GHI	Room 200	Room 267	Room 265
08:30-09:00 – Room 340 GHI Opening Session WeOp1			
09:00-10:00 Room 340 GHI Plenary Session WePL1 Shields up: Building Defense Minded UAVs Dr. David Casbeer Technical Area Lead – UAV Cooperative and Intelligent Control, Control Science Center Air Force Research Laboratory – Aerospace Systems Directorate			
10:00-10:30 Coffee Break			
10:30-12:30 WeA1 *Multirotor Design and Control I*	10:30-12:30 WeA2 *Perception and Cognition*	10:30-12:30 WeA3 *Micro and Mini UAS*	10:30-12:30 WeA4 *Aerial Robotic Manipulation I*
12:30-14:00 Lunch Break			
14:00-16:00 WeB1 *Best Paper Award Finalists*	14:00-16:00 WeB2 *UAS Applications I*	14:00-16:00 WeB3 *Path Planning I*	14:00-16:00 WeB4 *Aerial Robotic Manipulation II*
16:00 – 16:30 Coffee Break			
16:30 – 18:10 WeC1 *UAS Testbeds*	16:30 – 18:10 WeC2 *UAS Applications II*	16:30 – 18:10 WeC3 *Autonomy/Integration*	16:30 – 18:10 WeC4 *UAS Communications*

Thursday May 15

Room 340 GHI	Room 200	Room 267	Room 265
09:00-10:00 Room 340 GHI Plenary Session ThPL1 Fast, Efficient, and Robust Autonomy for Unmanned Aerial Systems Dr. Jonathan How R. C. Maclaurin Professor of Aeronautics and Astronautics, Massachusetts Institute of Technology AIAA Director – American Automatic Control Council			
10:00-10:30 Coffee Break			
10:30-12:30 ThA1 *Best Paper Award Finalists from Latin America and Africa (LAA)*	10:30-12:30 ThA2 *Test and Evaluation of Autonomous Aerial Systems*	10:30-12:30 ThA3 *Path Planning II*	10:30-12:30 ThA4 *Simulation*
12:30-14:00 Lunch Break			
14:00-15:40 ThB1 *Multirotor Design and Control II*	14:00-15:40 ThB2 *Test and Evaluation of Autonomous Aerial Systems II*	14:00-15:40 ThB3 *Path Planning III*	14:00-15:40 ThB4 *Sensor Fusion*
15:40 – 16:10 Coffee Break			
16:10-18:10 Rm 340AF *UAV Competition*			

Friday, May 16

Room 340 GHI	Room 200	Room 267	Room 265
09:00-10:00 Room 340 GHI Plenary Session FrPL1 What's the Problem? Challenges in Multirotor Research Dr. Pauline Pounds University of Queensland			
10:00-10:30 Coffee Break			
10:30-12:30 FrA1 *Advances in Aerial Robotics for Inspection and Maintenance*	10:30-12:30 FrA2 *UAS Applications III*	10:30-12:30 FrA3 *Regulations/Energy*	10:30-12:30 FrA4 *Control Architectures/Swarms*
12:30-14:00 Lunch Break			
14:00-16:00 FrB1 *Security/Swarms*	14:00-16:00 FrB2 *UAS Applications IV*	14:00-16:00 FrB3 *Autonomy*	14:00-16:00 FrB4 *Airspace Control*

Saturday, May 17

TUTORIALS / WORKSHOPS		
Location	**Time**	**Title**
Tutorial Session SaTW1 Room 200	9:00 – 13:00	**Modeling, Autonomous Navigation and Control of Multirotor UAVs:** *Merging Conventional and Proposed New Methodologies*
Tutorial Session SaTW2 Room 267	9:00 – 13:00	***Embodied-AI for Aerial Robots: What do we need for full autonomy***?

ICUAS '25 Technical Sessions

Wednesday, May 14

WeA1	Rm 340GHI
Multirotor Design and Control I (Regular Session)	
Chair: Sarcinelli-Filho, Mário	Federal University of Espirito Santo
Co-Chair: Arogeti, Shai	Ben-Gurion University of the Negev
10:30-10:50	WeA1.1
Dynamics and Control of a Hexacopter Propelled by Three Seesaws, pp. 1-8.	
Yecheskel, Dolev	Ben-Gurion University of the Negev
Arogeti, Shai	Ben-Gurion University of the Negev
10:50-11:10	WeA1.2
Trajectory Tracking for Quadrotors Using Tilt-Prioritized Attitude Control, pp. 9-14.	
Tavares, Luiz	Federal University of Espirito Santo
Bacheti, Vinícius Pacheco	Federal University of Espirito Santo
Sarcinelli-Filho, Mário	Federal University of Espirito Santo
Villa, Daniel Khede Dourado	Federal University of Espírito Santo
11:10-11:30	WeA1.3
Cable Optimization and Drag Estimation for Tether-Powered Multirotor UAVs, pp. 15-21.	
Beffert, Max	University of Tübingen
Zell, Andreas	University of Tübingen
11:30-11:50	WeA1.4
Slat-Inspired Reversible Wing for Stopped-Rotor Vehicles, pp. 22-28.	
Hilby, Kristan	Massachusetts Institute of Technology
Hughes, Max	Northwestern University
Hunter, Ian	Massachusetts Institute of Technology
11:50-12:10	WeA1.5
Motion Control in Multi-Rotor Aerial Robots Using Deep Reinforcement Learning, pp. 29-36.	
Shetty, Gaurav	Hochschule Bonn-Rhein-Sieg University of Applied Sciences
Ramezani, Mahya	University of Luxembourg
Habibi, Hamed	Nterdisci Plinary Centre for Security, Reliability and Trust, U
Voos, Holger	University of Luxembourg
Sanchez-Lopez, Jose-Luis	University of Luxembourg
12:10-12:30	WeA1.6
Deep Visual Servoing of an Aerial Robot Using Keypoint Feature Extraction, pp. 37-43.	
Sepahvand, Shayan	Toronto Metropolitan University
Amiri, Niloufar	Toronto Metropolitan University
Janabi Sharifi, Farrokh	Toronto Metropolitan University

WeA2	Rm 200
Perception and Cognition (Regular Session)	
Chair: Petric, Frano	University of Zagreb
Co-Chair: Boubin, Jayson	Binghamton University
10:30-10:50	WeA2.1
Aerial Maritime Vessel Detection and Identification, pp. 44-51.	
Barisic, Antonella	University of Zagreb
Petric, Frano	University of Zagreb
Bogdan, Stjepan	University of Zagreb
10:50-11:10	WeA2.2
Invisible Servoing: A Visual Servoing Approach with Return-Conditioned Latent Diffusion, pp. 52-59.	

Gerges, Bishoy	University of Twente
Bazzana, Barbara	University of Twente
Botteghi, Nicolò	University of Twente
Aboudorra, Youssef	University of Twente
Franchi, Antonio	Univ. of Twente and Sapienza Univ. of Rome

11:10-11:30 WeA2.3

REMIX: Real-Time Hyperspectral Anomaly Detection for Small UAVs, pp. 60-66.

Dastranj, Melika	Binghamton University
de Smet, Timothy	Aletair
Wigdahl-Perry, Courtney	State University of New York at Fredonia
Chiu, Kenneth	Binghamton University
Bihl, Trevor	Air Force Research Laboratory
Boubin, Jayson	Binghamton University

11:30-11:50 WeA2.4

An RF Direction Finding Payload for UAVs with Deep Learning Direction Prediction Via ResNet, pp. 67-74.

Willis, Andrew	University of North Carolina at Charlotte
Feshami, Braden	Vulcan Ventura
Vasan, Srini	Vulcan Ventura
Touma, James	Air Force Research Laboratory

11:50-12:10 WeA2.5

Onboard UAV State Estimation and Trajectory Prediction Using Multi-Task Reservoir Computing, pp. 75-82.

Souli, N.	University of Cyprus
Kardaras, Panagiotis	University of Cyprus
Grigoriou, Yiannis	University of Cyprus
Kolios, Panayiotis	University of Cyprus
Ellinas, Georgios	University of Cyprus

12:10-12:30 WeA2.6

Detection of Endangered Deer Species Using UAV Imagery: A Comparative Study between Efficient Deep Learning Approaches, pp. 83-90.

Roca, Agustin	Universidad De San Andrés
Castro, Gastón Ignacio	Universidad De San Andrés
Giribet, Juan Ignacio	University of San Andrés
Mas, Ignacio	ITBA
Torre, Gabriel	Universidad De San Andrés
Colombo, Leonardo, J	Centre for Automation and Robotics
Pereira, Javier	CONICET

WeA3 Rm 267

Micro and Mini UAS (Regular Session)

Chair: Flores, Gerardo	Texas A&M International University
Co-Chair: Ward, Timothy	University of Bristol

10:30-10:50 WeA3.1

Dynamical Control Model and Tracking Controller for a Novel Flapping Wing Drone Platform, pp. 91-98.

Cariño Escobar, Jossué	Universite Aix-Marseille
Le-Guellec, Lina	Univ Grenoble Alpes
Van Ruymbeke, Edwin	XTIM Bionic Bird
Marchand, Nicolas	GIPSA-Lab CNRS
Engels, Thomas	Aix-Marseille Université
Ruffier, Franck	CNRS / Aix-Marseille Univ

10:50-11:10 WeA3.2

Bio-Inspired UAS Swarm-Keeping Based on Computer Vision, pp. 99-105.

Garcia, Gonzalo	Virginia Commonwealth University
Eskandarian, Azim	Virginia Commonwealth University

11:10-11:30 WeA3.3

Aerodynamic State Estimation of a Bio-Inspired Distributed Sensing UAV at High Angles of Attack and

Sideslip, pp. 106-114.

Ward, Timothy	University of Bristol
Mukherjee, Sourish	University of Southampton
Windsor, Shane	University of Bristol
Araujo-Estrada, Sergio	University of Southampton

11:30-11:50 WeA3.4

Guaranteed Fixed-Wing UAS Lateral Safety Via Control Barrier Functions, pp. 115-123.

Xu, Jeffrey	University of Kansas
Marshall, Jeb	University of Kansas
Powers, Matthew	University of Kansas
Keshmiri, Shawn	University of Kansas

11:50-12:10 WeA3.5

Barrier Lyapunov Function-Based Control for Position-Based Visual Servoing of Fully Actuated UAVs within PX4, pp. 124-131.

Vega, Erandi	Centro De Investigaciones En Optica
Verdín, Rodolfo Isaac	Centro De Investigaciones En Optica
Aldana, Noé	Universidad Iberoamericana León
Flores, Gerardo	Texas A&M International University

12:10-12:30 WeA3.6

Low Reynolds Number Experimental Tests of an Eppler-186 Airfoil with Gurney Flap for Small-UAV, pp. 132-138.

Matias Garcia, Juan Carlos	National Institute for Aerospace Technology
Bardera-Mora, Rafael	National Institute for Aerospace Technology
Barroso Barderas, Estela	National Institute for Aerospace Technology
Rodríguez-Sevillano, Ángel Antonio	Universidad Politécnica De Madrid

WeA4 Rm 265

Aerial Robotic Manipulation I (Regular Session)

Chair: Brandao, Alexandre Santos	Federal University of Vicosa
Co-Chair: Castillo, Pedro	Université De Technologie De Compiègne

10:30-10:50 WeA4.1

Control Strategies for Real-Time Aerial Manipulation with Multi-DOF Arms: A Survey, pp. 139-146.

Barakou, Stamatina	National Technical University of Athens
Tzafestas, Costas	National Technical University of Athens
Valavanis, Kimon P.	University of Denver

10:50-11:10 WeA4.2

Soccer Player Tracking Using UAV Imagery: A Comparative Study of YOLO and Traditional Image Processing Algorithms, pp. 147-154.

Rezende, Felipe dos Anjos	Universidade Federal De Viçosa
Miranda Hudson, Thayron	Universidade Federal De Viçosa
Silva, Pedro Augusto Fialho	Universidade Federal De Viçosa
Alves, Werikson	Universidade Federal De Viçosa
Mendes, André	Universidade Federal De Viçosa
Brandao, Alexandre Santos	Universidade Federal De Viçosa

11:10-11:30 WeA4.3

Optimal Control of Dual Arm Manipulation for Flapping-Wing Robots in the Post-Perching Phase, pp. 155-161.

Sadeghi Kordkheili, Sahar	Universidad De Sevilla
Gonzalez-Morgado, Antonio	Universidad De Sevilla
Rafee Nekoo, Saeed	Universidad De Sevilla
Arrue, B.C.	Universidad De Sevilla
Ollero, Anibal	Universidad De Sevilla

11:30-11:50 WeA4.4

A Study on Impact-Aware Aerial Robots Colliding with the Environment at Non-Vanishing Speed, pp. 162-169.

Indukumar, Gayatri	University of Twente

Saccon, Alessandro	Eindhoven University of Technology
Franchi, Antonio	Univ. of Twente and Sapienza Univ. of Rome
Gabellieri, Chiara	University of Twente

11:50-12:10 WeA4.5

Full State Quaternion-Based Observer Control for Multirotor Aerial Grasping, pp. 170-176.

Garcia-Mosqueda, Inés	Tecnologico De Monterrey, School of Engineering and Sciences
Tevera-Ruiz, Alejandro	Cinvestav Unidad Saltillo
Abaunza, Hernan	Tecnologico De Monterrey
Castillo, Pedro	Université De Technologie De Compiègne
Sanchez-Orta, Anand Eleazar	Research Center for Advanced Studies - Cinvestav
Chazot, Jean-Daniel	Université De Technologie De Compiègne

12:10-12:30 WeA4.6

Performance Analysis of a Fully-Actuated Screwdriving UAV, pp. 177-184.

Lee, Louis Zu-Yue	University of Auckland
Stol, Karl	University of Auckland

WeB1 Rm 340GHI

Best Paper Award Finalists (Regular Session)

Chair: Tognon, Marco	INRIA
Co-Chair: Hamaza, Salua	TU Delft

14:00-14:20 WeB1.1

AgilePilot: DRL-Based Drone Agent for Real-Time Motion Planning in Dynamic Environments by Leveraging Object Detection, pp. 185-192.

Khan, Roohan Ahmed	Skolkovo Institute of Science and Technology
Serpiva, Valerii	Skolkovo Institute of Science and Technology
Tareke, Demetros Aschalew	Skolkovo Institute of Science and Technology
Fedoseev, Aleksey	Skolkovo Institute of Science and Technology
Tsetserukou, Dzmitry	Skolkovo Institute of Science and Technology

14:20-14:40 WeB1.2

A Time and Place to Land: Online Learning-Based Distributed MPC for Multirotor Landing on Surface Vessel in Waves, pp. 193-199.

Stephenson, Jess	Queen's University
Stewart, William Scott	Queen's University
Greeff, Melissa	Queen's University

14:40-15:00 WeB1.3

Contact-Informed Online Trajectory Replanning for Obstacle Avoidance in Unmanned Aerial Manipulators, pp. 200-206.

Garrard, YiZhuang	Arizona State University
Zhang, Wenlong	Arizona State University

15:00-15:20 WeB1.4

Koopman-Based Model Predictive Control of Quadrotors, pp. 207-213.

Martini, Simone	University of Denver
Todde, Edoardo	Politecnico Di Torino
Stefanovic, Margareta	University of Denver
Rutherford, Matthew	University of Denver
Rizzo, Alessandro	Politecnico Di Torino
Valavanis, Kimon P.	University of Denver

15:20-15:40 WeB1.5

FLIFO: A Passively Morphing Drone for Small Gap Traversal, pp. 214-221.

Ruggia, Marco	University of Applied Sciences of the Grisons
Bermes, Christian	University of Applied Sciences of the Grisons

15:40-16:00 WeB1.6

Online Defensive Motion Planning against Adversarial Swarm Attacks Using Bernstein Polynomials-Based Model Predictive Control, pp. 222-227.

Kang, Hyungsoo	University of Illinois Urbana-Champaign

Aoun, Christoph	University of Illinois
Kaminer, Isaac	Naval Postgraduate School
Hovakimyan, Naira	University of Illinois Urbana-Champaign

WeB2 — Rm 200

UAS Applications I (Regular Session)

Chair: Coopmans, Calvin	Utah State University
Co-Chair: Aldao Pensado, Enrique	University of Vigo

14:00-14:20 — WeB2.1

pLiRLo: LiDAR-Based Relative Localization with Retro-Reflective Marker, pp. 228-235.

Domislovic, Jakob	University of Zagreb
Milijas, Robert	University of Zagreb
Ivanovic, Antun	University of Zagreb
Car, Marko	University of Zagreb
Vasiljevic, Goran	University of Zagreb
Arbanas, Barbara	University of Zagreb
Petric, Frano	University of Zagreb
Orsag, Matko	University of Zagreb
Bogdan, Stjepan	University of Zagreb

14:20-14:40 — WeB2.2

Evaluating the Influence of Wind on UAV Path Planning for Bridge Inspections, pp. 236-242.

Aldao Pensado, Enrique	University of Vigo
Fontenla-Carrera, Gabriel	University of Vigo
Veiga-López, Fernando	University of Vigo
Gonzalez Jorge, Higinio	University of Vigo
Maria José, Morais	University of Minho
C. Matos, José	University of Minho

14:40-15:00 — WeB2.3

Autonomous UAV Navigation and Mapping for Accurate Fruit Detection and Counting in Controlled Environments: Simulation and Real-World Validation, pp. 243-248.

Garg, Kush	Delhi Technological University
Chandna, Nishant	Delhi Technological University
Aggarwal, Somin	Delhi Technological University
Sehgal, Chirag	Delhi Technological University
Gupta, Arjun	Delhi Technological University
Rohilla, Rajesh	Delhi Technological University

15:00-15:20 — WeB2.4

Barrier Coverage of a Non-Planar Terrain-Like Border with UAVs, pp. 249-255.

Kumar, Amit	Indian Institute of Science
Ghose, Debasish	Indian Institute of Science

15:20-15:40 — WeB2.5

Multi-Resolution UAV Path Replanning for Inspection of Tailings Dams, pp. 256-263.

Galvao Simplicio, Paulo Victor	West Virginia University
Pereira, Guilherme	West Virginia University

15:40-16:00 — WeB2.6

Towards Real-Time SLAM-Based Orthomosaic Generation for High-Resolution Scientific Multi-Band sUAS Imagery, pp. 264-271.

Sewell, Andres	Utah State University
Payne, Ethan	Utah State University
Coopmans, Calvin	Utah State University
Torres-Rua, Alfonso	Utah State University
Petruzza, Steve	Utah State University

WeB3	Rm 267
Path Planning I (Regular Session)	
Chair: Brandao, Alexandre Santos	Federal University of Vicosa
Co-Chair: Debnath, Dipraj	Queensland University of Technology

14:00-14:20	WeB3.1

Time-Synchronized B-Spline Path Planning for Multi-Agent UAV Systems with Fixed Speed Profiles, pp. 272-278.

Shumway, Landon	Brigham Young University
Beard, Randal W.	Brigham Young University

14:20-14:40	WeB3.2

Inspection of Moving Structures by UAVs Using a Robust Approach Cone Strategy, pp. 279-285.

Chakravarthy, Animesh	University of Texas at Arlington
Ghose, Debasish	Indian Institute of Science

14:40-15:00	WeB3.3

Effective Path Planning for UAVs in Complex and Unknown Environments through Integrated Q-Learning and Classical Algorithms, pp. 286-293.

Rocha, Lidia	UFSCar
Brandao, Alexandre Santos	Federal University of Vicosa
Kelen Cristiane, Teixeira Vivaldini	UFSCar

15:00-15:20	WeB3.4

NetSLAM: Network-Aware Path Planning for Edge-Assisted UAV Swarms, pp. 294-300.

Nasir, Zain-ul-Abideen	Binghamton University
Ben Ali, Ali J.	Binghamton University
Boubin, Jayson	Binghamton University

15:20-15:40	WeB3.5

DECK-GA: A Hybrid Clustering and Distance Efficient Genetic Algorithm for Scalable Multi-UAV Path Planning, pp. 301-308.

Debnath, Dipraj	Queensland University of Technology
Vanegas, Fernando	Queensland University of Technology
Sandino, Juan	Queensland University of Technology
Gonzalez, Luis Felipe	Queensland University of Technology

15:40-16:00	WeB3.6

HetSwarm: Cooperative Navigation of Heterogeneous Swarm in Dynamic and Dense Environments through Impedance-Based Guidance, pp. 309-315.

Zafar, Malaika	Skolkovo Institute of Science and Technology
Khan, Roohan Ahmed	Skolkovo Institute of Science and Technology
Fedoseev, Aleksey	Skolkovo Institute of Science and Technology
Jaiswal, Kumar Katyayan	IISER Bhopal
Baliyarasimhuni, Sujit, P	IISER Bhopal
Tsetserukou, Dzmitry	Skolkovo Institute of Science and Technology

WeB4	Rm 265
Aerial Robotic Manipulation II (Regular Session)	
Chair: Atkins, Ella	Virginia Tech
Co-Chair: Michieletto, Giulia	University of Padova

14:00-14:20	WeB4.1

Shifting Underactuated Configuration Variables in Aerial Manipulation by Adding an Actuated Arm, pp. 316-322.

Nail, Mark	University of Michigan
Atkins, Ella	University of Michigan
Gillespie, R. Brent	University of Michigan

14:20-14:40	WeB4.2

External-Wrench Estimation for Aerial Robots Exploiting a Learned Model, pp. 323-331.

Alharbat, Ayham	Saxion University of Applied Sciences
Ruscelli, Gabriele	Alma Mater Studiourum
Diversi, Roberto	University of Bologna

Mersha, Abeje Yenehun — Saxion University of Applied Sciences

14:40-15:00 — WeB4.3

Simulation of a Tilt-Rotor UAV with a Cable-Driven Gripper for High-Precision Physical Interaction, pp. 332-339.

Chen, Yun Ting — Singapore Polytechnic
Taylor, Joshua — National University of Singapore (NUS)
Imanberdiyev, Nursultan — Agency for Science, Technology and Research (A*STAR)
Camci, Efe — Institute for Infocomm Research (I2R), A*STAR

15:00-15:20 — WeB4.4

Design and Control of an Omnidirectional Aerial Robot with a Miniaturized Haptic Joystick for Physical Interaction, pp. 340-346.

Mellet, Julien — University of Naples Federico II
Berra, Andrea — FADA – CATEC
Marcellini, Salvatore — Leonardo S.p.A
Trujillo, Miguel Ángel — CATEC
Heredia, Guillermo — University of Seville
Ruggiero, Fabio — Università Degli Studi Di Napoli "Federico II"
Lippiello, Vincenzo — Università Di Napoli Federico II

15:20-15:40 — WeB4.5

Advancing Manipulation Capabilities of a UAV Featuring Dynamic Center-Of-Mass Displacement, pp. 347-354.

Hui, Tong — Technical University of Denmark
Fumagalli, Matteo — Danish Technical University

15:40-16:00 — WeB4.6

A Taxonomy on Contact-Aware Multi-Rotors for Interaction Tasks, pp. 355-361.

Piccina, Alberto — University of Padova
Bertoni, Massimiliano — University of Padova
Michieletto, Giulia — University of Padova

WeC1 — Rm 340GHI

UAS Testbeds (Regular Session)

Chair: Coopmans, Calvin — Utah State University
Co-Chair: Jafarnejadsani, Hamidreza — Stevens Institute of Technology

16:30-16:50 — WeC1.1

Understanding the Physical Design of Multi-Domain UAV Systems, pp. 362-369.

Ramos, Christian — University of Denver
Valavanis, Kimon P. — University of Denver
Rutherford, Matthew — University of Denver

16:50-17:10 — WeC1.2

Multi-Robot Coordination with Adversarial Perception, pp. 370-377.

Bahrami, Rayan — University of Maryland
Jafarnejadsani, Hamidreza — Stevens Institute of Technology

17:10-17:30 — WeC1.3

A Real-Time Aerial Imagery Collection, Mapping, and Remote Sensing Testbench for Uncrewed Missions, pp. 378-384.

Coopmans, Calvin — Utah State University
Snider, Richard M. — Utah State University
Toki, Sadikul Alim — Utah State University
Petruzza, Steve — Utah State University
Sewell, Andres — Utah State University
Montgomery, Emma — Utah State University

17:30-17:50 — WeC1.4

AIDERS: A Multi-UAV Platform for Disaster Management with Integrated Simulation and Real-Time Operations, pp. 385-392.

Manellanga, Rajitha Ayeshmantha — University of Cyprus
Theodorou, Xenios — University of Cyprus
Demetriou, Michalis — University of Cyprus

Manousakis, Konstantinos	University of Cyprus
Kolios, Panayiotis	University of Cyprus
Ellinas, Georgios	University of Cyprus

17:50-18:10 WeC1.5

Recreation of 3D UAS Flights in High-Realism Virtual Environments, pp. 393-399.

Beam, Christopher	University of North Carolina at Charlotte
Wolek, Artur	University of North Carolina at Charlotte
Willis, Andrew	University of North Carolina at Charlotte

WeC2 Rm 200

UAS Applications II (Regular Session)

Chair: Vitzilaios, Nikolaos	University of South Carolina
Co-Chair: Das, Amrita	University of North Dakota

16:30-16:50 WeC2.1

UAS-Assisted Corrosion Detection in Steel Using Combined Human and Machine Intelligence, pp. 400-407.

Das, Amrita	University of North Dakota
Dorafshan, Sattar	University of North Dakota

16:50-17:10 WeC2.2

A Cooperative Multi-UAV Framework for Bridge Inspection, pp. 408-415.

Gil Castilla, Miguel	University of Seville
Poma, Aguilar, Alvaro Ramiro	University of Seville
Caballero, Alvaro	University of Seville
Ollero, Anibal	University of Seville

17:10-17:30 WeC2.3

Robust Trajectory Tracking Control of a Multi-Rotor UAV Carrying a Cable Suspended Load, pp. 416-423.

N S, Abhinay	TATA Consultancy Services
Das, Kaushik	TATA Consultancy Services
Ghose, Debasish	Indian Institute of Science

17:30-17:50 WeC2.4

Automation of Structure Inspection Tasks Using DJI Quadrotors, pp. 424-431.

Oviedo De La Torre, David	Universidad De Los Andes
De la Rosa Rosero, Fernando	Universidad De Los Andes

17:50-18:10 WeC2.5

UAV-Based Railway Track Following, pp. 432-440.

Lewandowski, Keith	University of South Carolina
Sucin, Toma	University of South Carolina
Vitzilaios, Nikolaos	University of South Carolina

WeC3 Rm 267

Autonomy/Integration (Regular Session)

Chair: Yuan, Jiawei	University of Massachusetts Dartmouth
Co-Chair: Martini, Simone	University of Denver

16:30-16:50 WeC3.1

GSCE: A Prompt Framework with Enhanced Reasoning for Reliable LLM-Driven Drone Control, pp. 441-448.

Wang, Wenhao	University of Massachusetts Dartmouth
Li, Yanyan	California State University San Marcos
Jiao, Long	University of Massachusetts Dartmouth
Yuan, Jiawei	University of Massachusetts Dartmouth

16:50-17:10 WeC3.2

Graph-Based Decentralized Exploration and Semantic Inspection for Multi-Robot Systems, pp. 449-456.

Fahim, Nada Elsayed Abbas	University of Zagreb
Petrovic, Tamara	University of Zagreb

17:10-17:30 WeC3.3

The BEAST: Modular Open-Source Framework for BVLOS Drone Flights with Long-Term Autonomy, pp. 457-

464.

van Manen, Benjamin Ronald	Saxion University of Applied Sciences
ter Maat, Gerjen	Saxion
Boe, Mick	Saxion University of Applied Sciences
Mersha, Abeje Yenehun	Saxion University of Applied Sciences

17:30-17:50 WeC3.4

Koopman-Based Reinforcement Learning for LQ Control Gains Estimation of Quadrotors, pp. 465-472.

Martini, Simone	University of Denver
Sonmez, Serhat	Istanbul Medeniyet University
Stefanovic, Margareta	University of Denver
Rutherford, Matthew	University of Denver
Valavanis, Kimon P.	University of Denver

17:50-18:10 WeC3.5

A Simulation Platform for Intelligent UAV Cybersecurity and Reliability Analysis, pp. 473-480.

Yang, Boyin	University of Massachusetts Dartmouth
Li, Yanyan	California State University San Marcos
Callaghan, Ryan	University of Massachusetts Dartmouth
Song, Houbing	University of Maryland, Baltimore County
Yuan, Jiawei	University of Massachusetts Dartmouth

WeC4 Rm 265

UAS Communications (Regular Session)

Chair: Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo
Co-Chair: Baidya, Sabur	University of Louisville

16:30-16:50 WeC4.1

UAV Control with Vision-Based Hand Gesture Recognition Over Edge-Computing, pp. 481-488.

Abdalla, Sousannah	Alamein International University
Baidya, Sabur	University of Louisville

16:50-17:10 WeC4.2

Communication for UAV Swarms: An Open-Source, Low-Cost Solution Based on ESP-NOW, pp. 489-495.

Grøntved, Kasper Andreas Rømer	University of Southern Denmark
Ladig, Robert	Ritsumeikan University
Christensen, Anders Lyhne	University of Southern Denmark

17:10-17:30 WeC4.3

Comparative Performance Analysis of OLSR, BATMAN-ADV, and Babel in UAV Mesh Networks, pp. 496-503.

Diniz, Beatriz Aparecida	University of São Paulo
Ferrão, Isadora	University of São Paulo
da Silva, Leandro Marcos	University of São Paulo
Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo

17:30-17:50 WeC4.4

Event Driven CBBA with Reduced Communication, pp. 504-510.

Sao, Vinita	IISER Bhopal
Ho, Tu Dac	Norwegian University of Science and Technology
Bhore, Sujoy	IIT Bombay
Baliyarasimhuni, Sujit, P	IISER Bhopal

17:50-18:10 WeC4.5

A Framework for Safe Local 3D Path Planning Based on Online Neural Euclidean Signed Distance Fields, pp. 511-517.

Gil Garcia, Guillermo	Universidad Pablo De Olavide
Cobano, Jose Antonio	University Pablo De Olavide
Caballero, Fernando	University of Seville
Merino, Luis	Universidad Pablo De Olavide

Thursday, May 15

ThA1 Rm 340GHI
Best Paper Award Finalists from Latin America and Africa (LAA) (Regular Session)

Chair: Sanket, Nitin	Worcester Polytechnic Institute
Co-Chair: Hamaza, Salua	TU Delft

10:30-10:50 ThA1.1

Air Corridor Planning for UAVs Using a Cooperative Co-Evolutionary Approach and NURBS Representation, pp. 518-525.

Freitas, Elias José de Rezende	Universidade Federal De Minas Gerais, UFMG
Weiss Cohen, Miri	Braude Collège of Engineering
Guimarães, Frederico G.	Federal University of Minas Gerais
Pimenta, Luciano Cunha de Araújo	Universidade Federal De Minas Gerais

10:50-11:10 ThA1.2

Dual Quaternion-Based Control for Dynamic Robot Formations, pp. 526-533.

Giribet, Juan Ignacio	University of San Andrés
Marciano, Harrison	Federal University of Espirito Santo
Mas, Ignacio	ITBA
Ghersin, Alejandro	ITBA
Villa, Daniel Khede Dourado	Federal University of Espírito Santo
Sarcinelli-Filho, Mário	Federal University of Espirito Santo

11:10-11:30 ThA1.3

Propeller Damage Detection: Adapting Models to Diverse UAV Sizes, pp. 534-541.

Torre, Gabriel	Universidad De San Andrés
Pose, Claudio Daniel	Universidad De Buenos Aires
Giribet, Juan Ignacio	University of San Andrés

11:30-11:50 ThA1.4

Visual Control and Mapping for UAV-Based Platform Inspection, pp. 542-548.

Alves Fagundes Júnior, Leonardo	Universidade Federal De Viçosa
Soria, Carlos	Universidad Nacional De San Juan
Vassallo, Raquel	Federal University of Espirito Santo
Brandao, Alexandre Santos	Federal University of Vicosa

11:50-12:10 ThA1.5

Null Space-Based Control Embedding an Adaptive Sliding Mode Term Applied to a UAV-UAV Formation Carrying a Load, pp. 549-556.

Mafra Moreira, Mauro Sergio	Federal University of Espírito Santo
Villa, Daniel Khede Dourado	Federal University of Espírito Santo
Sarcinelli-Filho, Mário	Federal University of Espirito Santo

12:10-12:30 ThA1.6

Adaptive Load-Carrying Control Using Quadrotors in a Tandem Configuration, pp. 557-564.

Brandao, Alexandre Santos	Federal University of Vicosa
Alves Fagundes Junior, Leonardo	Universidade Federal De Viçosa
Castillo, Pedro	Université De Technologie De Compiègne

ThA2 Rm 200
Test and Evaluation of Autonomous Aerial Systems (Invited Session)

Chair: Costello, Donald	University of Maryland College Park
Co-Chair: Mwaffo, Violet	United States Naval Academy
Organizer: DeVries, Levi	United States Naval Academy
Organizer: Wickramasuriya, Maneesha	George Washington University
Organizer: Arslanian, Peter	Naval Air Systems Command - Naval Air Warfare Center Aircraft Di
Organizer: Fristachi, John	Calspan
Organizer: Prasinos, Mia	Air Force Institute of Technology

Organizer: Sakano, Kristy	University of Maryland at College Park
Organizer: Minton, Julia	NAWCAD
Organizer: Costello, Donald	University of Maryland College Park
Organizer: Bortoff, Zachary	University of Maryland

10:30-10:50 ThA2.1

*Test and Evaluation of Autonomous Aerial Systems**.

DeVries, Levi	United States Naval Academy
Wickramasuriya, Maneesha	George Washington University
Arslanian, Peter	Naval Air Systems Command - Naval Air Warfare Center Aircraft Di
Fristachi, John	Calspan
Prasinos, Mia	Air Force Institute of Technology
Sakano, Kristy	University of Maryland at College Park
Minton, Julia	NAWCAD
Costello, Donald	University of Maryland College Park
Bortoff, Zachary	University of Maryland

10:50-11:10 ThA2.2

Global Navigation Satellite System (GNSS) Emulator for Test and Evaluation of Flight Controller Performance (I), pp. 565-571.

McClelland, Matthew	United States Naval Academy
Cohen, Zachary	United States Naval Academy
Kutzer, Michael	United States Naval Academy
DeVries, Levi	United States Naval Academy

11:10-11:30 ThA2.3

Using Target Detection Probability to Evaluate Area Coverage by a UAV (I), pp. 572-578.

Bortoff, Zachary	University of Maryland
Luterman, Alec	University of Maryland
Paley, Derek	University of Maryland
Nogar, Stephen	U.S. Army Research Laboratory

11:30-11:50 ThA2.4

Precise Ranging to an Aerial Refueling Coupler Using a DNN and a Monocular Camera System (I), pp. 579-586.

Lowe, Ryan	United States Naval Academy
Maheshwari, Akshat	United States Naval Academy
Mwaffo, Violet	United States Naval Academy
Kutzer, Michael	United States Naval Academy
DeVries, Levi	United States Naval Academy
Costello, Donald	University of Maryland College Park

11:50-12:10 ThA2.5

A Framework for Black-Box Controller Design to Automatically Satisfy Specifications Using Signal Temporal Logic (I), pp. 587-594.

Sakano, Kristy	University of Maryland at College Park
Mockler, Joe	University of Maryland
Chen, Alexis	University of Maryland at College Park
Xu, Huan	University of Maryland

12:10-12:30 ThA2.6

Post-Quantum UAV Communications Encryption Tester (P-QUAVCET) (I), pp. 595-601.

Minton, Julia	NAWCAD
Collins, Daniel	NAWCAD
Creech, Michael	NAWCAD
Grossman, Joshua	NAWCAD
Manspeaker, Amber	NAWCAD
Hwang, George	NAWCAD
Rea, Charles	NavAir

ThA3	Rm 267
Path Planning II (Regular Session)	
Chair: Jafarnejadsani, Hamidreza	Stevens Institute of Technology
Co-Chair: Mehta, Varun	National Research Council Canada

10:30-10:50 ThA3.1

Optimization-Based Motion Planning for Vector Field Following in Dynamic Environments, pp. 602-608.

Akhihiero, David	West Virginia University
Olawoye, Uthman	West Virginia University
Pereira, Guilherme	West Virginia University

10:50-11:10 ThA3.2

Cellular Connectivity Risk-Aware Flight Path Planning for BVLOS UAV Operations, pp. 609-616.

Sajjadi, Sina	National Research Council Canada
Mehta, Varun	University of Ottawa
Janabi Sharifi, Farrokh	Toronto Metropolitan University
Mantegh, Iraj	National Research Council Canada

11:10-11:30 ThA3.3

Conflict Avoidance Using an Artificial Potential Field and the mCOWEX Algorithm, pp. 617-624.

Danielmeier, Lennart	RWTH Aachen University
Knaak, Florian	RWTH Aachen University
Voget, Nicolai	RWTH Aachen University
Hartmann, Max	RWTH Aachen University
Moormann, Dieter	RWTH Aachen University

11:30-11:50 ThA3.4

Team Orienteering and Scheduling Algorithms for Collaborative UAV-UGV Area Coverage with Battery Constraints, pp. 625-632.

Lee, Jaekyung Jackie	Texas A&M University
Rathinam, Sivakumar	Texas a & M University

11:50-12:10 ThA3.5

VLM-RRT: Vision Language Model Guided RRT Search for Autonomous UAV Navigation, pp. 633-640.

Ye, Jianlin	University of Cyprus
Papaioannou, Savvas	University of Cyprus
Kolios, Panayiotis	University of Cyprus

12:10-12:30 ThA3.6

Learning Optimal UAV Trajectory for Data Collection in 3D Reconstruction Model, pp. 641-648.

Gaudel, Bijay	Stevens Institute of Technology
Jafarnejadsani, Hamidreza	Stevens Institute of Technology

ThA4	Rm 265
Simulation (Regular Session)	
Chair: Willis, Andrew	University of North Carolina at Charlotte
Co-Chair: Caballero, Alvaro	University of Seville

10:30-10:50 ThA4.1

Multi-UAV Planning in Search and Rescue Missions Using Optimal Search Effort Allocation, pp. 649-656.

Sojo, Antonio	University of Sevilla, GRVC Lab
Perea, Alejandro	Universidad De Sevilla
Castell, Marco	Universidad De Sevilla
Juan, Perrela Clavería	Alpha Unmanned Systems S.L
Maza, Ivan	Universidad De Sevilla
Caballero, Alvaro	University of Seville
Ollero, Anibal	Universidad De Sevilla - Q-4118001-I

10:50-11:10 ThA4.2

Multiphysics Blast Simulation for 3D UAV Control Applications, pp. 657-664.

Parab, Surabhi	University of North Carolina at Charlotte
Zhang, Jincheng	University of North Carolina at Charlotte
Willis, Andrew	University of North Carolina at Charlotte

11:10-11:30	ThA4.3
Analysis and Validation of CFD Model in Propeller-Wing Configurations, pp. 665-672.	
Ghoshal, Kshitij	McGill University
Nahon, Meyer	McGill University

11:30-11:50	ThA4.4
UAV Simulation Environment for Fault Detection in Wind Farm Electrical Distribution Systems, pp. 673-680.	
Soares, Vítor Magalhães Dourado	USP - Universidade De São Paulo
Maroun de Almeida, Lucas	Universidade De São Paulo
Persiani Filho, Carlos Andre	University of São Paulo
Inoue, Roberto Santos	Universidade Federal De São Carlos
Grassi Junior, Valdir	Universidade De São Paulo
Terra, Marco Henrique	University of Sao Paulo at Sao Carlos
Oleskovicz, Mario	University of Sao Paulo - USP

11:50-12:10	ThA4.5
Real-Time Simulation of Complex 4D Wind Fields and Gusts for UAS Control System Development, pp. 681-688.	
Parab, Surabhi	University of North Carolina at Charlotte
Wolek, Artur	UNC Charlotte
Maity, Dipankar	University of North Carolina - Charlotte
Willis, Andrew	University of North Carolina at Charlotte

12:10-12:30	ThA4.6
UAV Path Planning and Control: Towards a Complete Mission Management System, pp. 689-696.	
Tsourveloudis, Christos	National Technical University of Athens
Doitsidis, Lefteris	Technical University of Crete

ThB1	Rm 340GHI
Multirotor Design and Control II (Regular Session)	
Chair: Harms, Marvin Chayton	NTNU
Co-Chair: Baldini, Alessandro	Università Politecnica Delle Marche

14:00-14:20	ThB1.1
Embedded Safe Reactive Navigation for Multirotors Systems Using Control Barrier Functions, pp. 697-704.	
Misyats, Nazar	École Normale Supérieure De Rennes
Harms, Marvin Chayton	NTNU
Nissov, Morten Christian	Norwegian University of Science and Technology
Jacquet, Martin	NTNU
Alexis, Kostas	NTNU

14:20-14:40	ThB1.2
Geometric Disturbance Observer Based Control for Multirotors, pp. 705-712.	
Baldini, Alessandro	Università Politecnica Delle Marche
Felicetti, Riccardo	Università Politecnica Delle Marche
Freddi, Alessandro	Università Politecnica Delle Marche
Monteriù, Andrea	Università Politecnica Delle Marche

14:40-15:00	ThB1.3
Offset-Aware Dual Quaternion Control for UAVs with Cable-Suspended Loads, pp. 713-720.	
Yuan, Yuxia	Technical University of Munich
Pries, Lukas	TU Munich
Ryll, Markus	TU Munich

15:00-15:20	ThB1.4
Design and Analysis of a Payload-Centric Controller for Collaborative Aerial Manipulation of a Slender Object, pp. 721-727.	
Williams, Connor Ian	University of Auckland
Skinner, Jaap	University of Auckland
Stol, Karl	University of Auckland

15:20-15:40	ThB1.5
Thrust Agility of Variable Pitch in Coaxial Rotor Pairs, pp. 728-735.	

Chen, Ruby	The University of Auckland
Zhao, HongYang	The University of Auckland
Al-zubaidi, Salim	University of Auckland
Kay, Nicholas	University of Auckland

ThB2 Rm 200

Test and Evaluation of Autonomous Aerial Systems II (Invited Session)

Chair: Costello, Donald	University of Maryland College Park
Co-Chair: Mwaffo, Violet	United States Naval Academy
Organizer: DeVries, Levi	United States Naval Academy
Organizer: Wickramasuriya, Maneesha	George Washington University
Organizer: Arslanian, Peter	Naval Air Systems Command - Naval Air Warfare Center Aircraft Di
Organizer: Fristachi, John	Calspan
Organizer: Prasinos, Mia	Air Force Institute of Technology
Organizer: Sakano, Kristy	University of Maryland at College Park
Organizer: Minton, Julia	NAWCAD
Organizer: Costello, Donald	University of Maryland College Park
Organizer: Bortoff, Zachary	University of Maryland

14:00-14:20 ThB2.1

An Analysis of Multi-Object Detection on 2024 Aerial Refueling Flight Test Data (I), pp. 736-741.

Prasinos, Mia	Air Force Institute of Technology

14:20-14:40 ThB2.2

Deep Learning-Based Relative Bearing Estimation between Naval Surface Vessels and UAS in Challenging Maritime Environments (I), pp. 742-748.

Miller, Sean	USNA
Mwaffo, Violet	United States Naval Academy
Costello, Donald	University of Maryland College Park

14:40-15:00 ThB2.3

Vision-In-The-Loop Simulation for Deep Monocular Pose Estimation of UAV in Ocean Environment (I), pp. 749-756.

Wickramasuriya, Maneesha	George Washington University
Beomyeol, Yu	George Washington University
Lee, Taeyoung	George Washington University
Snyder, Murray	George Washington University

15:00-15:20 ThB2.4

Optimizing Parameters for Hybrid DNN-UKF State Estimation in Autonomous Air Refueling, pp. 757-762.

Wagner, Leo	United States Naval Academy
Andersen, James	United States Naval Academy
Costello, Donald	University of Maryland College Park
Mwaffo, Violet	United States Naval Academy

ThB3 Rm 267

Path Planning III (Regular Session)

Chair: Tzes, Anthony	New York University Abu Dhabi
Co-Chair: Weintraub, Isaac E.	Air Force Research Laboratory

14:00-14:20 ThB3.1

Engagement Zones for a Turn Constrained Pursuer, pp. 763-768.

Chapman, Thomas	Air Force Research Laboratory
Weintraub, Isaac E.	Air Force Research Laboratory
Von Moll, Alexander	Air Force Research Laboratory
Garcia, Eloy	AFRL

14:20-14:40 ThB3.2

Optimal Fixed-Wing UAV Rendezvous Via LQR-Based Longitudinal Control, pp. 769-776.

Büyükekiz, Kadir Bulathan	Turkish Aerospace Inc

Ergezer, Halit	Cankaya University

14:40-15:00	ThB3.3

Energy-Aware Coverage Path Planner for Multirotor UAVs, pp. 777-784.

Escobar, Luis	West Virginia University
Pereira, Guilherme	West Virginia University

15:00-15:20	ThB3.4

Efficient Safe Trajectory Planning for an Omnidirectional Drone, pp. 785-792.

Mohamed Ali, Abdullah	New York University Abu Dhabi
Hamandi, Mahmoud	NYUAD
Tzes, Anthony	New York University Abu Dhabi

15:20-15:40	ThB3.5

Voxel-Based Simulation in Comparison for Path Planning of Autonomous Indoor Multicopters, pp. 793-800.

Kumpe, Hendrik	Institut Für Integrierte Produktion Hannover GGmbH
Küster, Benjamin	Institut Für Integrierte Produktion Hannover GGmbH
Stonis, Malte	Institut Für Integrierte Produktion Hannover GGmbH
Overmeyer, Ludger	Leibniz University Hanover

ThB4 — Rm 265

Sensor Fusion (Regular Session)

Chair: Kim, Dongbin	University of Hartford
Co-Chair: Amaral, Guilherme	INESC TEC - Institute for Systems and Computer Engineering, Technology and Science

14:00-14:20	ThB4.1

Data Fusion Approach for Unmodified UAV Tracking with Vision and mmWave Radar, pp. 801-808.

Amaral, Guilherme	INESC TEC
J. Martins, João	INESC TEC
Martins, Pedro	INESC TEC
Dias, André	INESC TEC
Almeida, José Miguel	INESC TEC
Silva, Eduardo	INESC TEC

14:20-14:40	ThB4.2

Enhanced UAV Navigation Systems through Sensor Fusion with Trident Quaternions, pp. 809-816.

Incicco, Sebastian	Facultad De Ingeniería, Universidad De Buenos Aires
Giribet, Juan Ignacio	University of San Andrés
Colombo, Leonardo, J	Centre for Automation and Robotics

14:40-15:00	ThB4.3

A Framework for the Consistency Analysis of Relative Pose Sensors for Unmanned Aerial Vehicles (UAVs), pp. 817-824.

Jung, Roland	University of Klagenfurt
Horyna, Jiri	Czech Technical University in Prague, FEE
Jantos, Thomas	University of Klagenfurt
Saska, Martin	Czech Technical University in Prague FEE
Weiss, Stephan	University of Klagenfurt

15:00-15:20	ThB4.4

From Detection to Traversal: A Probabilistic Framework for UAS-Assisted Landmine Mapping and Circumvention, pp. 825-831.

Steckenrider, J. Josiah	United States Military Academy
Kim, Dongbin	University of Hartford
Manjunath, Pratheek	United States Military Academy

15:20-15:40	ThB4.5

Navigating the Underground: Tackling Localization Challenges for UAVs in Tunnels (I), pp. 832-838.

González Marín, José Manuel	CATEC
Montes-Grova, Marco Antonio	CATEC
Perez-Grau, Francisco Javier	FADA – CATEC
Viguria, Antidio	FADA-CATEC

Friday, May 16

FrA1	Rm 340GHI
Advances in Aerial Robotics for Inspection and Maintenance (Invited Session)	
Chair: Caballero, Alvaro	University of Seville
Co-Chair: Loianno, Giuseppe	New York University
Organizer: Caballero, Alvaro	University of Seville
Organizer: Gonzalez-Morgado, Antonio	Universidad De Sevilla
Organizer: Ruggiero, Fabio	Università Degli Studi Di Napoli
Organizer: Loianno, Giuseppe	New York University

10:30-10:50 FrA1.1

Semi-Autonomous Interaction Framework for Contact-Based Operations with Commercial UAVs in GNSS-Denied Environments (I), pp. 839-846.

Gonzalez-Morgado, Antonio	Universidad De Sevilla
Zhang, Qi	Tampere University
Damigos, Gerasimos	Lulea University of Technology
Cuniato, Eugenio	ETH Zurich
Hui, Tong	Technical University of Denmark
Sahin, Erdem	Tampere University
Nikolakopoulos, George	Luleå University of Technology
Siegwart, Roland Y.	ETH Zürich
Fumagalli, Matteo	Danish Technical University
Ollero, Anibal	Universidad De Sevilla
Heredia, Guillermo	University of Seville

10:50-11:10 FrA1.2

Enhancing IMU Accuracy in MRAVs: A Theoretical and Experimental Approach to Vibration Damping (I), pp. 847-853.

Balandi, Lorenzo	INRIA
Robuffo Giordano, Paolo	IRISA / INRIA Rennes
Tognon, Marco	INRIA

11:10-11:30 FrA1.3

Simplifying Autonomous Aerial Operations: LUCAS, a Lightweight Framework for UAV Control and Supervision (I), pp. 854-861.

Murillo Alvarez, Jose Ignacio	FADA-CATEC
Montes-Grova, Marco Antonio	CATEC
Zahinos, Raul	CATEC
Trujillo, Miguel Ángel	CATEC
Viguria, Antidio	FADA-CATEC
Heredia, Guillermo	University of Seville

11:30-11:50 FrA1.4

Intuitive Human-Drone Collaborative Navigation in Unknown Environments through Mixed Reality (I), pp. 862-868.

Salunkhe, Sanket Ankush	Colorado School of Mines
Nedunghat, Pranav	New York University
Morando, Luca	New York University
Bobbili, Nishanth	New York University
Li, Guanrui	Worcester Polytechnic Institute
Loianno, Giuseppe	New York University

11:50-12:10 FrA1.5

Power Line Following Based on Measurements of the Magnetic Field (I), pp. 869-875.

Vasiljevic, Goran	University of Zagreb
Martinovic, Dean	University of Zagreb
Bogdan, Stjepan	University of Zagreb

12:10-12:30 FrA1.6

Aerial Transportation, Deployment and Retrieval of Dexterous Dual Arm Rolling Robot for Power Line Maintenance: Field Validation (I), pp. 876-881.

Suarez, Alejandro	University of Seville
Caballero, Alvaro	University of Seville
Ollero, Anibal	Universidad De Sevilla

FrA2 Rm 200

UAS Applications III (Regular Session)

Chair: Sanket, Nitin	Worcester Polytechnic Institute
Co-Chair: Maalouf, Guy	University of Southern Denmark

10:30-10:50 FrA2.1

Customized Design and Preliminary Testing of a Precision Spraying Drone for Vineyard Applications, pp. 882-889.

Primatesta, Stefano	Politecnico Di Torino
Enrico, Riccardo	Politecnico Di Torino
Carreño Ruiz, Manuel	Politecnico Di Torino
Bloise, Nicoletta	Politecnico Di Torino
Guglieri, Giorgio	Politecnico Di Torino

10:50-11:10 FrA2.2

A Semi-Autonomous UAV with Human Supervisory Control for Non-Destructive Inspections in Interaction with Concrete Structures, pp. 890-897.

Marcellini, Salvatore	Leonardo S.p.A
Marolla, Michele	Leonardo S.p.A
Lippiello, Vincenzo	Università Di Napoli Federico II

11:10-11:30 FrA2.3

Analyzing Deep-Learning Methods for Power Line Component Detection in Unmanned Aircraft System Imagery with Few Data, pp. 898-904.

Fourret, Guillaume	LIRMM, University of Montpellier, Drone Geofencing
Chaumont, Marc	LIRMM, University of Montpellier, University of Nîmes
Fiorio, Christophe	LIRMM, University of Montpellier
Subsol, Gérard	LIRMM, University of Montpellier
Brau, Samuel	Drone Geofencing

11:30-11:50 FrA2.4

Insights into Safe and Scalable BVLOS UAS Operations from Kenya's Ol Pejeta Conservancy, pp. 905-912.

Maalouf, Guy	University of Southern Denmark
Meier, Kilian	University of Bristol
Richardson, Thomas	University of Bristol
Guerin, David	IFATCA
Watson, Iain Matthew	University of Bristol
Schultz, Ulrik Pagh	University of Southern Denmark
Afridi, Saadia	Avy B.V
Rolland, Edouard George Alain	University of Southern Denmark
Jepsen, Jes Hundevadt	University of Southern Denmark
Njoroge, William	Ol Pejeta Conservancy
Jensen, Kjeld	University of Southern Denmark

11:50-12:10 FrA2.5

Heave Motion Estimation from IMU Measurements in Hybrid Aerial-Amphibious Drones and Horizontal Take-Off Window Prediction, pp. 913-920.

Capuozzo, Andrea	University of Naples Federico II
Ruggiero, Fabio	Università Degli Studi Di Napoli "Federico II"
Lippiello, Vincenzo	Università Di Napoli Federico II

12:10-12:30 FrA2.6

Data-Driven and Explainable Artificial Intelligence Modelling for Quadrotor Crash Area Prediction, pp. 921-928.

Sivakumar, Anush Kumar	Nanyang Technological University
T., Thanaraj	Nanyang Technological University
Feroskhan, Mir	Nanyang Technological University

FrA3	Rm 267
Regulations/Energy (Regular Session)	
Chair: Atkins, Ella	University of Michigan
Co-Chair: Pignaton de Freitas, Edison	Federal University of Rio Grande Do Sul

10:30-10:50	FrA3.1
Energy Aware Coverage Planning for a QuadPlane Small Uncrewed Aircraft System, pp. 929-936.	
Mathur, Akshay	University of Michigan
Atkins, Ella	University of Michigan

10:50-11:10	FrA3.2
Adaptive Optimal Path Following Guidance for Fixed-Wing Aerial Vehicles, pp. 937-943.	
Dodge, Andrew	University of Kansas
Baruth, Adam	University of Kansas
Keshmiri, Shawn	University of Kansas

11:10-11:30	FrA3.3
Regulatory and Operational Integration of High Altitude Platform Stations (HAPS) Considering the Brazilian and the European Perspectives, pp. 944-951.	
Erotokritou, Chrystel	Access Partnership
Stellatou, Sofia	Access Partnership
Formenton Vargas, Isadora	Rossi, Maffini, Milman & Grando Advogados
Pignaton de Freitas, Edison	Federal University of Rio Grande Do Sul

11:30-11:50	FrA3.4
Regulatory Landscape of Unmanned Aerial Systems in the Selected Countries in European Union: An In-Depth Analysis and the Imperative for Harmonization, pp. 952-958.	
Chrostowska, Martyna	Uczelnia Łazarskiego
Osiecki, Mateusz	Lazarski University in Warsaw
Fortonska, Agnieszka	University of Silesia

11:50-12:10	FrA3.5
Privacy Rights in the Context of Public Drone Use in the United States, pp. 959-966.	
Fortonska, Agnieszka	University of Silesia

12:10-12:30	FrA3.6
A Risk-Aware Mission Planning and Monitoring Methodology for UAS Operations, pp. 967-974.	
Primatesta, Stefano	Politecnico Di Torino

FrA4	Rm 265
Control Architectures/Swarms (Regular Session)	
Chair: Bradley, Justin	NC State University
Co-Chair: Rodriguez-Cortes, Hugo	Centro De Investigación Y De Estudios Avanzados Del Instituto Politécnico Nacional

10:30-10:50	FrA4.1
Control Barrier Function-Based Predictive Control for Close Proximity Operation of UAVs Inside a Tunnel, pp. 975-981.	
Mundheda, Vedant	Carnegie Mellon University
Kancharla, Damodar Datta	Chalmers University of Technology
Kandath, Harikumar	International Institute of Information Technology

10:50-11:10	FrA4.2
A Linear Complementarity Based MPC for Aerial Physical Interaction, pp. 982-987.	
Fuser, Riccardo	LAAS-CNRS
Nguyen, Hai-Nguyen (Hann)	RMIT Vietnam
Incremona, Gian Paolo	Politecnico Di Milano
Farina, Marcello	Politecnico Di Milano
Cognetti, Marco	LAAS-CNRS

11:10-11:30	FrA4.3
A Collision Avoidance Strategy for Commercial Quadrotors, pp. 988-993.	
Rodriguez-Cortes, Hugo	Centro De Investigación Y De Estudios Avanzados Del Instituto Po

Marco A., Martinez-Ramirez	CINVESTAV
Romero, Jose-Guadalupe	ITAM
Trujillo-Flores, Miguel	ITAM
Shao, Xiaodong	Beihang University

11:30-11:50 FrA4.4

UAV Resilience against Stealthy Attacks, pp. 994-1001.

Amorim, Arthur	University of Central Florida
Taylor, Max	The Ohio State University
Kann, Trevor	Carnegie Mellon University
Leavens, Gary	University of Central Florida
Harrison, William L.	Idaho National Laboratory
Joneckis, Lance	Idaho National Laboratory

11:50-12:10 FrA4.5

Co-Regulated Hierarchical Reinforcement Learning for Uncrewed Aircraft System Swarms, pp. 1002-1010.

Phillips, Grant	University of Nebraska-Lincoln
George, Jemin	US Army Research Laboratory
Bradley, Justin	NC State University

12:10-12:30 FrA4.6

Flocking Behavior for Dynamic and Complex Swarm Structures, pp. 1011-1018.

De Rojas Pita-Romero, Carmen	Universidad Politécnica De Madrid
Arias Perez, Pedro	Universidad Politecnica De Madrid
Fernandez-Cortizas, Miguel	Universidad Politecnica De Madrid
Perez-Segui, Rafael	Universidad Politécnica De Madrid
Campoy, Pascual	Universidad Politecnica Madrid

FrB1 Rm 340GHI

Security/Swarms (Regular Session)

Chair: Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo
Co-Chair: Negrao Costa, Andre	KTH

14:00-14:20 FrB1.1

A Systematic Review of GPS Spoofing: Methods, Tools, Tests, and Techniques in the State of the Art, pp. 1019-1026.

Allão, Daniel	Universidade De São Paulo
Ferrão, Isadora	University of São Paulo
Marçal, Vitor	Universidade De São Paulo
Ribeiro, Lucas	Universidade De São Paulo
Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo

14:20-14:40 FrB1.2

Collaborative Intrusion Detection System for Network and Flight Security in Unmanned Aerial Vehicles Group, pp. 1027-1034.

da Silva, Leandro Marcos	University of São Paulo
Ferrão, Isadora	University of São Paulo
Diniz, Beatriz Aparecida	University of São Paulo
Carciofi, Teodoro Prada	University of São Paulo
Zilio, Vicenzo D'Arezzo	University of São Paulo
Dezan, Catherine	Université De Bretagne Occidentale
Espes, David	Université De Bretagne Occidentale
Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo

14:40-15:00 FrB1.3

Performance Assessment of Counter-Drone Systems Using Bayesian Networks, pp. 1035-1042.

Bertrand, Sylvain	ONERA
Gayraud, Lionel	ONERA
Durieux, Jerome	ONERA

15:00-15:20 FrB1.4

UAV Audio Detection and Identification Using Short-Time Fourier Transform Spectrograms with Deep

Learning Models, pp. 1043-1048.

Lei, Helen	Cornell University
Gadgil, Ravi	San Jose State University
Amgothu, Sandeep Kumar	Texas A&M University-Corpus Christi
Kar, Dulal	Texas A&M University-Corpus Christi

15:20-15:40 FrB1.5

A Control-Theoretic Framework for Voronoi-Like Space Partitioning in Multi-Agent Drone Systems with Second Order Costs, pp. 1049-1056.

Negrao Costa, Andre	KTH
Ögren, Petter	KTH

15:40-16:00 FrB1.6

Dynamic Space Partition Algorithm with an Archimedean Spiral for Wildfire Detection Using a Swarm of UAVs, pp. 1057-1063.

Shi, Yinan	University of Bristol
Tzoumas, Georgios	University of Bristol
Hauert, Sabine	University of Bristol

FrB2 Rm 200

UAS Applications IV (Regular Session)

Chair: Carlson, Stephen	University of Nevada, Reno
Co-Chair: Sopegno, Laura	University of Palermo

14:00-14:20 FrB2.1

Vertical Dynamics of Flapping-Wing Flying Robot Facing Wind Disturbance: State-Dependent Riccati Equation and Equivalent Dynamics, pp. 1064-1070.

Capobianco, Eleonora	Universidad De Sevilla
Gonzalez-Morgado, Antonio	Universidad De Sevilla
Rafee Nekoo, Saeed	Universidad De Sevilla
Ollero, Anibal	Universidad De Sevilla

14:20-14:40 FrB2.2

RL-Based Control of UAS Subject to Significant Disturbance, pp. 1071-1077.

Chakraborty, Kousheek	Saxion University of Applied Sciences
Hof, Thijs	Saxion University of Applied Sciences
Alharbat, Ayham	Saxion University of Applied Sciences
Mersha, Abeje Yenehun	Saxion University of Applied Sciences

14:40-15:00 FrB2.3

VAPE: Viewpoint-Aware Pose Estimation Framework for Cooperative UAV Formation, pp. 1078-1085.

Kim, Young Ryun	Korea Aerospace University
Jung, Dongwon	Korea Aerospace University

15:00-15:20 FrB2.4

Automatic Identification of Safety Landing Points for VTOL UAVs Using Geodata, pp. 1086-1093.

König, Eva	RWTH Aachen University
Voget, Nicolai	RWTH Aachen University
Hartmann, Max	RWTH Aachen University
Moormann, Dieter	RWTH Aachen University

15:20-15:40 FrB2.5

Transformer-Based Physics Informed Proximal Policy Optimization for UAV Autonomous Navigation, pp. 1094-1099.

Sopegno, Laura	University of Palermo
Cirrincione, Giansalvo	MIS/UPJV
Martini, Simone	University of Denver
Rutherford, Matthew	University of Denver
Livreri, Patrizia	University of Palermo
Valavanis, Kimon P.	University of Denver

15:40-16:00 FrB2.6

A Dynamic Soaring Algorithm for Powered Fixed-Wing UAVs in Marine Environments, pp. 1100-1108.

Carlson, Stephen — University of Nevada, Reno
Papachristos, Christos — University of Nevada Reno

FrB3 — Rm 267
Autonomy (Regular Session)
Chair: Willis, Andrew — University of North Carolina at Charlotte
Co-Chair: Von Moll, Alexander — Air Force Research Laboratory

14:00-14:20 — FrB3.1
Synthesized Control for In-Field UAV Moving Target Interception Via Deep Reinforcement Learning and Fuzzy Logic, pp. 1109-1116.
Xia, Bingze — Concordia University
Akhlaque, Mohammad Ahsan — University of Ottawa
Mantegh, Iraj — National Research Council Canada
Bolic, Miodrag — University of Ottawa
Xie, Wenfang — Concordia University

14:20-14:40 — FrB3.2
Silent Drones: A Deep Learning Approach to Suppress Drone Propeller Noise, pp. 1117-1123.
Rizvi, Syeda Warisha Fatima — Hamad Bin Khalifa University
Ahmed, Fatimaelzahraa Ali — Hamad Medical Corporation
Qassmi, Noof — Qatar University
Al-Ali, Abdulla — Qatar University

14:40-15:00 — FrB3.3
A Reinforcement Learning Framework to Adaptively Schedule Controllers for UAVs Operating under Harsh Environmental Conditions, pp. 1124-1131.
Albool, Ibrahim — University of California, Irvine
Willis, Andrew — University of North Carolina at Charlotte
Wolek, Artur — University of North Carolina at Charlotte
Maity, Dipankar — University of North Carolina at Charlotte

15:00-15:20 — FrB3.4
Real-Time Mapping and Tree Measurements Using UAVs, pp. 1132-1137.
de Almeida Pereira, Jean Nelson — UFSCar Universidade Federal De São Carlos
Duarte de Souza, Caroline Elisa — UFSCar Universidade Federal De São Carlos
Lidia, Rocha — UFSCar Universidade Federal De São Carlos
Kelen Cristiane, Teixeira Vivaldini — UFSCar
Boshi, Raquel — UFSCar Universidade Federal De São Carlos
Brandao, Alexandre Santos — Federal University of Vicosa

15:20-15:40 — FrB3.5
One-Vs-One Threat-Aware Weaponeering with Basic Engagement Zones, pp. 1138-1145.
Von Moll, Alexander — Air Force Research Laboratory
Milutinovic, Dejan — University of California at Santa Cruz
Weintraub, Isaac E. — Air Force Research Laboratory
Casbeer, David — Air Force Research Laboratories

15:40-16:00 — FrB3.6
Fighter Jet Navigation and Combat Using Deep Reinforcement Learning with Explainable AI, pp. 1146-1151.
Kar, Swati — University of Tennessee at Chattanooga
Dey, Soumyabrata — Clarkson University
Banavar, Mahesh — Clarkson University
Sakib, Shahnewaz Karim — University of Tennessee at Chattanooga

FrB4 — Rm 265
Airspace Control (Regular Session)
Chair: Keshmiri, Shawn — University of Kansas
Co-Chair: Kolios, Panayiotis — University of Cyprus

14:00-14:20 — FrB4.1
Monotonically Weighted Nonlinear Model Predictive Control for Dynamics-Driven Visual Servoing of an Over-

Actuated Quadrotor, pp. 1152-1159.

Kamath, Archit Krishna	Nanyang Technological University
Sivakumar, Anush Kumar	Nanyang Technological University
Feroskhan, Mir	Nanyang Technological University

14:20-14:40 FrB4.2

On Cooperative Control of Two-Drones with a Slung Load, pp. 1160-1166.

Aghaee, Fateme	University of Southern Denmark
Jouffroy, Jerome	University of Southern Denmark

14:40-15:00 FrB4.3

A Robust Flight Controller Design: Investigating Guidance Failures Near TSS Heliport in Challenging Wind Conditions, pp. 1167-1174.

Kucuksayacigil, Gulnihal	University of Kansas
Keshmiri, Shawn	University of Kansas
Chrit, Mounir	University of North Dakota

15:00-15:20 FrB4.4

A Real-Time Autonomous Exploration Framework for Indoor 3D Environments Employing Multiple Unmanned Aerial Vehicles, pp. 1175-1182.

Nikolaidis, Antonis	KIOS, University of Cyprus
Laoudias, Christos	University of Cyprus
Kolios, Panayiotis	University of Cyprus

15:20-15:40 FrB4.5

Deep Neural Network-Based UAS Transport, pp. 1183-1189.

Rastgoftar, Hossein	University of Arizona
Zahed, Muhammad Junayed Hasan	University of Arizona

15:40-16:00 FrB4.6

Vision-Based Collision Avoidance and Path Planning for UAVs Using Bearing and Pixel Area, pp. 1190-1197.

Liu, Jen-Jui	Brigham Young University
Evans, Curtis P.	Brigham Young University
Beard, Randal W.	Brigham Young Univ

ICUAS '25 Paper Abstracts

Wednesday, May 14

WeA1	Rm 340GHI
Multirotor Design and Control I (Regular Session)	
Chair: Sarcinelli-Filho, Mário	Federal University of Espirito Santo
Co-Chair: Arogeti, Shai	Ben-Gurion University of the Negev

10:30-10:50	WeA1.1

Dynamics and Control of a Hexacopter Propelled by Three Seesaws, pp. 1-8

Yecheskel, Dolev	Ben-Gurion University of the Negev
Arogeti, Shai	Ben-Gurion University of the Negev

Standard drones propelled by four rotors are under-actuated systems. They use four control inputs to control four degrees of freedom independently. Hexacopters are driven by two more propellers, but since the direction of the total thrust remains normal to the drone's body, still only four degrees of freedom can be controlled independently. In this study, we describe a new hexacopter type consisting of three seesaws. Each seesaw is driven by two propellers, allowing rotation of the seesaw relative to the drone's body. Then, we develop the drone's unique control system and demonstrate its ability to maneuver with six controlled degrees of freedom while propelled by six motors only.

10:50-11:10	WeA1.2

Trajectory Tracking for Quadrotors Using Tilt-Prioritized Attitude Control, pp. 9-14

Tavares, Luiz	Federal University of Espirito Santo
Bacheti, Vinícius Pacheco	Federal University of Espirito Santo
Sarcinelli-Filho, Mário	Federal University of Espirito Santo
Villa, Daniel Khede Dourado	Federal University of Espírito Santo

This paper presents a trajectory-tracking approach for quadrotors using a tilt-prioritized attitude controller. The proposed control framework prioritizes tilt angles (the direction of the body z-axis) over yaw orientation to improve the translational trajectory tracking performance. A linear modulation parameter is introduced to enable a smooth transition between the UAV only tilting and the UAV tilting and orientating in yaw. Additionally, since it does not use operations with quaternions, matrix multiplication, or matrix inverses, the proposed controller is computationally efficient and easy to implement, making it well-suited for micro or small aerial vehicles. Real-world experiments validate the proposed method, demonstrating its effectiveness in agile trajectory tracking.

11:10-11:30	WeA1.3

Cable Optimization and Drag Estimation for Tether-Powered Multirotor UAVs, pp. 15-21

Beffert, Max	University of Tübingen
Zell, Andreas	University of Tübingen

The flight time of multirotor unmanned aerial vehicles (UAVs) is typically constrained by their high-power consumption. Tethered power systems present a viable solution to extend flight times while maintaining the advantages of multirotor UAVs, such as hover capability and agility. This paper addresses the critical aspect of cable selection for tether-powered multirotor UAVs, considering both hover and forward flight. Existing research often overlooks the trade-offs between cable mass, power losses, and system constraints. We propose a novel methodology to optimize cable selection, accounting for thrust requirements and power efficiency across various flight conditions. The approach combines physics-informed modeling with system identification to combine hover and forward flight dynamics, incorporating factors such as motor efficiency, tether resistance, and aerodynamic drag. This work provides an intuitive and practical framework for optimizing tethered UAV designs, ensuring efficient power transmission and flight performance. Thus allowing for better, safer, and more efficient tethered drones.

11:30-11:50	WeA1.4

Slat-Inspired Reversible Wing for Stopped-Rotor Vehicles, pp. 22-28

Hilby, Kristan	Massachusetts Institute of Technology
Hughes, Max	Northwestern University
Hunter, Ian	Massachusetts Institute of Technology

Reversible morphing wings, which can exchange the leading and trailing edges, expand architectural possibilities for aerial robotics (e.g., stopped-rotor configurations). However, few designs are scaled for uncrewed aerial vehicle (UAV) applications or effectively address the coupled aerodynamic and structural challenges of morphing. As such, we present a novel reversible wing design that uses rigid parallelogram slats mounted on a flexible substrate, creating a compliant yet aerodynamically robust structure. One-way fluid-structure interaction simulations validate the wing's structural performance under airflow. Compared to other reversed-flow wings, the proposed configuration doubles reverse-flow performance relative to a Clark-Y wing and improves upon the 0-degree angle of attack performance compared to other reversible morphing wings.

11:50-12:10	WeA1.5

Motion Control in Multi-Rotor Aerial Robots Using Deep Reinforcement Learning, pp. 29-36

Shetty, Gaurav	Hochschule Bonn-Rhein-Sieg University of Applied Sciences, Inter
Ramezani, Mahya	University of Luxembourg
Habibi, Hamed	Nterdisci Plinary Centre for Security, Reliability and Trust, U
Voos, Holger	University of Luxembourg
Sanchez-Lopez, Jose-Luis	University of Luxembourg

This paper investigates the application of Deep Reinforcement (DRL) Learning to address motion control challenges in drones for additive manufacturing (AM). Drone-based additive manufacturing promises flexible and autonomous material deposition in large-scale or hazardous environments. However, achieving robust real-time control of a multi-rotor aerial robot under varying payloads and potential disturbances remains challenging. Traditional controllers like PID often require frequent parameter re-tuning, limiting their applicability in dynamic scenarios. We propose a DRL framework that learns adaptable control policies for multi-rotor drones performing waypoint navigation in AM tasks. We compare Deep Deterministic Policy Gradient (DDPG) and Twin Delayed Deep Deterministic Policy Gradient (TD3) within a curriculum learning scheme designed to handle increasing complexity. Our experiments show TD3 consistently balances training stability, accuracy, and success, particularly when mass variability is introduced. These findings provide a scalable path toward robust, autonomous drone control in additive manufacturing.

12:10-12:30	WeA1.6

Deep Visual Servoing of an Aerial Robot Using Keypoint Feature Extraction, pp. 37-43

Sepahvand, Shayan	Toronto Metropolitan University
Amiri, Niloufar	Toronto Metropolitan University
Janabi Sharifi, Farrokh	Toronto Metropolitan University

The problem of image-based visual servoing (IBVS) of an aerial robot using deep-learning-based key point detection is addressed in this article. A monocular RGB camera mounted on the platform is utilized to collect visual data. A convolutional neural network (CNN) is then employed to extract the features serving as the visual data for the servoing task. This paper contributes to the field by circumventing not only the challenge stemming from the need for man-made marker detection in conventional visual servoing techniques but also enhancing the robustness against undesirable factors including occlusion, varying illumination, clutter, and background changes, thereby broadening the applicability of perception-guided motion control tasks in aerial robots. Additionally, extensive physics-based ROS Gazebo simulations are conducted to assess the effectiveness of this method, in contrast to many existing studies that rely solely on physics-less simulations. A demonstration video is available at https://youtu.be/Dd2Her8Ly-E.

WeA2	Rm 200
Perception and Cognition (Regular Session)	
Chair: Petric, Frano	University of Zagreb
Co-Chair: Boubin, Jayson	Binghamton University

10:30-10:50	WeA2.1

Aerial Maritime Vessel Detection and Identification, pp. 44-51

Barisic, Antonella	Faculty of Electrical Engineering and Computing (FER), Universit
Petric, Frano	University of Zagreb
Bogdan, Stjepan	Univ. of Zagreb

Autonomous maritime surveillance and target vessel identification in environments where Global Navigation Satellite Systems (GNSS) are not available is critical for several applications such as search and rescue and threat detection. When the target vessel is only described by visual cues and its last known position is not available, unmanned aerial vehicles (UAVs) must rely solely on on-board vision to scan a large search area under strict computational constraints. To address this challenge, we leverage the YOLOv8 object detection model to detect all vessels in the field of view. We then apply feature matching and hue histogram distance analysis to determine whether any detected vessel corresponds to the target. When found, we localize the target using simple geometric principles. We demonstrate the proposed method in real-world experiments during the MBZIRC2023 competition, integrated into a fully autonomous system with GNSS-denied navigation. We also evaluate the impact of perspective on detection accuracy and localization precision and compare it with the oracle approach.

10:50-11:10	WeA2.2

Invisible Servoing: A Visual Servoing Approach with Return-Conditioned Latent Diffusion, pp. 52-59

Gerges, Bishoy	University of Twente
Bazzana, Barbara	University of Twente
Botteghi, Nicolò	University of Twente
Aboudorra, Youssef	University of Twente
Franchi, Antonio	Univ. of Twente and Sapienza Univ. of Rome

In this paper, we present a novel visual servoing (VS) approach based on latent Denoising Diffusion Probabilistic Models (DDPMs), that explores the application of generative models for vision-based navigation of UAVs (Uncrewed Aerial Vehicles).

Opposite to classical VS methods, the proposed approach allows reaching the desired target view, even when the target is initially not visible. This is possible thanks to the learning of a latent representation that the DDPM uses for planning and a dataset of trajectories encompassing target-invisible initial views. A compact representation is learned from raw images using a Cross-Modal Variational Autoencoder. Given the current image, the DDPM generates trajectories in the latent space driving the robotic platform to the desired visual target. The approach has been validated in simulation using two generic multi-rotor UAVs (a quadrotor and a hexarotor). The results show that we can successfully reach the visual target, even if not visible in the initial view. A video summary with simulations can be found in: https://youtu.be/2Hb3nkkcszE.

11:10-11:30	WeA2.3

REMIX: Real-Time Hyperspectral Anomaly Detection for Small UAVs, pp. 60-66

Dastranj, Melika	Binghamton University
de Smet, Timothy	Aletair
Wigdahl-Perry, Courtney	State University of New York at Fredonia
Chiu, Kenneth	Binghamton University
Bihl, Trevor	Air Force Research Laboratory
Boubin, Jayson	Binghamton University

Unmanned aerial vehicles (UAV) have emerged in recent years as powerful, maneuverable sensors capable of real-time computer vision. Real-time image processing onboard UAV often requires data or model compression, acceleration, or edge offloading and is generally restricted to conventional RGB cameras. In this study, we consider real-time in-situ processing for hyperspectral imaging (HSI). HSI cameras detect many wavelengths of light. Material-specific spectral signatures can be matched to camera outputs to identify materials in a UAV's environment, but HSI cameras produce large amounts of information that generally require offline processing by heavy-weight software. We present REMIX, a real-time hyperspectral processing payload for small UAV. REMIX uses a custom software library, light-weight hyperspectral camera, and small embedded device to process and visualize HSI data in real-time. REMIX processes HSI lines under 5ms, allowing HSI perception to be visualized in real-time where conventional methods may take hours. We show that, when properly configured, adding real-time processing via REMIX degrades UAV flight time by only 4% and increases HSI processing speeds by up to 6X compared to naive payloads, and further decreases post-processing time by 20.48X compared to conventional methods, even when using significantly less powerful equipment.

11:30-11:50	WeA2.4

An RF Direction Finding Payload for UAVs with Deep Learning Direction Prediction Via ResNet, pp. 67-74

Willis, Andrew	University of North Carolina at Charlotte
Feshami, Braden	Vulcan Ventura
Vasan, Srini	Vulcan Ventura
Touma, James	Air Force Research Laboratory

This article describes an RF Direction Finding (DF) payload developed for UAV systems. DF payloads sense RF signals using an antenna array and process the received signals at each antenna location to estimate the number of transmitting RF sources and their bearing relative to the payload. This article uses an open-source Software Defined Radio (SDR) known as the KrakenSDR which senses transmitted RF data with (5) antennas. A new deep learning architecture is proposed for estimating the azimuthal Direction of Arrival (DoA) of RF signals from the sensed KrakenSDR antenna data. The recent availability of the compact and comparatively lightweight KrakenSDR hardware for DF applications make academic investigation of this sensor for UAS possible. DF payloads are used in a wide variety of important applications including search-and-rescue, signal intelligence, RF source geolocation, spectrum monitoring, spectrum enforcement and disaster management contexts. This article describes results for a new DoA estimation algorithm and includes discussion on integration challenges, mechanical and electromagnetic design considerations and the payload Size Weight and Power-Cost (SWaP-C) metrics using the KrakenSDR hardware.

11:50-12:10	WeA2.5

Onboard UAV State Estimation and Trajectory Prediction Using Multi-Task Reservoir Computing, pp. 75-82

Souli, N.	University of Cyprus
Kardaras, Panagiotis	University of Cyprus
Grigoriou, Yiannis	University of Cyprus
Kolios, Panayiotis	University of Cyprus
Ellinas, Georgios	University of Cyprus

The rapid advancements in unmanned aerial vehicle (UAV) technology have led to their use in different applications, ranging from critical infrastructure monitoring and search-and-rescue to remote sensing. However, UAV operations are easily affected by environmental conditions and sensor malfunctions that lead to the need for an efficient, accurate, and trustworthy state identification and trajectory prediction framework. This work proposes an innovative real-time UAV system with the two-fold objective of state identification and trajectory prediction, employing a lightweight multi-task learning framework based on reservoir computing (RC) network architecture to achieve reliable and robust UAV operations. Specifically, custom multi-task models are designed and fine-tuned to obtain multi-modal sequential data (related to drone movement) by exploiting the ability of shared feature learning in an RC-based network architecture to accurately achieve and enhance real-time and simultaneous drone state classification and trajectory prediction. A real-world dataset is also created to train and evaluate the proposed multi-task model, encompassing drone movements recorded during numerous outdoor experiments. Finally, a UAV prototype system is implemented and extensively tested in a real-world environment to demonstrate its enhanced performance in trajectory prediction and drone state identification compared to existing methods.

12:10-12:30	WeA2.6

Detection of Endangered Deer Species Using UAV Imagery: A Comparative Study between Efficient Deep Learning Approaches, pp. 83-90

Roca, Agustin	Universidad De San Andrés
Castro, Gastón Ignacio	Universidad De San Andrés
Giribet, Juan Ignacio	University of San Andrés
Mas, Ignacio	ITBA
Torre, Gabriel	Universidad De San Andrés
Colombo, Leonardo, J	Centre for Automation and Robotics (CAR)
Pereira, Javier	CONICET

This study compares the performance of state-of-the-art neural networks including variants of the YOLOv11 and RT-DETR models for detecting marsh deer in UAV imagery, in scenarios where specimens occupy a very small portion of the image and are occluded by vegetation. We extend previous analysis by adding precise segmentation masks for our datasets enabling fine-grained training of a YOLO model with a segmentation head included. Experimental results show the effectiveness of incorporating the segmentation head achieving superior detection performance. This work contributes valuable insights for improving UAV-based wildlife monitoring and conservation strategies through scalable and accurate AI-driven detection systems.

WeA3	Rm 267
Micro and Mini UAS (Regular Session)	
Chair: Flores, Gerardo	Texas A&M International University
Co-Chair: Ward, Timothy	University of Bristol

10:30-10:50	WeA3.1

Dynamical Control Model and Tracking Controller for a Novel Flapping Wing Drone Platform, pp. 91-98

Cariño Escobar, Josué	Universite Aix-Marseille
Le-Guellec, Lina	Univ Grenoble Alpes
Van Ruymbeke, Edwin	XTIM Bionic Bird
Marchand, Nicolas	GIPSA-Lab CNRS
Engels, Thomas	Aix-Marseille Université
Ruffier, Franck	CNRS / Aix-Marseille Univ

This work focuses on the design and control of a novel type of Flapping-Wing Micro Aerial Vehicle (FWMAV). The drone, known as the X-Fly, is a new under-actuated robotic platform that also has an inner control loop to stabilize its roll angle thanks to an onboard IMU. Such assistance makes the X-Fly easier to pilot. The under-actuation and the flapping oscillations make modelling and the control of the X-Fly a challenging task.

A dynamical control model is introduced that is able to take advantage of the stabilized roll dynamics to separate the platform into two almost independent sub-systems, one for the altitude and another for the position on the x-y plane.

A trajectory tracking controller for the altitude and a circular trajectory are then proposed and tested in order to corroborate the validity of the presented model.

10:50-11:10	WeA3.2

Bio-Inspired UAS Swarm-Keeping Based on Computer Vision, pp. 99-105

Garcia, Gonzalo	Virginia Commonwealth University
Eskandarian, Azim	Virginia Commonwealth University

This paper employs a biologically inspired logic for trajectory generation for a swarm of autonomous aerial vehicles, using passive distance estimation from onboard visual cameras. The method is inspired by swarming birds that use the perception of neighboring birds to modify their own motion, based on passive sensory data. Based on birds' spatial proximity, the logic enables stable swarming without explicit inter-agent active distance control and specific neighbor identification. A decentralized technique is used that utilizes optimal guidance and control for trajectory tracking without centralized computations while progressing in a general direction and speed. Each agent, equipped with visual cameras, achieves a cohesive and coordinated contribution to the formation. The approach is validated through simulation using unmanned aircraft models controlled by nonlinear model predictive controllers, and by inferring distance from images between adjacent agents.

11:10-11:30	WeA3.3

Aerodynamic State Estimation of a Bio-Inspired Distributed Sensing UAV at High Angles of Attack and Sideslip, pp. 106-114

Ward, Timothy	University of Bristol
Mukherjee, Sourish	University of Southampton
Windsor, Shane	University of Bristol
Araujo-Estrada, Sergio	University of Southampton

Biological fliers' remarkable maneuverability and robust flight control are aided by information from dense arrays of distributed flow sensors on their wings. Bio-inspired fixed-wing uncrewed aerial vehicles (UAVs) with a “flight-by-feel” control approach could mimic these abilities, allowing safe operation in cluttered urban areas. Existing work has focused on longitudinal

parameter estimation and control at low angles of attack. This wind-tunnel study estimates both the longitudinal and lateral-directional aerodynamic states of a bio-inspired distributed pressure sensing UAV at angles of attack and sideslip up to 25° and 45°. Four span-wise strips of pressure sensors were found to show strong, location dependent variation with angle of sideslip across all angles of attack, indicating that distributed pressure sensing arrays can encode lateral-directional flow information. This was supported by the use of the pressure signals in estimator algorithms, which showed the angle of sideslip estimation was possible with both a linear partial-least-squares regression-based estimator and a non-linear feed-forward artificial neural network estimator. The non-linear estimator could predict angle of sideslip with a lower error than the linear estimator, with a root-mean-square error (RMSE) of 0.70° for the former compared to 1.23° for the latter. They both showed good estimation of angle of attack, even in the post-stall regime, with an RMSE of 0.58° for the linear estimator and 0.54° for the non-linear estimator. These results show that pressure-based distributed sensing can capture a complete aerodynamic picture of a UAV, unlocking the potential of a "flight-by-feel" control system informed by the aerodynamic states of the vehicle across a wide range of aerodynamic conditions.

11:30-11:50	WeA3.4

Guaranteed Fixed-Wing UAS Lateral Safety Via Control Barrier Functions, pp. 115-123

Xu, Jeffrey	University of Kansas
Marshall, Jeb	University of Kansas
Powers, Matthew	University of Kansas
Keshmiri, Shawn	University of Kansas

Despite the exponential and promising growth in urban air mobility, this sector faces multifaceted technological and societal challenges. Among the most critical is the development of safe, scalable collision avoidance systems capable of operating within the highly dynamic and congested airspace of metropolitan environments, where complex flight routes must navigate dense infrastructure, variable weather, and unpredictable traffic patterns. Traditional collision avoidance methods, such as potential field methods and TCAS, have limitations at low altitudes and in spatially congested metropolitan areas. This work presents a safety-critical control design using control barrier functions that not only guarantee safe operation but can also be applied to any existing system with minimal impact. Six degrees of freedom simulations show that the controller maintains the ego vehicle's safety across multiple scenarios and is capable of running in real-time for real-world implementation.

11:50-12:10	WeA3.5

Barrier Lyapunov Function-Based Control for Position-Based Visual Servoing of Fully Actuated UAVs within PX4, pp. 124-131

Vega, Erandi	Centro De Investigaciones En Optica
Verdín, Rodolfo Isaac	Centro De Investigaciones En Optica
Aldana, Noé	Universidad Iberoamericana León
Flores, Gerardo	Texas A&M International University

Position-Based Visual Servoing (PBVS) is a widely used technique for UAV control, enabling precise motion based on visual feedback. This paper presents a nonlinear control strategy based on a Barrier Lyapunov Function (BLF) to ensure exponential stability in fully actuated UAVs performing PBVS tasks. Unlike underactuated multirotors, fully actuated drones provide independent control of translation and orientation, making them well-suited for vision-based applications. We propose a velocity-state feedback control law that guarantees stability by leveraging a BLF-based approach. The method ensures that the velocity errors remain bounded while converging exponentially to zero, enhancing robustness in trajectory tracking. The control framework is integrated within the PX4 autopilot system and validated through Software-in-the-Loop (SITL) simulations in Gazebo, demonstrating its effectiveness in real-time UAV operations. Software-in-the-loop simulation results confirm the proposed controller's capability to track PBVS-generated velocity references accurately while maintaining stability under varying conditions. The integration of homography-based visual control further improves precision in vision-based UAV navigation. This work contributes to developing nonlinear control techniques for fully actuated UAVs, bridging the gap between theoretical control design and real-time implementation.

12:10-12:30	WeA3.6

Low Reynolds Number Experimental Tests of an Eppler-186 Airfoil with Gurney Flap for Small-UAV, pp. 132-138

Matias Garcia, Juan Carlos	National Institute for Aerospace Technology
Bardera-Mora, Rafael	National Institute for Aerospace Technology
Barroso Barderas, Estela	National Institute for Aerospace Technology
Rodríguez-Sevillano, Ángel Antonio	Universidad Politécnica De Madrid

An experimental wind tunnel study is performed on an EPPLER-186 airfoil equipped with a Gurney flap. The main goal is to improve the lift coefficient and lift-to-drag ratio of a small Unmanned Aerial Vehicle (UAV) during different flight conditions. This way, the vehicles would perform better aerodynamics, reducing take-off and landing distances. The aerodynamic forces are obtained using an external balance to quantify the effect on the flow with the various sizes of Gurney flaps installed. Adding the device at the trailing edge significantly increases lift values at low angles of attack (up to +0.32 points in lift coefficient). Drag values also increase, but for cruise flight at low angles of attack aerodynamic efficiency increases up to +6 points with respect to the base wing without Gurney flaps.

WeA4	Rm 265
Aerial Robotic Manipulation I (Regular Session)	

Chair: Brandao, Alexandre Santos	Federal University of Vicosa
Co-Chair: Castillo, Pedro	Université De Technologie De Compiègne

10:30-10:50	WeA4.1

Control Strategies for Real-Time Aerial Manipulation with Multi-DOF Arms: A Survey, pp. 139-146

Barakou, Stamatina	National Technical University of Athens
Tzafestas, Costas	National Technical University of Athens
Valavanis, Kimon P.	University of Denver

This survey summarizes key control approaches and architectures that reflect the state-of-the-art in aerial manipulation. The central objective is to provide a thorough resource for researchers exploring multirotor configurations suitable for real-time aerial manipulation applications. The focus is on evaluating and comparing prototype systems and their corresponding controller designs, emphasizing real-time implementation, regardless of the number of DOFs of the attached manipulator(s) and of specific applications. The survey groups control methods in three categories based on the specific architecture that is followed: coupled, partially coupled, and decoupled. The metrics used for the comparative study include system configuration, total weight, modeling approach, control architecture, robustness, implementation complexity, task execution precision, and achieved results (via simulations or experiments).

10:50-11:10	WeA4.2

Soccer Player Tracking Using UAV Imagery: A Comparative Study of YOLO and Traditional Image Processing Algorithms, pp. 147-154

Rezende, Felipe dos Anjos	Universidade Federal De Viçosa
Miranda Hudson, Thayron	Universidade Federal De Viçosa
Silva, Pedro Augusto Fialho	Universidade Federal De Viçosa
Alves, Werikson	Universidade Federal De Viçosa
Mendes, André	Universidade Federal De Viçosa
Brandao, Alexandre Santos	Universidade Federal De Viçosa

Player tracking is a useful tool for tactical analysis and performance evaluation in soccer, providing valuable insights into player movements and team dynamics. This project investigates the feasibility of tracking players using UAV-captured imagery, employing both YOLO and traditional image processing algorithms (TIPA). Initial validation focuses on robot soccer players due to their predictable and controllable movements. Comparative analysis considers processing time, computational cost, adaptability to environmental changes, sensitivity to lighting variations, ability to handle dynamic conditions, tracking accuracy, and real-time performance. Results indicate that, under equivalent hardware and preparation time conditions, YOLO achieves performance comparable to traditional techniques. Nonetheless, the selection of the most suitable approach should be guided by task-specific demands, available computational resources, and the time allocated for system development and deployment.

11:10-11:30	WeA4.3

Optimal Control of Dual Arm Manipulation for Flapping-Wing Robots in the Post-Perching Phase, pp. 155-161

Sadeghi Kordkheili, Sahar	Universidad De Sevilla
Gonzalez-Morgado, Antonio	Universidad De Sevilla
Rafee Nekoo, Saeed	Universidad De Sevilla
Arrue, B.C.	Universidad De Sevilla
Ollero, Anibal	Universidad De Sevilla

This work investigates cooperative dual-arm manipulation between two ornithopters in the post-perching phase. Flapping wing aerial systems are lightweight platforms designed to imitate bird flight, suitable for environmental monitoring tasks. When interacting with their environment, these systems must be able to perch on a branch as an initial step, followed by adjusting their position to achieve the desired pose and workspace. This research explores the application of a Port-Hamiltonian-based control method for designing and analysing controllers in cooperative manipulation by two ornithopters during the post-perching phase. The connection of end effectors while holding an object adds complexity and constraints to the problem. To address this, an energy-based approach using Optimal Port-Hamiltonian control and Optimal Load Distribution (OLD) is employed to evenly distribute the load between the arms. The effectiveness and advantages of this method are demonstrated through the defined scenario in which an optimal control law is implemented to derive an efficient trajectory for cooperative manipulation while tracking the desired elliptical path.

11:30-11:50	WeA4.4

A Study on Impact-Aware Aerial Robots Colliding with the Environment at Non-Vanishing Speed, pp. 162-169

Indukumar, Gayatri	University of Twente
Saccon, Alessandro	Eindhoven University of Technology
Franchi, Antonio	Univ. of Twente and Sapienza Univ. of Rome
Gabellieri, Chiara	University of Twente

Enabling aerial robots to handle dynamic contacts happening at non-vanishing speeds can enlarge the range of their applications. In this work, we propose an impact- aware strategy to allow aerial multirotor robots to recover from impacts. The method leverages a reactive strategy not requiring low-level changes to the motion controller commonly implemented onboard quadrotors, which might be not viable or not desirable for most users. Extensive simulation tests show that the proposed strategy considerably increases the tolerated velocity at impact in tasks in which the robot either picks an object up or collides against an object to clear its way. Preliminary experimental results using Crazyflie UAVs are also presented.

11:50-12:10	WeA4.5

Full State Quaternion-Based Observer Control for Multirotor Aerial Grasping, pp. 170-176

Garcia-Mosqueda, Inés	Tecnologico De Monterrey, School of Engineering and Sciences
Tevera-Ruiz, Alejandro	Cinvestav Unidad Saltillo
Abaunza, Hernan	Tecnologico De Monterrey
Castillo, Pedro	Université De Technologie De Compiègne
Sanchez-Orta, Anand Eleazar	Research Center for Advanced Studies - Cinvestav
Chazot, Jean-Daniel	Université De Technologie De Compiègne

This paper presents an enhanced observer control strategy for multirotor aerial grasping. Unlike previous approaches, which focused solely on translational dynamics, this method incorporates dual observers—one for the translational subsystem and another for the rotational dynamics. By leveraging quaternions, the proposed control framework provides a singularity-free representation of orientation while naturally decoupling rotational and translational dynamics. This allows the system to be treated as fully actuated in both position and orientation, improving disturbance rejection and compensating for torques induced by off-center or asymmetrically shaped objects during grasping. A passive, non-actuated gripper further enhances the drone's ability to interact with objects in real-world scenarios. Experimental validations confirm the robustness and adaptability of the proposed approach, demonstrating its effectiveness in handling dynamic variations in mass and torque while maintaining stable flight.

12:10-12:30	WeA4.6

Performance Analysis of a Fully-Actuated Screwdriving UAV, pp. 177-184

Lee, Louis Zu-Yue	University of Auckland
Stol, Karl	University of Auckland

The task of horizontal aerial screwdriving has been a relatively unexplored area of aerial manipulation yet has immense potential and use cases in fields such as construction, maintenance and inspection, especially in dangerous or costly scenarios. This paper presents an analysis of a novel screwdriving actuator integrated with a fully actuated UAV, identifying critical performance limits of the proposed design. As the UAV uses frictional torque generated from a high friction contact plate to counteract reactional torque from screwdriving, a relationship is derived to identify the minimum contact plate annulus diameter. The robustness of the UAV and screwdriving actuator are also quantified by identifying relationships for preventing pivoting about the contact plate from lateral disturbances. An analysis in screw torque requirements is performed and a flight test is conducted to investigate the performance of the screwdriving actuator in flight, which shows successful mitigation of reactional torques up to 0.03 Nm.

WeB1	Rm 340GHI
Best Paper Award Finalists (Regular Session)	
Chair: Tognon, Marco	Inria
Co-Chair: Hamaza, Salua	TU Delft

14:00-14:20	WeB1.1

AgilePilot: DRL-Based Drone Agent for Real-Time Motion Planning in Dynamic Environments by Leveraging Object Detection, pp. 185-192

Khan, Roohan Ahmed	Skolkovo Institute of Science and Technology
Serpiva, Valerii	Skolkovo Institute of Science and Technology
Tareke, Demetros Aschalew	Skolkovo Institute of Science and Technology
Fedoseev, Aleksey	Skolkovo Institute of Science and Technology
Tsetserukou, Dzmitry	Skolkovo Institute of Science and Technology

Autonomous drone navigation in dynamic environments remains a critical challenge, especially when dealing with unpredictable scenarios including fast-moving objects with rapidly changing goal positions. While traditional planners and classical optimisation methods have been extensively used to address this dynamic problem, they often face real-time, unpredictable changes that ultimately lead to sub-optimal performance in terms of adaptiveness and real-time decision making. In this work, we propose a novel motion planner, AgilePilot, based on Deep Reinforcement Learning (DRL) that is trained in dynamic conditions, coupled with real-time Computer Vision (CV) for object detections during flight. The training-to-deployment framework bridges the Sim2Real gap, leveraging sophisticated reward structures that promote both safety and agility depending upon environmental conditions. The system can rapidly adapt to changing environments, while achieving a maximum speed of 3.0 m/s in real-world scenarios. In comparison, our approach outperforms classical algorithms such as Artificial Potential Field (APF) based motion planner by 3 times, both in performance and tracking accuracy of dynamic targets by using velocity predictions while exhibiting 90% success rate in 75 conducted experiments. This work highlights the effectiveness of DRL in tackling real-time dynamic navigation challenges, offering intelligent safety and agility.

14:20-14:40	WeB1.2

A Time and Place to Land: Online Learning-Based Distributed MPC for Multirotor Landing on Surface Vessel in Waves, pp. 193-199

Stephenson, Jess	Queen's University
Stewart, William Scott	Queen's University
Greeff, Melissa	Queen's University

Landing a multirotor unmanned aerial vehicle (UAV) on an uncrewed surface vessel (USV) extends the operational range and offers recharging capabilities for maritime and limnology applications, such as search-and-rescue and environmental monitoring. However, autonomous UAV landings on USVs are challenging due to the unpredictable tilt and motion of the vessel caused by waves. This movement introduces spatial and temporal uncertainties, complicating safe, precise landings. Existing autonomous landing techniques on unmanned ground vehicles (UGVs) rely on shared state information, often causing time delays due to communication limits. This paper introduces a learning-based distributed Model Predictive Control (MPC) framework for autonomous UAV landings on USVs in wave-like conditions. Each vehicle's MPC optimizes for an artificial goal and input, sharing only the goal with the other vehicle. These goals are penalized by coupling and platform tilt costs, learned as a Gaussian Process (GP). We validate our framework in comprehensive indoor experiments using a custom-designed platform attached to a UGV to simulate USV tilting motion. Our approach achieves a 53% increase in landing success compared to an approach that neglects the impact of tilt motion on landing. For accompanying video: https://youtu.be/g4cCmE9Rgxs.

14:40-15:00	WeB1.3

Contact-Informed Online Trajectory Replanning for Obstacle Avoidance in Unmanned Aerial Manipulators, pp. 200-206

Garrard, YiZhuang	Arizona State University
Zhang, Wenlong	Arizona State University

Autonomous exploration in unknown areas is a challenge for unmanned aerial vehicles when traditional ranging sensors such as LIDARs or cameras fail due to dust, fog, or lack of illumination. In these situations, contact-informed navigation is leveraged by utilizing the end-effector of an unmanned aerial manipulator (UAM) to detect and exploit obstacle contacts. This work presents a contact-informed online replanning algorithm that updates an obstacle-bounding region using online wrench estimates, enabling a UAM to navigate around an unknown convex polyhedral obstacle. The planner generates joint-space setpoints that guide the tool center point (TCP) to track a reference trajectory while ensuring the multirotor body avoids the obstacle-bounding region. Two simulation cases show that this approach prevents multirotor body collisions and ensures TCP trajectory tracking.

15:00-15:20	WeB1.4

Koopman-Based Model Predictive Control of Quadrotors, pp. 207-213

Martini, Simone	University of Denver
Todde, Edoardo	Politecnico Di Torino
Stefanovic, Margareta	University of Denver
Rutherford, Matthew	University of Denver
Rizzo, Alessandro	Politecnico Di Torino
Valavanis, Kimon P.	University of Denver

A novel formulation of model predictive control (MPC) coupled with Koopman operator theory is presented and tested for the trajectory tracking problem of a quadrotor UAV. The analytical derivation of Koopman observables allows for the quadrotor model to be written as a fully actuated quasi-linear system which enables the control problem to be posed as a linear control problem. In fact, the adopted approach embeds the quadrotor nonlinear dynamics into a quasi-linear form through the evolution of the Koopman operator generalized eigenfunctions, a special kind of Koopman observables. Hence, the linear MPC formulation in Koopman coordinates is equivalent to a nonlinear implementation in the original state space. Moreover, in an enhancement from the standard feedback linearization, the Koopman based quadrotor model does not present underactuation, which drastically simplifies the computational requirement for the solution of the MPC optimization problem. The presented methodology is tested through detailed numerical simulations and results are compared to single-loop nonlinear MPC (NMPC). The satisfactory tracking performance is additionally enhanced by the obtained computational speedup which is crucial for real time implementation of flight controllers.

15:20-15:40	WeB1.5

FLIFO: A Passively Morphing Drone for Small Gap Traversal, pp. 214-221

Ruggia, Marco	University of Applied Sciences of the Grisons
Bermes, Christian	University of Applied Sciences of the Grisons

Drones that can morph their shape are used to sidestep a design trade-off when the traversal of small gaps is required. Typically, small drones that are able to fit through small gaps are less efficient than larger drones that can't fit through the same gaps. Morphing drones combine both advantages by being big and efficient in their normal configuration, and by temporarily becoming small and inefficient in their morphed configuration. The presented FLIFO (flip + fold) morphing drone manages to shrink to half its width, while maintaining full controllability. It does so purely passively, without requiring any additional actuators besides the ones needed for flight. This is an unprecedented accomplishment in morphing drones. Concretely, FLIFO's design consists of four simple hinges placed in a particular orientation on each arm, that cause the morphing once the drone flips upside down. Test flights of a prototype have successfully shown that this design can transition robustly between configurations while remaining in a tightly confined space, barely larger than the drone itself.

15:40-16:00	WeB1.6

Online Defensive Motion Planning against Adversarial Swarm Attacks Using Bernstein Polynomials-Based Model Predictive Control, pp. 222-227

Kang, Hyungsoo	University of Illinois Urbana-Champaign
Aoun, Christoph	University of Illinois
Kaminer, Isaac	Naval Postgraduate School

Hovakimyan, Naira	University of Illinois Urbana-Champaign

This paper proposes an online motion planning algorithm for defender drones to protect a High-Value Unit (HVU) against a swarm of attacker drones. We formulate an optimal motion planning problem and approximate its solutions using Bernstein polynomials. The favorable geometric properties of the polynomials allow us to compute the cost function and constraints efficiently. Since the attackers' dynamics are generally imperfectly known, we resort to model predictive control (MPC) approach. By predicting future trajectories of the attackers over a short time interval, we calculate optimal trajectories for the defenders to shoot down the attackers and maintain the survival probability of the HVU close to one. This optimization problem is solved recursively with a receding time horizon until the attackers are incapacitated.

WeB2	Rm 200
UAS Applications I (Regular Session)	
Chair: Coopmans, Calvin	Utah State University
Co-Chair: Aldao Pensado, Enrique	University of Vigo

14:00-14:20	WeB2.1

ρLiRLo: LiDAR-Based Relative Localization with Retro-Reflective Marker, pp. 228-235

Domislovic, Jakob	University of Zagreb
Milijas, Robert	University of Zagreb
Ivanovic, Antun	University of Zagreb
Car, Marko	University of Zagreb
Vasiljevic, Goran	University of Zagreb
Arbanas, Barbara	University of Zagreb
Petric, Frano	University of Zagreb
Orsag, Matko	University of Zagreb
Bogdan, Stjepan	University of Zagreb

This paper presents ρLiRLo, a LiDAR-based Relative Localization method, designed for reliable robot navigation and control in GNSS-denied environments. ρLiRLo enhances point cloud processing using intensity filtering with a retro-reflective marker. The marker's position is determined via Euclidean clustering, while a Kalman filter tracks the robot's pose. To improve localization accuracy in dynamic conditions, IMU measurements are integrated, and a robotic manipulator actively tracks the marker, expanding LiDAR's field of view. The method is demonstrated on an Unmanned Aerial Vehicle (UAV) in both indoor and outdoor experiments. Indoor tests benchmark localization against OptiTrack motion capture, while outdoor experiments are conducted in a maritime environment with the tracking system mounted on an Unmanned Surface Vehicle (USV).To mitigate the challenges of dynamic sea conditions, IMU measurements are used to compensate for disturbances introduced by waves and wind. ρLiRLo demonstrates high accuracy, low-latency feedback, and strong potential for applications in GNSS-denied settings.

14:20-14:40	WeB2.2

Evaluating the Influence of Wind on UAV Path Planning for Bridge Inspections, pp. 236-242

Aldao Pensado, Enrique	University of Vigo
Fontenla-Carrera, Gabriel	University of Vigo
Veiga-López, Fernando	Universidade De Vigo
Gonzalez Jorge, Higinio	University of Vigo
Maria José, Morais	University of Minho
C. Matos, José	University of Minho

Infrastructure inspections using UAVs have surged in recent years thanks to their ability to capture high-resolution imagery in hard-to-reach areas. Their versatility has garnered significant interest in applications such as bridge inspections, offering the potential to substantially reduce both costs and inspection time. However, UAVs are highly sensitive to environmental factors like turbulence and wind gusts, which can compromise their stability and lead to accidents. This is particularly critical in bridge inspections, where structural components such as pillars, decks, and cables generate complex wind patterns, including vortices and turbulence. To address these challenges, this paper presents a wind assessment methodology for UAV-based bridge inspections. To this end, an automated 3D urban geometry modeling methodology was developed using open-source geospatial data, and wind predictions were calculated via the CFD (Computational Fluid Dynamics) software OpenFOAM. A practical case study was carried out in Porto, Portugal, to validate the proposed methodology.

14:40-15:00	WeB2.3

Autonomous UAV Navigation and Mapping for Accurate Fruit Detection and Counting in Controlled Environments: Simulation and Real-World Validation, pp. 243-248

Garg, Kush	Delhi Technological University
Chandna, Nishant	Delhi Technological University
Aggarwal, Somin	Delhi Technological University
Sehgal, Chirag	Delhi Technological University
Gupta, Arjun	Delhi Technological University
Rohilla, Rajesh	Delhi Technological University

This paper presents a solution for high accuracy fruit counting in a Controlled Environment Agriculture (CEA) settings using Unmanned Aerial Vehicles (UAV) implemented in simulation and real-world scenarios. Using the fine-tuned YOLOv8 model for precise object detection and classification along with a custom path planning algorithm for simulation. This approach integrates a hybrid A* Traveling Salesman Problem (TSP) algorithm for efficient 3D path planning. The solution is further extended to the real-life scenario using LiDAR based mapping and point-cloud filtering techniques to avoid recounting of fruits. The suggested methodology increases operating efficiency, reduces dependency on human labor, and improves accuracy. Experimental results, derived from both simulations and real-world testing, achieving a fruit-count accuracy of 98% and 90% respectively, demonstrate the effectiveness of this integrated approach. This solution was implemented in the International Conference of Unmanned Aircraft System (ICUAS) UAV Competition 2024, securing 2nd position in the simulation phase (out of 24 teams) and 3rd overall in the real-world phase.

15:00-15:20	WeB2.4

Barrier Coverage of a Non-Planar Terrain-Like Border with UAVs, pp. 249-255

Kumar, Amit	Indian Institute of Science
Ghose, Debasish	Indian Institute of Science

Intrusion detection is a critical application in UAV networks with downward-facing cameras, where the barrier coverage problem entails strategically positioning UAVs to protect a region's perimeter. For a terrain-like border, achieving optimal UAV placement is challenging due to factors like resolution, overlap constraints, and varying altitudes across the terrain that have not been explored in previous studies. This paper addresses the barrier coverage problem in the context of a terrain-like border using Unmanned Aerial Vehicles (UAVs). We first simplify the 3D problem into an equivalent 2D model and introduce a resolution cost to evaluate the quality of terrain coverage. We also define the overlapping length and formulate an optimization problem to ensure barrier coverage for an initially uncovered belt. Our approach is validated through several example simulations.

15:20-15:40	WeB2.5

Multi-Resolution UAV Path Replanning for Inspection of Tailings Dams, pp. 256-263

Galvao Simplicio, Paulo Victor	West Virginia University
Pereira, Guilherme	West Virginia University

Autonomous inspection of large and complex structures with a commercial unmanned aerial vehicle (UAV) is a challenging problem that has been addressed in recent years. In this paper, we address the global motion planning problem of creating autonomous inspection missions for UAVs considering photogrammetry constraints. We focus on the inspection of large tailings dams, which are dam structures used to store waste byproducts of mining. Our method uses a prior sparse point cloud of the dam to generate a voxel grid, where paths satisfying photogrammetry constraints are tested for collisions. We then apply the A* algorithm as a local planner to avoid obstacles within the global mission. Moreover, we address the problem of changing routes online by using octree-based multi-resolution grids for efficient and fast pathfinding. Our results, obtained using tridimensional maps of an actual coal mine tailings dam, show that using octrees for multi-resolution motion planning is faster than using a fixed voxel grid in online missions while inspecting large structures.

15:40-16:00	WeB2.6

Towards Real-Time SLAM-Based Orthomosaic Generation for High-Resolution Scientific Multi-Band sUAS Imagery, pp. 264-271

Sewell, Andres	Utah State University
Payne, Ethan	Utah State University
Coopmans, Calvin	Utah State University
Torres-Rua, Alfonso	Utah State University
Petruzza, Steve	Utah State University

The increasing availability of high-resolution, multi-spectral cameras for small Unmanned Aerial Systems (sUAS) has enabled detailed aerial mapping for applications such as precision agriculture and environmental monitoring. However, generating orthomosaics from high-resolution imagery presents significant computational challenges, particularly for real-time processing on resource-constrained edge devices. This paper evaluates the feasibility of SLAM-based orthomosaic generation for high-resolution, multi-band sUAS imagery. We systematically analyze trade-offs in resolution scaling, feature extraction strategies, and incremental bundle adjustment techniques, quantifying their effects on accuracy, computational cost, and scalability. Our results show that while global bundle adjustment improves accuracy, localized selection strategies significantly reduce processing time, improving real-time processing performance. Additionally, we discuss the limitations of existing SLAM-based pipelines in handling high-resolution imagery and highlight opportunities to improve performance. By identifying key computational bottlenecks and accuracy trade-offs, this study provides insights for optimizing SLAM-based aerial mapping pipelines for real time scientific grade data analysis.

WeB3	Rm 267
Path Planning I (Regular Session)	
Chair: Brandao, Alexandre Santos	Federal University of Vicosa
Co-Chair: Debnath, Dipraj	Queensland University of Technology

14:00-14:20	WeB3.1

Time-Synchronized B-Spline Path Planning for Multi-Agent UAV Systems with Fixed Speed Profiles, pp. 272-278

Shumway, Landon	Brigham Young University

Beard, Randal W. | Brigham Young University

Most UAV path planning methods assume that speed is constant or controllable within certain constraints. However, some applications require UAVs to follow predefined speed profiles. This paper proposes a novel offline path planning algorithm for multi-agent UAV systems with fixed speed profiles that facilitates scheduled arrivals at desired final states in R2- space using uniform B-splines. The B-splines are parameterized by a path variable to decouple the path geometry from the speed profile, and a path extension algorithm is introduced for timely arrival. We present the path planning methods and demonstrate their effectiveness through Monte Carlo simulations of a formation control example. Results show that the proposed algorithm consistently ensures simultaneous arrival within 0.2 seconds in all cases, with an average deviation of only 0.07 seconds, regardless of initial conditions. This approach offers an effective solution for coordinated UAV missions with fixed speed profiles.

14:20-14:40 | WeB3.2

Inspection of Moving Structures by UAVs Using a Robust Approach Cone Strategy, pp. 279-285

Chakravarthy, Animesh | University of Texas at Arlington
Ghose, Debasish | Indian Institute of Science

In this paper, we consider the problem of inspecting a moving structure, which could be a train or a convoy, using a UAV. The moving structure is assumed to have gaps on its side to allow the UAV to enter or fly through it. Unlike earlier work in this area, since the structure is moving, the gap also moves along with it. The problem then reduces to one of a UAV trying to enter a moving window. We use the relative velocity framework to define a safe approach cone for the UAV so that its velocity vector, if directed inside this cone, will allow the UAV to pass through the window. We show that several parameters, such as the speeds of the window and the UAV, play an important part in deciding the angular span of the safe approach cone and thus have a bearing on the robustness of the guidance strategy. We establish a few theoretical results and illustrate them via simulations.

14:40-15:00 | WeB3.3

Effective Path Planning for UAVs in Complex and Unknown Environments through Integrated Q-Learning and Classical Algorithms, pp. 286-293

Rocha, Lidia | UFSCar
Brandao, Alexandre Santos | Federal University of Vicosa
Kelen Cristiane, Teixeira Vivaldini | UFSCar

This paper addresses the challenge of finding the shortest path in complex environments by integrating machine learning and traditional algorithms to enhance path planning techniques. The goal is to strike a balance between path length and processing time, ensuring reliable trajectories for Unmanned Aerial Vehicles. We explore four methodologies: Reinforcement Learning, Sample-Based, Geometric-Based, and Polynomial-Based Methods. Our main focus is on harnessing Reinforcement Learning for its adaptability and experiential learning capabilities in complex environments, despite its known slow convergence and high computational costs. Our proposed algorithm optimizes each step of the standard Reinforcement Learning method, Q-Learning, using classical techniques to refine its core behavior and overcome limitations. Testing in various simulated complex and unknown environments demonstrates the algorithm's efficacy in enhancing path planning efficiency and accuracy. Our approach successfully reduces path lengths by 11%, decreases flight time by 35%, and lowers processing time by 64% compared to the original Q-Learning approach.

15:00-15:20 | WeB3.4

NetSLAM: Network-Aware Path Planning for Edge-Assisted UAV Swarms, pp. 294-300

Nasir, Zain-ul-Abideen | Binghamton University
Ben Ali, Ali J. | Binghamton University
Boubin, Jayson | Binghamton University

Mapping and Localization in large environments is becoming increasingly important for autonomous UAV swarms. UAV swarms solving problems in disaster response, infrastructure inspection, and agriculture rely on fresh and accurate maps to make navigation decisions. SLAM methods are capable of providing highly accurate maps through visual information but are computationally heavy and ill-suited for UAV onboard computational profiles. For this reason, UAV swarms often dedicate one or more drones to frequent mapping, while other drones use map information for planning and trajectory generation. UAV swarms also centralize heavy-weight workloads like AI inference and SLAM map combination at the edge to extend UAV battery lives at the cost of network provisioning. Both map sharing and offloading necessitate high network bandwidth, but few SLAM or planning approaches account for this. We present NetSLAM, a network assisted SLAM and planning system that builds environmental maps and UAV trajectories that meet quality of service (QoS) requirements. NetSLAM embeds network information into SLAM maps so planning can compensate for changes in network connectivity across the environment. We also present Net*, a path planning algorithm which utilizes NetSLAM maps to build trajectories that maintain QoS requirements to maximize performance. Through real-world experiments and simulation, we show that NetSLAM maps network environments with limited additional overhead compared to existing SLAM approaches. NetSLAM improves swarm QoS by 2.35x while increasing path length by less than 14.7% compared to naive pathfinding.

15:20-15:40 | WeB3.5

DECK-GA: A Hybrid Clustering and Distance Efficient Genetic Algorithm for Scalable Multi-UAV Path Planning, pp. 301-308

Debnath, Dipraj | Queensland University of Technology
Vanegas, Fernando | Queensland University of Technology
Sandino, Juan | Queensland University of Technology
Gonzalez, Luis Felipe | Queensland University of Technology

The Multi-Travelling Salesman Problem (mTSP) provides a fundamental mathematical framework for modelling the complexities of effective and optimised multi-UAV path planning and for developing solution strategies. Different methodologies have been studied for multi-UAV path planning, such as clustering-based techniques for waypoint allocation. Despite classical Kmeans clustering being commonly employed for its efficiency, centroid instability produces an inefficient distribution of UAVs. Traditional Genetic Algorithms (GA) often encounter difficulties with premature convergence and ineffective crossover operations, leading to suboptimal paths. This paper presents DECK-GA, a hybrid framework that combines Dynamic Centroid Kmeans (DCKmeans) clustering with Distance Efficient Genetic Algorithm (DEGA) to address centroid instability, suboptimal UAV path distribution, and premature convergence. DECK-GA applies DCKmeans to improve centroid initialisation and integration, maintaining stable cluster formations; and DEGA to enhance path planning through fitness-proportionate selection and adaptive crossover mutation, increasing diversity and accelerating convergence. DECK-GA is tested in a simulated environment using 30 and 100 randomly distributed 3D waypoints, minimising travel distances by 56.06% and 69.03%, respectively. Computation times are reduced to 28.17 and 43.21 seconds, correspondingly surpassing classical Kmeans, GA, and other six additional clustering methods combined with traditional GAs and DEGA. The enhancements show the efficiency of DECK-GA in multi-UAV waypoint clustering and path planning for the mTSP, especially in applications that require efficient global path optimisation using GNSS waypoints.

15:40-16:00	WeB3.6

HetSwarm: Cooperative Navigation of Heterogeneous Swarm in Dynamic and Dense Environments through Impedance-Based Guidance, pp. 309-315

Zafar, Malaika	Skolkovo Institute of Science and Technology
Khan, Roohan Ahmed	Skolkovo Institute of Science and Technology
Fedoseev, Aleksey	Skolkovo Institute of Science and Technology
Jaiswal, Kumar Katyayan	IISER Bhopal
Baliyarasimhuni, Sujit, P	IISER Bhopal
Tsetserukou, Dzmitry	Skolkovo Institute of Science and Technology

With the growing demand for efficient logistics and warehouse management, unmanned aerial vehicles (UAVs) are emerging as a valuable complement to automated guided vehicles (AGVs). UAVs enhance efficiency by navigating dense environments and operating at varying altitudes. However, their limited flight time, battery life, and payload capacity necessitate a supporting ground station. To address these challenges, we propose HetSwarm, a heterogeneous multi-robot system that combines a UAV and a mobile ground robot for collaborative navigation in cluttered and dynamic conditions. Our approach employs an artificial potential field (APF)-based path planner for the UAV, allowing it to dynamically adjust its trajectory in real time. The ground robot follows this path while maintaining connectivity through impedance links, ensuring stable coordination. Additionally, the ground robot establishes temporal impedance links with low-height ground obstacles to avoid local collisions, as these obstacles do not interfere with the UAV's flight.

Experimental validation of HetSwarm in diverse environmental conditions demonstrated a 90% success rate across 30 test cases. The ground robot exhibited an average deviation of 45 cm near obstacles, confirming effective collision avoidance. Compared to the Conflict-Based Search (CBS) algorithm, our approach enables agents to navigate within 25 cm of obstacles, whereas CBS maintains a minimum clearance of 73 cm, highlighting our method's efficiency in utilizing space in real-time. Extensive simulations in the Gym PyBullet environment further validated the robustness of our system for real-world applications, demonstrating its potential for dynamic, real-time task execution in cluttered environments.

WeB4	Rm 265
Aerial Robotic Manipulation II (Regular Session)	
Chair: Atkins, Ella	Virginia Tech
Co-Chair: Michieletto, Giulia	University of Padova

14:00-14:20	WeB4.1

Shifting Underactuated Configuration Variables in Aerial Manipulation by Adding an Actuated Arm, pp. 316-322

Nail, Mark	University of Michigan
Atkins, Ella	University of Michigan
Gillespie, R. Brent	University of Michigan

Multicopter uncrewed aircraft systems (UAS) commonly use parallel rotors to create body-fixed thrust and torque for control, leaving these systems underactuated. Underactuation poses a significant challenge in tasks where attitude is critical, such as in collision-based aerial manipulation. Planning and control of system state at collision is required to ensure safe post-collision recovery. In particular, setting up pre-impact states such that impulses do not produce moments about mass centers can ensure recoverable departure velocities. To address the underactuated nature of UAS for collision-based aerial manipulation, this paper presents a UAS with an attached actuated pogostick. While the UAS with actuated pogostick is still underactuated, closing a control loop on the collision variables critical to managing collision response becomes possible with the new system equations. The proposed approach leverages an optimal trajectory planner coupled with a run-time controller based on partial feedback linearization of the UAS with actuated pogostick. Results show that the addition of the actuated pogostick enables setup for recoverable post-collision states when given dynamically feasible trajectories from the optimal trajectory planner.

14:20-14:40	WeB4.2

External-Wrench Estimation for Aerial Robots Exploiting a Learned Model, pp. 323-331

Alharbat, Ayham	Saxion University of Applied Sciences
Ruscelli, Gabriele	Alma Mater Studiourum

Diversi, Roberto — University of Bologna
Mersha, Abeje Yenehun — Saxion University of Applied Sciences

This paper presents an external wrench estimator that uses a hybrid dynamics model consisting of a first-principles model and a neural network. This framework addresses one of the limitations of the state-of-the-art model-based wrench observers: the wrench estimation of these observers comprises the external wrench (e.g. collision, physical interaction, wind); in addition to residual wrench (e.g. model parameters uncertainty or unmodeled dynamics). This is a problem if these wrench estimations are to be used as wrench feedback to a force controller, for example. In the proposed framework, a neural network is combined with a first-principles model to estimate the residual dynamics arising from unmodeled dynamics and parameters uncertainties, then, the hybrid trained model is used to estimate the external wrench, leading to a wrench estimation that has smaller contributions from the residual dynamics, and affected more by the external wrench. This method is validated with numerical simulations of an aerial robot in different flying scenarios and different types of residual dynamics, and the statistical analysis of the results shows that the wrench estimation error has improved significantly compared to a model-based wrench observer using only a first-principles model.

14:40-15:00	WeB4.3

Simulation of a Tilt-Rotor UAV with a Cable-Driven Gripper for High-Precision Physical Interaction, pp. 332-339

Chen, Yun Ting — Singapore Polytechnic
Taylor, Joshua — National University of Singapore
Imanberdiyev, Nursultan — Agency for Science, Technology and Research (A*STAR)
Camci, Efe — Institute for Infocomm Research (I2R), A*STAR

Performing tasks at high altitudes can be inconvenient and unsafe for humans. Unmanned aerial vehicles (UAVs) with physical interaction capabilities are on hand to address these issues. Our previous work introduced one such UAV: a multi-rotor with a pair of tilting rotors and a novel, cable-driven, front-mounted gripper, which improved position accuracy during interaction tasks. However, the UAV could only interact with vertical surfaces, and its control performance was limited by a simple pilot-assisted position controller during interaction. This manuscript advances that work by developing an improved version of our UAV. The modified design includes two pairs of tiltrotors, which can tilt simultaneously to angle the drone body, allowing interaction with non-vertical targets at specific angles. We develop a high-fidelity simulation package that accurately replicates our new UAV design's physical characteristics and dynamics, including the cable-driven gripper. This simulation package provides a virtual testbed for designing and evaluating advanced interaction control algorithms, minimizing the risks, costs, and time of physical prototyping. We demonstrate its utility by safely testing autonomous control strategies, including force control, in a tree-grasping scenario. We also give insights into hyperparameter selections, challenges faced, and current limitations while developing such a versatile package that involves simulating elastic components such as cables, springs, and soft finger pads. We open-source our simulation package for the community's benefit at https://tinyurl.com/ypwzje2a.

15:00-15:20	WeB4.4

Design and Control of an Omnidirectional Aerial Robot with a Miniaturized Haptic Joystick for Physical Interaction, pp. 340-346

Mellet, Julien — University of Naples Federico II
Berra, Andrea — FADA – CATEC
Marcellini, Salvatore — Leonardo S.p.A
Trujillo, Miguel Ángel — CATEC
Heredia, Guillermo — University of Seville
Ruggiero, Fabio — Università Degli Studi Di Napoli "Federico II"
Lippiello, Vincenzo — Università Di Napoli Federico II

Fully actuated aerial robots have shown superiority in Aerial Physical Interaction (APhI) in recent years. This work presents a minimal setup for aerial telemanipulation, improving accessibility to such technologies. The design and control of a 6-Degrees of Freedoms (DoF) joystick with 4-(DoF) haptic feedback are detailed. It is the first haptic device with standard Remote Controller (RC) form factor for APhI. Miniaturizing the haptic device adds sense of touch to RC, enhancing physical awareness. The goal is to provide operators with an extra sense—beyond vision and sound—to support safe (APhI). To the best of the authors' knowledge, this is the first 6-DoF aerial teleoperation system capable of decoupling single-axis input commands. The proposed robot hardware design reduces the number of components, aiming for easier maintenance and improved force and thrust-to-weight ratios. Open-source physics-based simulation and successful early flight tests highlight the tool's promise for future APhI applications.

15:20-15:40	WeB4.5

Advancing Manipulation Capabilities of a UAV Featuring Dynamic Center-Of-Mass Displacement, pp. 347-354

Hui, Tong — Technical University of Denmark
Fumagalli, Matteo — Danish Technical University

As aerial robots gain traction in industrial applications, there is growing interest in enhancing their physical interaction capabilities. Pushing tasks performed by aerial manipulators have been successfully demonstrated in contact-based inspections. However, more complex industrial applications require these systems to support higher-DoF (Degree of Freedom) manipulators and generate larger forces while pushing (e.g., drilling, grinding). This paper builds on our previous work, where we introduced an aerial vehicle that can dynamically vary its CoM (Center of Mass) location to improve force exertion during interactions. We propose a novel approach to further enhance this system's force generation by optimizing its CoM location during interactions. Additionally, we study the case of this aerial vehicle equipped with a 2-DoF manipulation arm to extend the system's functionality in tool-based tasks. The effectiveness of the proposed methods is validated through simulations,

demonstrating the potential of this system for advanced aerial manipulation in practical settings.

15:40-16:00	WeB4.6

A Taxonomy on Contact-Aware Multi-Rotors for Interaction Tasks, pp. 355-361

Piccina, Alberto	University of Padova
Bertoni, Massimiliano	University of Padova
Michieletto, Giulia	University of Padova

The cutting-edge contact-aware ability of aerial platforms has opened new frontiers in aerial robotics, enabling applications beyond traditional contact-free operations. Performing in-contact tasks and smoothly transitioning between navigation and interaction phases introduce significant challenges, especially in complex scenarios. This paper focuses on multi-rotors designed for physical interaction tasks, reviewing the most used aerial platforms, interaction tools, and control methodologies tailored for contact-aware applications. Special attention is given to the contact detection phase, which bridges the gap between contact-free and in-contact operational phases, ensuring precise and safe engagement with the target.

WeC1	Rm 340GHI
UAS Testbeds (Regular Session)	
Chair: Coopmans, Calvin	Utah State University
Co-Chair: Jafarnejadsani, Hamidreza	Stevens Institute of Technology

16:30-16:50	WeC1.1

Understanding the Physical Design of Multi-Domain UAV Systems, pp. 362-369

Ramos, Christian	University of Denver
Valavanis, Kimon P.	University of Denver
Rutherford, Matthew	University of Denver

Unmanned multi-domain robotic systems are rapidly advancing, with many innovative platforms designed to operate across multiple environmental domains, typically involving the combination of air and either land, water-surface, or underwater capabilities. These systems are designed to seamlessly transition between and operate effectively in these diverse environments, opening new possibilities for numerous fields - including military, research, search and rescue, and commercial applications. Categorization of the various forms of technology utilized in each innovative design is challenging due to the varying descriptions and definitions within each source publication. This paper is written to describe the current state of physical design for unmanned multi-domain robotic platforms, as well as standardize the definitions and comparatively categorize the design features, propulsion methods, and domain-transition capabilities of many hybrid systems. Descriptions of the terminology used are provided throughout this article as each bi-domain system category is introduced. A complete comparative table of all findings is provided near the end of this manuscript, complete with respective categories, design features, and domain-transition details.

16:50-17:10	WeC1.2

Multi-Robot Coordination with Adversarial Perception, pp. 370-377

Bahrami, Rayan	University of Maryland
Jafarnejadsani, Hamidreza	Stevens Institute of Technology

This paper investigates the resilience of perception-based multi-robot coordination with wireless communication to online adversarial perception. A systematic study of this problem is essential for many safety-critical robotic applications that rely on the measurements from learned perception modules. We consider a (small) team of quadrotor robots that rely only on an Inertial Measurement Unit (IMU) and the visual data measurements obtained from a learned multi-task perception module (e.g., object detection) for downstream tasks, including relative localization and coordination. We focus on a class of adversarial perception attacks that cause misclassification, mislocalization, and latency. We propose that the effects of adversarial misclassification and mislocalization can be modeled as sporadic (intermittent) and spurious measurement data for downstream tasks. To address this, we present a framework for resilience analysis of multi-robot coordination with adversarial measurements. The framework integrates data from Visual-Inertial Odometry (VIO) and the learned perception model for robust relative localization and state estimation in the presence of adversarially sporadic and spurious measurements. The framework allows for quantifying the degradation in system observability and stability in relation to the success rate of adversarial perception. Finally, experimental results on a multi-robot platform demonstrate the real-world applicability of our methodology for resource-constrained robotic platforms.

17:10-17:30	WeC1.3

A Real-Time Aerial Imagery Collection, Mapping, and Remote Sensing Testbench for Uncrewed Missions, pp. 378-384

Coopmans, Calvin	Utah State University
Snider, Richard M.	Utah State University
Toki, Sadikul Alim	Utah State University
Petruzza, Steve	Utah State University
Sewell, Andres	Utah State University
Montgomery, Emma	Utah State University

As uncrewed aerial systems continue to grow in popularity and importance, the long-term and scalable use of these systems for remote sensing and imagery data collection remains a valuable and achievable goal. To enable these systems at scale,

real-time onboard imagery processing is required. To determine the feasibility of real-time remote sensing systems, many factors must be accounted for, including the ability of the sensing and processing algorithms to operate on and collect data from real-world scenes and deliver actionable intelligence to the data consumer. In this paper, a holistic simulation system based on ROS 2 and Gazebo is presented, which allows for real-time processing algorithms to be tested and proven for flight in an accurate and extensible way. By using ROS 2 and USU AggieAir's STARDOS platform, it is possible to show how the remote sensing system and onboard real-time processing algorithms are applicable to the aerial remote sensing task (i.e. it can demonstrate feasibility for physical deployment based on accurate simulated data processing).

17:30-17:50	WeC1.4

AIDERS: A Multi-UAV Platform for Disaster Management with Integrated Simulation and Real-Time Operations, pp. 385-392

Manellanga, Rajitha Ayeshmantha	University of Cyprus
Theodorou, Xenios	University of Cyprus
Demetriou, Michalis	University of Cyprus
Manousakis, Konstantinos	University of Cyprus
Kolios, Panayiotis	University of Cyprus
Ellinas, Georgios	University of Cyprus

Rapid integration and analysis of dynamic data are essential for effective disaster response, as timely insights can significantly impact decision-making and resource allocation. Unmanned aerial vehicles (UAVs) enhance situational awareness by providing real-time aerial surveillance to first responders. This work proposes the AIDERS platform, a multi-UAV platform designed and developed to support real and simulated UAV operations for disaster management. The platform enables collaborative autonomous UAV operations, allowing multiple UAVs to navigate and survey an area while streaming live video feeds for real-time detection of people, objects, and disaster-related damage. Additionally, its simulation capabilities enable extensive testing and validation before real-world deployment. This work demonstrates the robustness of the AIDERS platform through experiments with simulated swarms of up to eight UAVs.

17:50-18:10	WeC1.5

Recreation of 3D UAS Flights in High-Realism Virtual Environments, pp. 393-399

Beam, Christopher	University of North Carolina at Charlotte
Wolek, Artur	University of North Carolina at Charlotte
Willis, Andrew	University of North Carolina at Charlotte

This article presents an approach for recreating experimental Unmanned Aerial Vehicle (UAV) flight in the state-of-the-art 3D simulation software. Through the use of the Unreal Engine, AirSim simulator, and the Cesium for Unreal plugin with Google Maps, we demonstrate replicating an experiment of a real-world flight in the digital twin environment of the same location. Work investigates the viability of replicating real-world experiments by assessing the similarity between the experimental results of the real-world and digital twin experiments. The experiments involve analyzing the image telemetry and map generated of the real-world and digital twin images using the Direct Sparse Odometry (DSO) algorithm. The results have shown that replicating the real-world experiment in the digital environment produces similar results to those seen in the real-world. This will allow researchers to explore the impact of sensor, vehicle, and algorithm parameters in a controlled, repeatable environment before real-world deployment.

WeC2	Rm 200
UAS Applications II (Regular Session)	
Chair: Vitzilaios, Nikolaos	University of South Carolina
Co-Chair: Das, Amrita	University of North Dakota

16:30-16:50	WeC2.1

UAS-Assisted Corrosion Detection in Steel Using Combined Human and Machine Intelligence, pp. 400-407

Das, Amrita	University of North Dakota
Dorafshan, Sattar	University of North Dakota

Corrosion is one of the most common defects in steel infrastructures. Crewed visual inspection is the conventional method for corrosion detection in civil infrastructure, which can be dangerous, inconsistent, and labor-intensive. These limitations encouraged the researchers to explore the feasibility of using the Uncrewed Aerial System (UAS) for autonomous real-time corrosion detection using artificial intelligence. A human-machine interface was implemented to take inspector input in sequential training of a corrosion detection model on visual imagery. The model was trained to detect corrosion using smartphone images. The model output was validated or corrected by the inspector after each inspection. The model was then retrained on the inspector output and used in the next inspection. Each dataset consisted of 225 x 225 pixels image tiles labeled as with corrosion and without corrosion. Six combinations of UAS inspection datasets were used to evaluate how the deep learning model performance changed in terms of true positive rate (TPR), true negative rate (TNR), false positive rate (FPR) and false negative rate (FNR). Before retraining 84.78% of images with corrosion were correctly predicted by the model, and the TNR value was 82.75%. The result showed that the adapted deep learning model performance improved with more inspection, as expected. In particular, the number of reported false calls made by the model reduced. While the improvement was not always tangible due to corrosion image diversity in texture and color, however, the same amount of training, regardless of their order, led to improved but comparable performance.

16:50-17:10	WeC2.2

A Cooperative Multi-UAV Framework for Bridge Inspection, pp. 408-415

Gil Castilla, Miguel | University of Seville
Poma, Aguilar, Alvaro Ramiro | University of Seville
Caballero, Alvaro | University of Seville
Ollero, Anibal | Universidad De Sevilla

Bridges are vital infrastructure assets whose maintenance is essential to ensure safety and efficient traffic flow. However, due to their nature, they are often located in hard-to-reach places, which makes their regular inspection challenging and risky for human operators. This paper presents a comprehensive multi-UAV (Unmanned Aerial Vehicle) framework for fast and efficient cooperative bridge inspection, leveraging commercial UAVs with open-source tools and integrating both a custom Ground Control Station and advanced multi-UAV motion planning based on Signal Temporal Logic. The proposed approach enables autonomous and safe data collection while minimizing operational constraints and human intervention, making it a valuable contribution to UAV-based infrastructure monitoring. The presented framework has been validated in a real-world environment, showcasing its effectiveness in coordinating UAV teams for autonomous structural inspections.

17:10-17:30 | WeC2.3

Robust Trajectory Tracking Control of a Multi-Rotor UAV Carrying a Cable Suspended Load, pp. 416-423

N S, Abhinay | Tata Consultancy Services
Das, Kaushik | TATA Consultancy Service
Ghose, Debasish | Indian Institute of Science

In this paper, the synthesis of a robust trajectory tracking controller for a UAV carrying a slung load is presented using hierarchical sliding mode and super-twisting methodologies. A second order sliding mode disturbance observer is used in conjunction with the sliding mode controller. Since the slung load system is underactuated, the sliding mode closed-loop dynamics is analyzed to derive conditions for the sliding surface parameters that guarantee stability. Lyapunov analysis is used to prove the stability of the system. A controllability analysis is also carried out. Simulation results are presented for different cases to demonstrate the performance of the proposed controller.

17:30-17:50 | WeC2.4

Automation of Structure Inspection Tasks Using DJI Quadrotors, pp. 424-431

Oviedo De La Torre, David | Universidad De Los Andes
De la Rosa Rosero, Fernando | Universidad De Los Andes

This paper presents the design and implementation of a system to automate the task of inspection of a physical structure, surrounded by one of three boundary models provided (plane, box or cylinder), using a DJI quadrotor. First, the system plans the flight trajectory of the quadrotor accordingly, to ensure that the whole surface's model is covered in the inspection and then executes the flight autonomously. The system is made up of two main software components: a ROS2 robotics application and Android application. The ROS2-based application is used to plan the flight path and control the quadrotor to follow the path, and the Android application to allow communication with the quadrotor using the DJI Mobile SDK V4. The system was tested using the Gazebo simulator and the DJI Assistant 2 simulator to ensure correct functionality. Finally, it was tested in experimental scenarios by flying a DJI Mavic Pro quadrotor with effective results.

17:50-18:10 | WeC2.5

UAV-Based Railway Track Following, pp. 432-440

Lewandowski, Keith | University of South Carolina
Sucin, Toma | University of South Carolina
Vitzilaios, Nikolaos | University of South Carolina

Given the pivotal role of the railroad industry in modern transportation and the potential risks associated with track malfunctions, the inspection and maintenance of railroad tracks emerges as a critical concern. Existing solutions rely on large, expensive, and time-consuming platforms that are very accurate, however, they require the line to be blocked during the inspection. The use of Unmanned Aerial Vehicles (UAVs) can significantly reduce track downtime and cost while maintaining inspection capabilities. However, current solutions focus on the inspection task while UAVs are programmed to follow predefined paths on the network. This paper presents an autonomous, vision-based track following system that was developed, implemented, and tested onboard a UAV. Notably, this system operates independently of external sensors, such as GPS, thanks to its utilization of advanced computer vision techniques. Two approaches were developed utilizing a forward-facing camera and a downward-facing camera. The experimental results of several field trials show the efficiency of the developed system.

WeC3 | Rm 267

Autonomy/Integration (Regular Session)

Chair: Yuan, Jiawei | University of Massachusetts Dartmouth
Co-Chair: Martini, Simone | University of Denver

16:30-16:50 | WeC3.1

GSCE: A Prompt Framework with Enhanced Reasoning for Reliable LLM-Driven Drone Control, pp. 441-448

Wang, Wenhao | University of Massachusetts Dartmouth
Li, Yanyan | California State University San Marcos
Jiao, Long | University of Massachusetts Dartmouth

Yuan, Jiawei — University of Massachusetts Dartmouth

The integration of Large Language Models (LLMs) into robotic control, including drones, has the potential to revolutionize autonomous systems. Research studies have demonstrated that LLMs can be leveraged to support robotic operations. However, when facing tasks with complex reasoning, concerns and challenges are raised about the reliability of solutions produced by LLMs. In this paper, we propose a prompt framework with enhanced reasoning to enable reliable LLM-driven control for drones. Our framework consists of novel technical components designed using Guidelines, Skill APIs, Constraints, and Examples, namely GSCE. GSCE is featured by its reliable and constraint-compliant code generation. We performed thorough experiments using GSCE for the control of drones with a wide range of task complexities. Our experiment results demonstrate that GSCE can significantly improve task success rates and completeness compared to baseline approaches, highlighting its potential for reliable LLM-driven autonomous drone systems.

16:50-17:10 WeC3.2

Graph-Based Decentralized Exploration and Semantic Inspection for Multi-Robot Systems, pp. 449-456

Fahim, Nada Elsayed Abbas — University of Zagreb
Petrovic, Tamara — University of Zagreb

This paper presents a decentralized graph-based exploration and inspection framework for multi-robot systems, designed to address challenges in subterranean and large-scale environments. Unlike prior works that focus solely on exploration or inspection, this framework integrates volumetric exploration, semantic inspection, and dynamic task allocation into a unified decentralized system. A key novelty of this work is the seamless integration of these modules in a multi-robot setting, allowing UAVs to autonomously coordinate their tasks without relying on centralized control. The framework employs a hierarchical graph structure, utilizing a dense local graph for immediate navigation and a sparse global graph for long-term planning and repositioning. Extensive simulations in large-scale complex-shaped environments demonstrate that the proposed approach improves the completeness of the generated maps, reduces inconsistencies in the constructed mesh, and accelerates the overall exploration-inspection process compared to existing decentralized strategies.

17:10-17:30 WeC3.3

The BEAST: Modular Open-Source Framework for BVLOS Drone Flights with Long-Term Autonomy, pp. 457-464

van Manen, Benjamin Ronald — Saxion University of Applied Sciences
ter Maat, Gerjen — Saxion
Boe, Mick — Saxion University of Applied Sciences
Mersha, Abeje Yenehun — Saxion University of Applied Sciences

The rapid growth of the drone market, driven by cost-effective computing and sensor advancements, has expanded applications in safety, security, agriculture, logistics, and infrastructure inspection. The introduction of EU drone regulations in 2020 has enabled Beyond Visual Line-of-Sight (BVLOS) and autonomous operations, opening opportunities for long-term unmanned missions. However, commercial drone systems remain reliant on Remote Piloted Aircraft Systems (RPAS) and predefined waypoint navigation, while autonomous operations are often confined to research settings.

In this work, we present The BEAST framework, a modular open-source framework for long-term, robust, and autonomous BVLOS operations. This framework is designed to integrate intelligent drones into real-world environments while ensuring regulatory compliance. The BEAST framework includes essential components such as obstacle avoidance, intelligent fail-safe mechanisms, reliable communication, and a weather-proof docking station. Unlike previous approaches that address isolated BVLOS challenges, The BEAST provides a comprehensive, end-to-end solution encompassing mission planning, autonomous navigation, and operational safety. The framework has been implemented and validated across multiple drone platforms in safety and security applications.

17:30-17:50 WeC3.4

Koopman-Based Reinforcement Learning for LQ Control Gains Estimation of Quadrotors, pp. 465-472

Martini, Simone — University of Denver
Sonmez, Serhat — Istanbul Medeniyet University
Stefanovic, Margareta — University of Denver
Rutherford, Matthew — University of Denver
Valavanis, Kimon P. — University of Denver

In this research, Koopman operator theory is employed to achieve faster training time and improved performance of a reinforcement learning (RL) based linear quadratic controller (LQ). The proposed methodology, called K-RL-LQ, is implemented for the trajectory tracking problem of a quadrotor UAV. Using the evolution of analytically derived Koopman generalized eigenfunctions allows for the embedding of quadrotor nonlinear dynamics into a quasi-linear model. Specifically, the resulting Koopman based quadrotor dynamics have linear state matrix and state dependent control matrix. Additionally, the obtained formulation is fully actuated, hence, compared to traditional model based hierarchical control the advantages are twofold: i) the controller can be formulated using linear control strategies in Koopman formulation which will result in a nonlinear control law in the original state space; ii) the trajectory tracking task can be achieved through a single control loop. Using this formulation, an RL agent is trained to estimate the controller parameters of a linear quadratic control law. Notably, it is shown that using a reward function and observation space based on Koopman generalized eigenfunctions over the state space, leads to a considerably faster training time and improved overall performances.

17:50-18:10 WeC3.5

A Simulation Platform for Intelligent UAV Cybersecurity and Reliability Analysis, pp. 473-480

Yang, Boyin — University of Massachusetts Dartmouth
Li, Yanyan — California State University San Marcos

Callaghan, Ryan | University of Massachusetts Dartmouth
Song, Houbing | University of Maryland, Baltimore County
Yuan, Jiawei | University of Massachusetts Dartmouth

Unmanned aerial vehicles (UAVs) are increasingly adopted in various applications due to their high mobility and advanced sensing capabilities. However, they also face significant security threats and reliability concerns arising from external adversarial attacks and internal system failures. AI and machine learning techniques have shown promise in detecting security threats and anomalies in UAVs, but their effectiveness heavily depends on high-quality UAV security datasets for training. In this paper, we present an open-source simulation platform designed to model diverse UAV security scenarios. Our platform offers flexible customization of attacking effects on major UAV components, including onboard sensors, communication systems, vision modules, and flight control. Additionally, it provides rapid generation and collection of UAV system data under adversarial conditions, facilitating intelligent cybersecurity and reliability analysis. Our experiments successfully simulated over 30 attacking effects toward UAVs, demonstrating our platform's capability to support extensive UAV security research.

WeC4	Rm 265
UAS Communications (Regular Session)	
Chair: Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo
Co-Chair: Baidya, Sabur	University of Louisville

16:30-16:50	WeC4.1

UAV Control with Vision-Based Hand Gesture Recognition Over Edge-Computing, pp. 481-488

Abdalla, Sousannah | Alamein International University
Baidya, Sabur | University of Louisville

Gesture recognition presents a promising avenue for interfacing with unmanned aerial vehicles (UAVs) due to its intuitive nature and potential for precise interaction. This research conducts a comprehensive comparative analysis of vision-based hand gesture detection methodologies tailored for Edge-Assisted UAV Control. The existing gesture recognition approaches involving cropping, zooming, and color-based segmentation, do not work well for this kind of applications in dynamic conditions and suffer in performance with increasing distance and environmental noises. We propose to use a novel approach leveraging hand landmarks drawing and classification for gesture recognition-based UAV control. With experimental results we show that our proposed method outperforms the other existing methods in terms of accuracy, noise resilience, and efficacy across varying distances, thus providing robust control decisions. However, implementing the deep learning-based computer intensive gesture recognition algorithms on the UAV's onboard computer is significantly challenging in terms of performance. Hence, we propose to use a edge-computing based framework to offload the heavier computing tasks, thus achieving closed-loop real-time performance. With implementation over AirSim simulator as well as over a real-world UAV, we show the advantage of our end-to-end gesture recognition-based UAV control system.

16:50-17:10	WeC4.2

Communication for UAV Swarms: An Open-Source, Low-Cost Solution Based on ESP-NOW, pp. 489-495

Grøntved, Kasper Andreas Rømer | University of Southern Denmark
Ladig, Robert | Ritsumeikan University
Christensen, Anders Lyhne | University of Southern Denmark

Multi-UAV systems tend to require complex infrastructure to deploy in real-world scenarios, limiting their accessibility and scalability. In addition, current research often relies on custom solutions or proprietary hardware to facilitate inter-UAV communication. In this paper, we propose an open-source, low-cost, plug-and-play solution for enabling decentralized UAV-to-UAV communication over 2.4GHz Wi-Fi using a connection-less protocol. Our approach simplifies the deployment of decentralized systems by allowing UAVs to easily exchange any type of binary data, seamlessly interfacing with ROS2. The solution uses an ad-hoc style network that allows UAVs to join or leave dynamically without requiring centralized governance or a priori configuration. We describe the architecture of the system, assess the network performance in an outdoor environment using UAVs, and the system's ability to share information as a swarm through Hardware-in-the-loop (HITL) and experiments using UAVs. Our results show that the proposed system facilitates connectivity and is able to transmit mission-critical data for real-world UAV operations. HITL experiments show that a decentralized planning algorithm running on three simulated UAVs can effectively reach consensus on decentralized task allocation. We have made the code public and thus provide a viable solution for researchers seeking to implement decentralized UAV swarms using cost-effective Commercial Off the Shelf (COTS) hardware and minimal infrastructure.

17:10-17:30	WeC4.3

Comparative Performance Analysis of OLSR, BATMAN-ADV, and Babel in UAV Mesh Networks, pp. 496-503

Diniz, Beatriz Aparecida | University of São Paulo
Ferrão, Isadora | University of São Paulo
da Silva, Leandro Marcos | University of São Paulo
Branco, Kalinka Regina Lucas Jaquie Castelo | University of São Paulo

Unmanned Aerial Vehicles (UAVs) have been increasingly applied in different scenarios, requiring efficient communication networks to handle swarm operations that rely on dynamic ad-hoc infrastructures without fixed support. Mesh architecture, with its ability to offer multipath communications, emerges as a solution to overcome the challenges imposed by high mobility and frequent topology changes. This study, carried out in a real environment with Raspberry Pi devices, compared the routing protocols OLSR, BATMAN-ADV, and Babel, justifying their choices based on the observed performance: OLSR demonstrated greater stability and efficiency for variable traffic loads due to its rapid route adaptation. Babel stood out in highly-mobility

scenarios because it presented lower latency, attributed to its agile information update. At the same time, BATMAN-ADV, although efficient in certain conditions, showed greater resource consumption and instability under heavy traffic. The main contribution of this article lies in the detailed comparative analysis of the three protocols in a real environment, analyzing the practical characteristics for selecting the most appropriate routing protocol according to the specific requirements of each application scenario.

17:30-17:50	WeC4.4

Event Driven CBBA with Reduced Communication, pp. 504-510

Sao, Vinita	IISER Bhopal
Ho, Tu Dac	Norwegian University of Science and Technology (IIK)
Bhore, Sujoy	IIT Bombay
Baliyarasimhuni, Sujit, P	IISER Bhopal

In numerous applications, such as multi-drone surveillance and search-and-rescue missions, the deployment of multiple robots is essential to accomplish several tasks simultaneously. As vehicles have limited communication range, it is essential to have a decentralized task allocation algorithm to allocate tasks to robots effectively. One such algorithm is the consensus-based bundle adjustment (CBBA) algorithm, which has shown promise in working with multi-robots and has theoretical guarantees. However, CBBA requires communication at every instance, which can cause communication congestion and packet dropouts that lead towards performance degradation. In this paper, we propose an event-driven communication mechanism to overcome communication issues while retaining the theoretical properties of CBBA in terms of convergence and performance bounds. Theoretically, we show that the solution quality remains the same as that of CBBA and validate through Monte-Carlo simulations for varying numbers of targets, agents and bundles. The results show that the proposed algorithm (ED-CBBA) achieves up to 52% reduction in the number of messages transmitted.

17:50-18:10	WeC4.5

A Framework for Safe Local 3D Path Planning Based on Online Neural Euclidean Signed Distance Fields, pp. 511-517

Gil Garcia, Guillermo	Universidad Pablo De Olavide
Cobano, Jose Antonio	University Pablo De Olavide
Caballero, Fernando	University of Seville
Merino, Luis	Universidad Pablo De Olavide

This paper presents a framework that integrates a distance-aware 3D local path planning algorithm based on Euclidean Signed Distance Fields (ESDFs) with a system that trains a Sinusoidal Representation neural network (SIREN) using the HIO-SDF network structure. The main contribution of the paper is a software framework that incorporates online generated ESDF into local planners for efficient and safe 3D path planning by leveraging the ESDF properties. The framework includes a neural network that can be used by the local planner as an up-to-date representation of the environment. Experimental validation shows favorable results in exploiting the intrinsic characteristics of online ESDFs and acknowledges this framework as a feasible method to perform local path computation. Planner code is available at: https://github.com/robotics-upo/neural_esdf_local.

Thursday, May 15

ThA1	Rm 340GHI
Best Paper Award Finalists from Latin America and Africa (LAA) (Regular Session)	
Chair: Sanket, Nitin	Worcester Polytechnic Institute
Co-Chair: Hamaza, Salua	TU Delft

10:30-10:50	ThA1.1

Air Corridor Planning for UAVs Using a Cooperative Co-Evolutionary Approach and NURBS Representation, pp. 518-525

Freitas, Elias José de Rezende	Universidade Federal De Minas Gerais
Weiss Cohen, Miri	Braude Collège of Engineering
Guimarães, Frederico G.	Federal University of Minas Gerais
Pimenta, Luciano Cunha de Araújo	Universidade Federal De Minas Gerais

This paper addresses the problem of planning feasible air corridors for UAVs. We propose a novel path planner based on a co-evolutionary approach that considers minimum curvature, no-fly zones, interactions with other air corridors, and adherence to specified altitude-safe zones, with each central path represented by a Non-Uniform Rational B-Spline (NURBS) curve. In addition, our approach accommodates UAVs, such as fixed-wing aircraft, which cannot hover or remain stationary in the air, by providing paths that guide the robots to tangent landing or take-off regions (vertiports). The results of different scenarios with different numbers of vertiports and no-fly zones demonstrate the planner's ability to generate a set of feasible air corridors.

10:50-11:10	ThA1.2

Dual Quaternion-Based Control for Dynamic Robot Formations, pp. 526-533

Giribet, Juan Ignacio	University of San Andrés
Marciano, Harrison	Federal University of Espirito Santo
Mas, Ignacio	ITBA
Ghersin, Alejandro	ITBA
Villa, Daniel Khede Dourado	Federal University of Espírito Santo
Sarcinelli-Filho, Mário	Federal University of Espirito Santo

This paper evaluates a dual quaternion-based control algorithm designed to manage dynamic changes in the number of vehicles in robot formations. By defining a virtual structure, the algorithm coordinates the formation's position, orientation, and shape parameters, ensuring seamless transitions when the number of vehicles changes. The approach enables a low-level controller to calculate commands for individual robots while maintaining the overall formation integrity. The strategy's performance is analyzed through simulations, demonstrating its effectiveness in handling variations in the number of vehicles of robotic formations.

11:10-11:30	ThA1.3

Propeller Damage Detection: Adapting Models to Diverse UAV Sizes, pp. 534-541

Torre, Gabriel	Universidad De San Andrés
Pose, Claudio Daniel	Facultad De Ingeniería - Universidad De Buenos Aires
Giribet, Juan Ignacio	University of San Andrés

This manuscript introduces a transfer learning method for adapting propeller fault detection neural networks to different unmanned aerial vehicles (UAVs). After training a simple model for detecting if any propeller in a specific vehicle has a failure (in this case, a chipped tip), a domain adaptation based in the vehicles' physics is performed in order to use the same model to detect failures in vehicles with different structures, weights, or motor-propeller sets. A key feature is that the detection model uses only inertial sensors that are standard in commercial UAVs, making it broadly applicable without the need for additional hardware.

11:30-11:50	ThA1.4

Visual Control and Mapping for UAV-Based Platform Inspection, pp. 542-548

Alves Fagundes Júnior, Leonardo	Universidade Federal De Viçosa
Soria, Carlos	Universidad Nacional De San Juan
Vassallo, Raquel	Federal University of Espirito Santo
Brandao, Alexandre Santos	Federal University of Vicosa

Autonomous take-off and landing capabilities are crucial in UAV vision-based missions, ensuring adaptive navigation, especially in challenging environments where real-time identification and interaction with a variety of landing platforms are required. In this context, this paper presents a servo-visual controller that uses pattern detection and color segmentation techniques to identify take-off/landing platforms and estimate their current orientation. The proposed system was subjected to experimental validation with four platforms positioned in different orientations, heights, and positions, demonstrating its versatility in various conditions. Our study addresses the Flying Robots Trial League challenge, which emulates mapping and inspection tasks in offshore platforms.

11:50-12:10	ThA1.5

Null Space-Based Control Embedding an Adaptive Sliding Mode Term Applied to a UAV-UAV Formation Carrying a Load, pp. 549-556

Mafra Moreira, Mauro Sergio	Federal University of Espírito Santo
Villa, Daniel Khede Dourado	Federal University of Espírito Santo
Sarcinelli-Filho, Mário	Federal University of Espirito Santo

This paper proposes a null space-based behavioral controller embedding an adaptive sliding mode control law to guide the formation of two UAVs (unmanned aerial vehicles) carrying a cable-suspended load when tracking a trajectory. This controller is based on hierarchically organizing the two subtasks, moving the formation accordingly and keeping the formation shape. The influence of the load on the UAVs, including the force dragging each UAV towards the other, is dealt with as a perturbation, which the sliding mode term allows us to reject. The proposed controller guides the UAVs as a virtual structure corresponding to the straight line linking them, keeping both at the same altitude, preserving the distance between them, and rejecting the disturbance caused by the load. Keeping the formation shape is the priority, and moving the formation is the secondary task. This approach modifies the control signal for the UAVs, ensuring a rigid shape for the formation, thus preserving the distance between the UAVs, keeping them at the same altitude, and providing additional energy to reject the load disturbance, hence improving the performance of the UAV-UAV-load system. Therefore, the whole system is dealt with as a virtual structure for which the null space-based controller, the formation controller, generates velocity references for the two UAVs, whereas a dynamic compensator embedding an adaptive sliding mode control law works as an individual controller for the drones, reducing the disturbance caused by the load.

12:10-12:30	ThA1.6

Adaptive Load-Carrying Control Using Quadrotors in a Tandem Configuration, pp. 557-564

Brandao, Alexandre Santos	Federal University of Vicosa
Alves Fagundes Junior, Leonardo	Universidade Federal De Viçosa
Castillo, Pedro	Université De Technologie De Compiègne

This paper presents an adaptive control strategy for cooperative cargo transportation using quadcopters in a tandem configuration. By modeling the payload and the unmanned aerial vehicles (UAVs) as a unified rigid-body system, the proposed framework addresses the dynamic interactions among them, ensuring robust performance in tasks such as cargo transportation. The system uses an underactuated adaptive control approach, capable of dealing with variations in payload weight while maintaining stability and agility during flight. The proposed strategy is validated through numerical experiments, demonstrating its effectiveness in trajectory tracking tasks. The results show the system's ability to adapt the parameters of the system modeling to the observed and measured values, guaranteeing the tracking of the proposed trajectory and the robust payload handling. This work contributes to the development of cooperative aerial cargo transportation systems, with applications in transportation missions that exceed the individual capacity of each UAV.

ThA2	Rm 200
Test and Evaluation of Autonomous Aerial Systems (Invited Session)	
Chair: Costello, Donald	University of Maryland College Park
Co-Chair: Mwaffo, Violet	United States Naval Academy
Organizer: DeVries, Levi	United States Naval Academy
Organizer: Wickramasuriya, Maneesha	George Washington University
Organizer: Arslanian, Peter	Naval Air Systems Command - Naval Air Warfare Center Aircraft Di
Organizer: Fristachi, John	Calspan
Organizer: Prasinos, Mia	Air Force Institute of Technology
Organizer: Sakano, Kristy	University of Maryland at College Park
Organizer: Minton, Julia	NAWCAD
Organizer: Costello, Donald	University of Maryland College Park
Organizer: Bortoff, Zachary	University of Maryland

10:30-10:50	ThA2.1

*Test and Evaluation of Autonomous Aerial Systems**

DeVries, Levi	United States Naval Academy
Wickramasuriya, Maneesha	George Washington University
Arslanian, Peter	Naval Air Systems Command - Naval Air Warfare Center Aircraft Di
Fristachi, John	Calspan
Prasinos, Mia	Air Force Institute of Technology
Sakano, Kristy	University of Maryland at College Park
Minton, Julia	NAWCAD
Costello, Donald	University of Maryland College Park
Bortoff, Zachary	University of Maryland

10:50-11:10	ThA2.2

Global Navigation Satellite System (GNSS) Emulator for Test and Evaluation of Flight Controller Performance (I), pp. 565-571

McClelland, Matthew	United States Naval Academy
Cohen, Zachary	United States Naval Academy
Kutzer, Michael	United States Naval Academy
DeVries, Levi	United States Naval Academy

Global navigation satellite system (GNSS) receivers have become ubiquitous geopositioning sensors in unmanned aerial, ground, and surface systems (UxS). GNSS requires line of sight communication with orbiting satellites and the resulting measurements' precision and accuracy can be greatly affected by satellite geometry, atmospheric conditions, and obstructions from buildings or foliage, among other effects. These uncertainties can be difficult to manipulate for test and evaluation of a small-scale UAS control system's robustness to GNSS uncertainty. This work presents the implementation of a GNSS emulator with the same interface design as a GNSS receiver. Using a Raspberry Pi connected wirelessly to a local positioning source, we provide a plug-and-play alternative to a standard commercial-off-the-shelf (COTS) GNSS unit that communicates using the DroneCAN protocol. This system allows the user to simulate GNSS measurements and GNSS performance changes by generating synthetic measurements in a controlled laboratory setting. Data collected from outdoor flights in four different environments is used to characterize baseline GNSS message parameter values, which quantify the fix quality in different geographic locations. This information is used to generate synthetic GNSS measurements fed to a Cube autopilot running ArduCopter flight control software in hardware in the loop simulation. Results show the GNSS emulator can send DroneCAN GNSS messages providing position and fix quality information to the flight controller. These results illustrate how the plug-and-play GNSS emulator can enable test and evaluation of flight controller robustness to uncertainties, signal dropout, and other conditions affecting GNSS measurements in a controlled laboratory environment.

11:10-11:30	ThA2.3

Using Target Detection Probability to Evaluate Area Coverage by a UAV (I), pp. 572-578

Bortoff, Zachary	University of Maryland
Luterman, Alec	University of Maryland
Paley, Derek	University of Maryland
Nogar, Stephen	U.S. Army Research Laboratory

A common task for unmanned aerial vehicles (UAVs) is wide area search using an onboard camera with an object detection model. However, constraints of flight time, camera optics, and onboard computer, particularly in time sensitive applications like search and rescue, require trade-offs in strategies that balance precision and speed. To address these needs, we propose a novel method for evaluating coverage path plans by estimating the probabilities of detection and false alarm for ground targets for a set of poses that the UAV can reach in the search domain. To demonstrate our method, we evaluate trajectories for various coverage path plans flown by a UAV in a high-fidelity simulation.

11:30-11:50	ThA2.4

Precise Ranging to an Aerial Refueling Coupler Using a DNN and a Monocular Camera System (I), pp. 579-586

Lowe, Ryan	USNA
Maheshwari, Akshat	USNA
Mwaffo, Violet	United States Naval Academy
Kutzer, Michael	United States Naval Academy
DeVries, Levi	United States Naval Academy
Costello, Donald	University of Maryland College Park

The Office of Naval Research's Advanced Autonomous Air-to-Air Refueling System (A4RS) project explores the application of deep neural networks (DNNs) for automated UAV refueling. In this study, we present a monocular camera system integrated with a DNN to accurately estimate coordinates and range to a refueling drogue within the final 25 feet of approach. Our method employs a similar-triangle algorithm that computes a range from DNN-generated bounding boxes, with ground truth provided by a calibrated motion capture system. Experiments using UR10, YASKAWA, and Linear Track manipulators demonstrate that the DNN achieves perfect precision and recall, with an mAP50 of 0.995 and mAP50-95 scores of 0.945 for the drogue, 0.851 for the coupler, and 0.898 overall. Combined with the monocular vision system, the estimated coupler range is within 4 inches of the motion capture measurements for distances between 7 and 25 feet, aside from minor deviations at 20 and 23 feet. This work advances the prospects of automated air-to-air refueling by providing a robust, vision-based solution for accurate target detection and range estimation.

11:50-12:10	ThA2.5

A Framework for Black-Box Controller Design to Automatically Satisfy Specifications Using Signal Temporal Logic (I), pp. 587-594

Sakano, Kristy	University of Maryland at College Park
Mockler, Joe	University of MD
Chen, Alexis	University of Maryland at College Park
Xu, Huan	University of Maryland

We present a framework for including human-readable specifications in the design of black-box autonomous systems, or systems whose construct are prohibitively complex to analyze or intuit. By integrating parametric Signal Temporal Logic (pSTL), we can systematically evaluate and refine deep reinforcement learning policies to ensure compliance with predefined system

specifications. Our approach is tested in a simulated autonomous driving environment, where we train a deep reinforcement learning agent in Mario Kart SNES using Proximal Policy Optimization. The agent is evaluated based on its ability to navigate a structured driving course while satisfying a set of a priori requirements; this evaluation is performed by writing and solving the parameters in a pSTL statement. This work contributes to the broader effort of bridging formal methods and data-driven learning, providing insights for researchers and operators alike in developing AI-based controllers for real-world autonomous systems.

12:10-12:30	ThA2.6

Post-Quantum UAV Communications Encryption Tester (P-QUAVCET) (I), pp. 595-601

Minton, Julia	NAWCAD
Collins, Daniel	NAWCAD
Creech, Michael	NAWCAD
Grossman, Joshua	NAWCAD
Manspeaker, Amber	NAWCAD
Hwang, George	NAWCAD
Rea, Charles	NavAir

Unencrypted communications between unmanned aerial vehicles (UAVs) are susceptible to various security attacks, such as interception and spoofing. Both symmetric and asymmetric cryptography currently allow for secure communication between parties. However, industry and academia are working on implementing quantum computers, which will invalidate several of the most widely used cryptographic algorithms. As researchers develop novel quantum encryption methods, they will need standardized testing approaches to determine which are most optimal, especially for the unique characteristics of UAV systems. This paper describes a methodology to test and measure the efficiency of key exchange algorithms for a UAV communicating with a ground control station (GCS). The method requires a framework that models a UAV performing tasks while communicating in encrypted messages with the GCS. In addition, the calculations used for comparing algorithms require a purpose-built bandwidth equation for the quantum algorithm. The first test of this methodology is an experiment designed to compare classical key exchange with the 256-bit Advanced Encryption Standard (AES-256) and quantum key distribution (QKD) used with a variety of parameters in the framework. A comparison of the runtime of each model facilitates the evaluation of each key exchange algorithm for UAV systems. This methodology can be used to test the efficiency of other post-quantum cryptographic algorithms in the future.

ThA3	Rm 267
Path Planning II (Regular Session)	
Chair: Jafarnejadsani, Hamidreza	Stevens Institute of Technology
Co-Chair: Mehta, Varun	National Research Council Canada

10:30-10:50	ThA3.1

Optimization-Based Motion Planning for Vector Field Following in Dynamic Environments, pp. 602-608

Akhihiero, David	West Virginia University
Olawoye, Uthman	West Virginia University
Pereira, Guilherme	West Virginia University

This paper proposes a method for integrating trajectory optimization with vector field-based motion planning methods. This approach aims to address motion planning challenges, particularly in scenarios like UAV navigation, where vector fields are efficient but struggle with dynamic obstacles and motion constraints. Such challenges also include scenarios where there is no defined goal configuration such as border following, loitering, and curve circulation. Several vector field methods have been proposed to solve these problems, but they are prone to failure when encountering previously unmodeled or dynamic obstacles as well as no-fly zones. The method proposed in this paper uses a vector field for high-level planning. The vector field is used to create paths for the vehicle, which are optimized for smoothness, obstacle avoidance, and vector field adherence before they are followed. The result is a smooth path that is fast to plan and easy to follow for a motion-constrained vehicle. A series of simulations was used to validate this methodology, which is compared with a previous method that uses RRT*.

10:50-11:10	ThA3.2

Cellular Connectivity Risk-Aware Flight Path Planning for BVLOS UAV Operations, pp. 609-616

Sajjadi, Sina	National Research Council Canada
Mehta, Varun	University of Ottawa
Janabi Sharifi, Farrokh	Toronto Metropolitan University
Mantegh, Iraj	National Research Council Canada

This study develops a framework to advance Beyond Visual Line of Sight (BVLOS) Uncrewed Aerial Vehicle (UAV) flight operations, focusing on assessing and incorporating the risks associated with cellular connectivity degradation or loss in flight path planning. We utilize stochastic metrics for a detailed analysis of cellular communication reliability, forming the core of our navigation strategy. The process is carried out in four steps: 1) Surveying the operational area to create maps that probabilistically represent cellular network signal connectivity; 2) Utilizing these maps over the potential flight volume, for flight path planning aimed at minimizing the likelihood of losing communication while adhering to shortest route; 3) Carrying out the flight according to the optimized route; and 4) Updating and refining the probabilistic maps with data collected during the flight. This approach not only achieves a balance between operational efficiency and the minimization of connectivity risks but also systematically enhances the reliability and safety of BVLOS UAV operations. Integrating stochastic cellular network assessments into UAV flight planning, this work paves the way for safer and more robust BVLOS operations.

11:10-11:30	ThA3.3

Conflict Avoidance Using an Artificial Potential Field and the mCOWEX Algorithm, pp. 617-624

Danielmeier, Lennart	RWTH Aachen University
Knaak, Florian	RWTH Aachen University
Voget, Nicolai	RWTH Aachen University
Hartmann, Max	RWTH Aachen University
Moormann, Dieter	RWTH Aachen University

This paper presents a combination of an artificial potential field (APF) and the modified Constrained Wavefront Expansion (mCOWEX) algorithm for conflict avoidance in UAVs. As the goal of highly automated UAVs is to be used in shared airspace, i.e. airspace that is used by manned and unmanned aircraft, automatic conflict detection and avoidance is a key requirement. The mCOWEX algorithm presents a capable algorithm to avoid complex conflict scenarios but often generates paths that are hard to predict for human pilots. The APF-mCOWEX algorithm presented in this paper generates paths that are more predictable for human pilots while still being able to solve complex scenarios. The APF-mCOWEX algorithm is a modified form of the original mCOWEX algorithm. These modifications include changes to the placement logic of waves in the mCOWEX algorithm, and a changed cost function based on APFs. The final algorithm is then validated on different scenarios of varying complexity.

11:30-11:50	ThA3.4

Team Orienteering and Scheduling Algorithms for Collaborative UAV-UGV Area Coverage with Battery Constraints, pp. 625-632

Lee, Jaekyung Jackie	Texas A&M University
Rathinam, Sivakumar	Texas a & M University

This paper proposes a FOV-aware, area-based coordination framework for UAV–UGV collaborative surveillance under real-world constraints such as limited battery capacity and road-constrained UGV mobility. Unlike traditional point-based reconnaissance approaches, our method discretizes the surveillance region into realistic grid cells based on UAV camera footprints and guides UAVs to maximize coverage using heading-constrained field-of-view (FOV) planning. A single UGV navigates a predefined fixed route extracted from GeoJSON road data and serves as a mobile charging station with two wireless pads. We formulate the task as a Team Orienteering Problem (TOP) and address it using a structured meta-heuristic algorithm. Key innovations include heading-aware path construction, dynamic reward reinitialization to prevent local stagnation, and tight synchronization with an ILP-based UAV scheduling algorithm that considers operational flight time and charging constraints. UAVs autonomously select their next positions within a ±5° heading cone to optimize new area coverage while minimizing redundant overlap. Simulation results conducted over the Texas A&M campus demonstrate that our method achieves up to 19% higher area coverage, reduces redundancy by 11.3%, and lowers UAV charging delays compared to point-based and naive area-based baselines. These findings validate the effectiveness of integrating FOV-driven spatial planning with temporal scheduling and adaptive reward modeling, offering a scalable and robust framework for autonomous persistent surveillance missions.

11:50-12:10	ThA3.5

VLM-RRT: Vision Language Model Guided RRT Search for Autonomous UAV Navigation, pp. 633-640

Ye, Jianlin	University of Cyprus
Papaioannou, Savvas	KIOS CoE, University of Cyprus
Kolios, Panayiotis	University of Cyprus

Path planning is a fundamental capability of autonomous Unmanned Aerial Vehicles (UAVs), enabling them to efficiently navigate toward a target region or explore complex environments while avoiding obstacles. Traditional path-planning methods, such as Rapidly exploring Random Trees (RRT), have proven effective but often encounter significant challenges. These include high search space complexity, suboptimal path quality, and slow convergence, issues that are particularly problematic in high-stakes applications like disaster response, where rapid and efficient planning is critical. To address these limitations and enhance path-planning efficiency, we propose Vision Language Model RRT (VLM-RRT), a hybrid approach that integrates the pattern recognition capabilities of Vision Language Models (VLMs) with the path-planning strengths of RRT. By leveraging VLMs to provide initial directional guidance based on environmental snapshots, our method biases sampling toward regions more likely to contain feasible paths, significantly improving sampling efficiency and path quality. Extensive quantitative and qualitative experiments with various state-of-the-art VLMs demonstrate the effectiveness of this proposed approach.

12:10-12:30	ThA3.6

Learning Optimal UAV Trajectory for Data Collection in 3D Reconstruction Model, pp. 641-648

Gaudel, Bijay	Stevens Institute of Technology
Jafarnejadsani, Hamidreza	Stevens Institute of Technology

The advancement of 3D modeling applications in various domains has been significantly propelled by innovations in 3D computer vision models. However, the efficacy of these models, particularly in large-scale 3D reconstruction, is dependent on the quality and coverage of viewpoints. This paper addresses optimizing the trajectory of an unmanned aerial vehicle (UAV) for collecting optimal Next-Best View (NBV) for 3D reconstruction models. Unlike traditional methods that rely on predefined criteria or continuous tracking of the 3D model's development, our approach leverages reinforcement learning to select the NBV based solely on single camera images and the relative positions of the UAV with the reference points to a target. The UAV is positioned with respect to four reference waypoints at the structure's corners, maintaining its orientation (field of view) towards the structure. Our method eliminates the need for continuous tracking of 3D reconstruction accuracy in policy learning for 3D reconstruction, thereby enhancing the efficiency and autonomy of the data collection process. The implications of this research extend to applications in inspection, surveillance, and mapping, where optimal viewpoint selection is crucial for

information gain and operational efficiency.

ThA4	Rm 265
Simulation (Regular Session)	
Chair: Willis, Andrew	University of North Carolina at Charlotte
Co-Chair: Caballero, Alvaro	University of Seville

10:30-10:50	ThA4.1

Multi-UAV Planning in Search and Rescue Missions Using Optimal Search Effort Allocation, pp. 649-656

Sojo, Antonio	University of Sevilla
Perea, Alejandro	Universidad De Sevilla
Castell, Marco	Universidad De Sevilla
Juan, Perrela Clavería	Alpha Unmanned Systems S.L
Maza, Ivan	Universidad De Sevilla
Caballero, Alvaro	University of Seville
Ollero, Anibal	Universidad De Sevilla

In this paper we present a new search planning method for a coordinated swarm of UAVs based on the Theory of Search which provides a precise and robust probabilistic model for Search and Rescue (SAR) operations where lost victims need to be found as soon as possible. Using any ``a priori'' information about the victims' positions, a probability density function for each one is built and used to compute the optimal search effort allocation for the resources available. The priority assigned to each region of the area of interest is derived for such allocation using probability theory. This defines a set of priority sub-areas that span all the possible locations where a victim could be located. The optimal UAV distribution and order at which each sub-area is visited is computed using a Traveling Salesman Problem solver. The coverage paths within each sub-area are computed using an energy-aware path planner. We also address how to solve potential collisions with the terrain and/or other UAVs of the team. We have performed extensive simulations to validate our approach obtaining promising results in terms of probability of finding the victims and path feasibility.

10:50-11:10	ThA4.2

Multiphysics Blast Simulation for 3D UAV Control Applications, pp. 657-664

Parab, Surabhi	University of North Carolina at Charlotte
Zhang, Jincheng	University of North Carolina at Charlotte
Willis, Andrew	University of North Carolina at Charlotte

This paper presents a novel simulation framework designed for high-fidelity multi-physics simulation of shock waves due to blast phenomena. The framework includes simulation of the physical pressure wave, and the acoustic and visual phenomena associated with the blast event using the Gazebo environment. The framework integrates advanced technologies, including the Robot Operating System (ROS), QGroundControl, and PX4 Software-In-The-Loop (SITL), to synchronize visual, acoustic, and dynamic pressure data, ensuring realistic and efficient simulations. A key innovation in this framework is the use of a client-server architecture, which enables real-time adjustments and precise multimedia data synchronization, effectively minimizing latency and improving overall simulation quality and allowing multi-vehicle simulations in a single virtual scene. The specialized plugins employed for rendering and acoustic modeling capture the intricate dynamics of explosions, enhancing the realism of visual and auditory representations. Creation of this technology allows development of control algorithms that improve autonomous vehicle control algorithms in the presence of extreme perturbations with impacts in autonomous vehicle safety and defense sectors. The proposed framework offers a robust solution for interactive simulations, demonstrating significant advancements in both the fidelity and applicability of blast effect modeling.

11:10-11:30	ThA4.3

Analysis and Validation of CFD Model in Propeller-Wing Configurations, pp. 665-672

Ghoshal, Kshitij	McGill University
Nahon, Meyer	McGill University

Recent advances in Unmanned Aerial Vehicle (UAV) designs have increasingly incorporated Distributed Electric Propulsion (DEP) systems, characterized by multiple propellers attached on the leading edge of the wing. The increased interest in DEP necessitates understanding the aerodynamic effect of such multi-propeller configurations on aircraft performance. The development of a propeller model using Computational Fluid Dynamics (CFD) ensures flexibility in simulating different situations and analyzing the flow around the wing. In the present study, a CFD model developed to simulate the propeller slipstream was validated in the presence of a wing in different configurations. Simulations were assessed by varying freestream velocity, propeller advance ratio, and wing geometry. The effects produced by a single propeller were examined first before extending the analysis to multi-propeller configurations. The aerodynamic coefficients, specifically lift and drag, were compared to existing experimental results, demonstrating good agreement.

11:30-11:50	ThA4.4

UAV Simulation Environment for Fault Detection in Wind Farm Electrical Distribution Systems, pp. 673-680

Soares, Vítor Magalhães Dourado	USP - Universidade De São Paulo
Maroun de Almeida, Lucas	Universidade De São Paulo
Persiani Filho, Carlos Andre	University of São Paulo
Inoue, Roberto Santos	Universidade Federal De São Carlos

Grassi Junior, Valdir	Universidade De São Paulo
Terra, Marco Henrique	University of Sao Paulo at Sao Carlos
Oleskovicz, Mario	University of Sao Paulo - USP

The application of Unmanned Aerial Vehicles (UAVs) in electrical system inspection and maintenance has grown significantly - although most research focuses on transmission systems, with relatively few works addressing distribution networks. In this context, this paper introduces an innovative simulation environment designed to replicate real-world conditions for UAV-based fault detection missions in wind farms electrical distribution networks. By leveraging Unity for visualization and user interaction, and Python for simulating a DJI Matrice 350 aircraft's dynamic behavior, this computational platform enables the testing of task operational concepts with minimal risk and cost. The proposed system features an intuitive user interface, supports weather integration, and allows for flexible mission configurations through a user-friendly interface. The results demonstrate the environment's capability to simulate realistic scenarios, highlighting its potential to support the development and validation of UAV technologies for electrical systems inspections.

11:50-12:10 ThA4.5

Real-Time Simulation of Complex 4D Wind Fields and Gusts for UAS Control System Development, pp. 681-688

Parab, Surabhi	University of North Carolina at Charlotte
Wolek, Artur	UNC Charlotte
Maity, Dipankar	University of North Carolina - Charlotte
Willis, Andrew	University of North Carolina at Charlotte

This article describes a new suite of simulation plugins for the Gazebo 3D simulator to facilitate realistic simulation of time-varying 3D wind fields and gusts. The plugins integrate with ROS and Pixhawk PX4 Software-In-The-Loop (SITL) firmware to aid in the development of robust UAS control systems. Our approach features two main components: (1) real-time plugins for simulating environmental and sensed versions of complex, spatially varying wind velocity fields, using a Fourier-based compression of large CFD datasets, and (2) real-time plugins for modeling environmental and sensed versions of short-duration windblasts. By building on open-source Gazebo and ROS software, the developed framework provides high-accuracy physics simulation with support for multiple vehicles, fostering improved flight controller design and testing in cluttered or challenging atmospheric conditions.

12:10-12:30 ThA4.6

UAV Path Planning and Control: Towards a Complete Mission Management System, pp. 689-696

Tsourveloudis, Christos	National Technical University of Athens
Doitsidis, Lefteris	Technical University of Crete

Unmanned Aerial Vehicles (UAVs) mission management requires methodologies that rely on sophisticated path planning and following capabilities. In this paper, we examine the performance of two different control approaches for achieving flyable paths that are represented by B-Splines. A Proximal Policy Optimization (PPO) approach, which belongs to the Reinforcement Learning (RL) methodologies, is presented and evaluated for the control of the roll angle of a fixed-wing UAV in the presence of varying wind conditions. The performance of the PPO is examined in parallel with a simple PD-like Fuzzy Logic Controller (FLC) of Mamdani type. It turns out that the trained roll controller (RL) is just slightly better than the heuristically (FLC) designed one in terms of statistical performance, while being less transparent and generic. Potential future research directions are identified for further refinement of the method and expansion of the application scope.

ThB1 Rm 340GHI

Multirotor Design and Control II (Regular Session)

Chair: Harms, Marvin Chayton	NTNU
Co-Chair: Baldini, Alessandro	Università Politecnica Delle Marche

14:00-14:20 ThB1.1

Embedded Safe Reactive Navigation for Multirotors Systems Using Control Barrier Functions, pp. 697-704

Misyats, Nazar	École Normale Supérieure De Rennes
Harms, Marvin Chayton	NTNU
Nissov, Morten Christian	Norwegian University of Science and Technology
Jacquet, Martin	NTNU
Alexis, Kostas	NTNU

Aiming to promote the wide adoption of safety filters for autonomous aerial robots, this paper presents a safe control architecture designed for seamless integration into widely used open-source autopilots. Departing from methods that require consistent localization and mapping, we formalize the obstacle avoidance problem as a composite control barrier function constructed only from the online onboard range measurements. The proposed framework acts as a safety filter, modifying the acceleration references derived by the nominal position/velocity control loops, and is integrated into the PX4 autopilot stack. Experimental studies using a small multirotor aerial robot demonstrate the effectiveness and performance of the solution within dynamic maneuvering and unknown environments.

14:20-14:40 ThB1.2

Geometric Disturbance Observer Based Control for Multirotors, pp. 705-712

Baldini, Alessandro	Università Politecnica Delle Marche

Felicetti, Riccardo	Università Politecnica Delle Marche
Freddi, Alessandro	Università Politecnica Delle Marche
Monteriù, Andrea	Università Politecnica Delle Marche

In this paper we propose a disturbance observer-based control for the class of multirotor aerial vehicles having co-planar and collinear propellers, following a geometric approach. The control scheme is based on the well-known inner-outer loop structure, where the tracking control problem on the group of rotations is extended with an observer. To prove the asymptotic stability of the tracking error, a Lyapunov stability analysis is provided, taking into account kinematics, dynamics, and disturbance observer errors. For this purpose, disturbance rejection is achieved leveraging the disturbance model, which is assumed to be generated by exogenous systems having arbitrary orders. Simulations are performed on a hexarotor under elaborate external disturbances, which take into account unmodeled dynamics and time-varying wind effects. Simulation results show that the proposed control scheme can compensate for the disturbances, even when the embedded exogenous system model is coarse, outperforming the baseline geometric controller without disturbance compensation.

14:40-15:00	ThB1.3

Offset-Aware Dual Quaternion Control for UAVs with Cable-Suspended Loads, pp. 713-720

Yuan, Yuxia	Technical University of Munich
Pries, Lukas	TU Munich
Ryll, Markus	TU Munich

Modeling the kinematics and dynamics of UAVs with cable-suspended loads using dual quaternions remains an area requiring further exploration, especially when considering the offset between the attachment point and the UAV's center of mass. This work introduces a novel control strategy based on dual quaternions for sling load cargo UAV (cUAV) systems with offset attachments. Leveraging the mathematical efficiency and compactness of dual quaternions, we establish a unified representation of the kinematics and dynamics of both the UAV and its suspended load. Extensive simulations and real-world experiments were conducted to evaluate the accuracy and robustness of the proposed strategy. The results demonstrate the controller's reliability and stability across various conditions in practical cUAV applications. This study makes a contribution to the presentation of this novel control strategy that harnesses the benefits of dual quaternions for cUAVs. Our work also holds promise for inspiring future innovations in under-actuated systems control using dual quaternions.

15:00-15:20	ThB1.4

Design and Analysis of a Payload-Centric Controller for Collaborative Aerial Manipulation of a Slender Object, pp. 721-727

Williams, Connor Ian	University of Auckland
Skinner, Jaap	University of Auckland
Stol, Karl	University of Auckland

This paper presents the development of a payload-centric controller for manipulating a slender object with two multirotor UAVs. The paper formulates a 2.5D planar problem that allows the payload to be oriented and positioned in the horizontal plane while independently controlling the height. The aim is to enable abstracted dynamics of the UAVs providing the lift, to allow for simple control of the payload whilst enabling disproportionate control effort between the two UAVs. The control system has been experimentally implemented with two Crazyfly UAVs connected by a lightweight slender payload. In comparison to a combined position setpoint controller, the payload-centric control system shows a reduction in steady-state error for hover tests and reference tracking, and a reduction in oscillations caused by the UAVs competing to hold position. Reference tracking testing validates the performance of the reference tracking controller. The payload-centric controller is tested in simulation with a heterogeneous multi-lift system to demonstrate the versatility of the controller.

15:20-15:40	ThB1.5

Thrust Agility of Variable Pitch in Coaxial Rotor Pairs, pp. 728-735

Chen, Ruby	University of Auckland
Zhao, HongYang	University of Auckland
Al-zubaidi, Salim	University of Auckland
Kay, Nicholas	University of Auckland

Coaxial rotors offer design advantages for drones, in that they enable a smaller airframe while allowing for larger rotors. While larger rotors provide greater thrust and efficiency, they are not optimal for gust rejection, as their high inertia limits the rotor response frequency. Variable pitch propellers are a solution, decoupling the rotor response from the rotational inertia, but increase the complexity and mass of the system. This work looks at the agility advantages of a design compromise, using variable pitch only on the lower rotor of a coaxial pair. The results show that adapting variable-pitch lower rotor into coaxial configuration increased the overall stacked efficiency by 22%, and improved agility by 10.8% compared to the fixed-pitch, enhancing the overall coaxial performance.

ThB2	Rm 200

Test and Evaluation of Autonomous Aerial Systems II (Invited Session)

Chair: Costello, Donald	University of Maryland College Park
Co-Chair: Mwaffo, Violet	United States Naval Academy
Organizer: DeVries, Levi	United States Naval Academy
Organizer: Wickramasuriya, Maneesha	George Washington University

Organizer: Arslanian, Peter	Naval Air Systems Command - Naval Air Warfare Center Aircraft Di
Organizer: Fristachi, John	Calspan
Organizer: Prasinos, Mia	Air Force Institute of Technology
Organizer: Sakano, Kristy	University of Maryland at College Park
Organizer: Minton, Julia	NAWCAD
Organizer: Costello, Donald	University of Maryland College Park
Organizer: Bortoff, Zachary	University of Maryland

14:00-14:20 ThB2.1

An Analysis of Multi-Object Detection on 2024 Aerial Refueling Flight Test Data (I), pp. 736-741

Prasinos, Mia — Air Force Institute of Technology

Autonomous aerial refueling (AAR) enables extended mission endurance for both manned and unmanned aircraft without relying on ground-based support. Traditional AAR methods use active sensors such as radar and light detection and ranging (LiDAR), which are susceptible to jamming and interference. This paper investigates a passive, vision-based approach using You Only Look Once (YOLO) convolutional neural networks (CNNs) to detect and track refueling components using only monocular imagery. Two flight test campaigns were conducted to evaluate system performance: one using a scale model unmanned aircraft system (UAS) receiver and the other using full-scale aircraft. The results demonstrate that larger objects like tankers can be accurately tracked at greater distances, while smaller objects like drogues require closer proximity for reliable pose estimation. A method leveraging a separate network for tanker tracking provides azimuth and elevation cues, guiding the receiver toward the drogue until it is close enough for precise docking. Additionally, extensive flight imagery was collected for future validation using recorded Global Positioning System (GPS) data. These findings highlight the feasibility of vision-based AAR and inform future work toward a fully autonomous refueling capability.

14:20-14:40 ThB2.2

Deep Learning-Based Relative Bearing Estimation between Naval Surface Vessels and UAS in Challenging Maritime Environments (I), pp. 742-748

Miller, Sean	United States Naval Academy
Mwaffo, Violet	United States Naval Academy
Costello, Donald	University of Maryland College Park

This paper introduces a deep neural network (DNN) framework designed to accurately determine the relative bearing between a naval surface vessel and an uncrewed aerial system (UAS) using video data collected from drone operations in a maritime environment. Utilizing a dataset of 2,773 augmented images categorized into twelve 30-degree angular classes, the DNN was trained with the YOLOv11s architecture to identify and localize the relative bearing of a Yard Patrol vessel effectively. The model demonstrated exceptional performance, achieving an overall precision of 89%, recall of 91.3%, and a mean average precision (mAP) of 93.6% at a 50% intersection over union (IoU) threshold. Furthermore, the mAP averaged 83.1% across IoU thresholds from 50% to 95%, highlighting the model's robustness in diverse conditions. These metrics indicate that the DNN can reliably estimate the UAS's bearing relative to the naval vessel, thereby facilitating autonomous recovery operations in communication-denied maritime environments. This advancement supports the United States Navy's initiative to integrate rotary-wing UASs onto existing naval platforms, ensuring safe and efficient flight operations from stern landing areas

14:40-15:00 ThB2.3

Vision-In-The-Loop Simulation for Deep Monocular Pose Estimation of UAV in Ocean Environment (I), pp. 749-756

Wickramasuriya, Maneesha	George Washington University
Beomyeol, Yu	George Washington University
Lee, Taeyoung	George Washington University
Snyder, Murray	George Washington University

This paper proposes a vision-in-the-loop simulation environment for deep monocular pose estimation of a UAV operating in an ocean environment. Recently, a deep neural network with a transformer architecture has been successfully trained to estimate the pose of a UAV relative to the flight deck of a research vessel, overcoming several limitations of GPS-based approaches. However, validating the deep pose estimation scheme in an actual ocean environment poses significant challenges due to the limited availability of research vessels and the associated operational costs. To address these issues, we present a photo-realistic 3D virtual environment leveraging recent advancements in Gaussian splatting, a novel technique that represents 3D scenes by modeling image pixels as Gaussian distributions in 3D space, creating a lightweight and high-quality visual model from multiple viewpoints. This approach enables the creation of a virtual environment, integrating multiple real-world images collected in situ. The resulting simulation enables the indoor testing of flight maneuvers while verifying all aspects of flight software, hardware, and the deep monocular pose estimation scheme. This approach provides a cost-effective solution for testing and validating the autonomous flight of shipboard UAVs, specifically focusing on vision-based control and estimation algorithms.

15:00-15:20 ThB2.4

Optimizing Parameters for Hybrid DNN-UKF State Estimation in Autonomous Air Refueling, pp. 757-762

Wagner, Leo	United States Naval Academy
Andersen, James	United States Naval Academy
Costello, Donald	University of Maryland College Park
Mwaffo, Violet	United States Naval Academy

The future of the United States Navy's (USN) carrier airwing hinges on effective Uncrewed Aerial Vehicles (UAVs), whose autonomy critically depends on robust aerial refueling systems. This work seeks to refine the process and measurement noise parameters in a hybrid Deep Neural Network (DNN) and Kalman Filter (KF) framework to improve drogue tracking reliability under challenging operational conditions. The proposed study employs a structured experimentation protocol combining simulated lab environments—featuring robotic arms replicating drogue motions—along with video datasets from actual refueling operations. Preliminary results obtained via a trial-and-error tuning approach indicate promising performance, achieving an overall RMSE of 0.155~m. Building on these encouraging findings, we seek to implement systematic fine-tuning methods, specifically grid search and Bayesian optimization, to further reduce RMSE and enhance system accuracy and robustness. The ultimate goal is to advance the operational readiness of autonomous aerial refueling, laying the groundwork for the next generation of USN carrier-based aviation.

ThB3	Rm 267
Path Planning III (Regular Session)	
Chair: Tzes, Anthony	New York University Abu Dhabi
Co-Chair: Weintraub, Isaac E.	Air Force Research Laboratory

14:00-14:20	ThB3.1

Engagement Zones for a Turn Constrained Pursuer, pp. 763-768

Chapman, Thomas	Air Force Research Laboratory
Weintraub, Isaac E.	Air Force Research Laboratory
Von Moll, Alexander	Air Force Research Laboratory
Garcia, Eloy	AFRL

This work derives two basic engagement zone models, describing regions of potential risk or capture for a mobile vehicle by a pursuer. The pursuer is modeled having turn- constraints rather than simple motion. Turn-only (C-Paths) and turn-straight (CS-Paths) paths are considered for the pursuer of limited range. Following the derivation, a simulation of a vehicle avoiding the pursuer's engagement zone is provided.

14:20-14:40	ThB3.2

Optimal Fixed-Wing UAV Rendezvous Via LQR-Based Longitudinal Control, pp. 769-776

Büyükekiz, Kadir Bulathan	Turkish Aerospace Inc
Ergezer, Halit	Cankaya University

This paper proposes an optimal control-based rendezvous strategy for fixed-wing Unmanned Aerial Vehicles (UAVs) using a Linear Quadratic Regulator (LQR). The goal is to precisely track a moving target while maintaining flight stability and avoiding predefined restricted areas. The controller optimally adjusts UAVs flight parameters to minimize trajectory errors and enhance robustness against environmental disturbances. A penalty-based method is integrated to prevent UAVs from entering restricted areas while ensuring smooth trajectory adaptation. The proposed approach has been tested in MATLAB simulations under multiple scenarios, demonstrating its effectiveness in achieving stable and efficient rendezvous maneuvers. The results confirm that LQR-based control and adaptive penalty mechanisms offer a practical solution for fixed-wing UAV operations in constrained environments.

14:40-15:00	ThB3.3

Energy-Aware Coverage Path Planner for Multirotor UAVs, pp. 777-784

Escobar, Luis	West Virginia University
Pereira, Guilherme	West Virginia University

Coverage Path Planning (CPP) is crucial for UAV applications such as inspection and surveying. While existing CPP methods often focus on minimizing distance or time, energy consumption remains a critical, relatively unexamined constraint, especially for multirotor drones. This paper proposes a novel CPP approach that directly incorporates an energy model into the path-planning process. By utilizing a Mixed Integer Linear Programming (MILP) framework and an energy model, the proposed method aims to minimize energy consumption while ensuring complete coverage of the target area. Simulations and experimental results demonstrate that the proposed approach gives optimal solutions, and using this richer heuristic reduces the processing time for the MILP problem, opening the door for faster online CPP planners.

15:00-15:20	ThB3.4

Efficient Safe Trajectory Planning for an Omnidirectional Drone, pp. 785-792

Mohamed Ali, Abdullah	New York University Abu Dhabi
Hamandi, Mahmoud	New York University Abu Dhabi
Tzes, Anthony	New York University Abu Dhabi

The computation of a safe path between two target points for an omnidirectional drone is considered. The drone is equipped with eight fixed unidirectional thrusters, enabling full pose control. Given a priori knowledge of the environment map, a preliminary path is generated using a variant of RRT*. A corresponding trajectory is then fitted to this path and executed by the drone.

To enhance safety and efficiency, the velocity along the path is adaptively assigned, balancing caution near critical obstacles with minimizing travel time in open spaces. The adaptive velocity limits are proportional to the distance between the drone's convex hull at various poses along the path and the surrounding environment. Distance computation is optimized by focusing

on obstacles in the direction of motion, representing obstacle facets with axis-aligned voxels, and pruning distant obstacles before calculating the exact distance between the convex hull and the environment map.

The proposed approach is validated through simulation studies, demonstrating effective navigation through narrow gaps at odd angles while ensuring minimal travel time and maintaining required safety margins.

15:20-15:40	ThB3.5

Voxel-Based Simulation in Comparison for Path Planning of Autonomous Indoor Multicopters, pp. 793-800

Kumpe, Hendrik	Institut Für Integrierte Produktion Hannover GGmbH
Küster, Benjamin	Institut Für Integrierte Produktion Hannover GGmbH
Stonis, Malte	Institut Für Integrierte Produktion Hannover GGmbH
Overmeyer, Ludger	Leibniz University Hanover

The utilization of simulations for the development of path planning algorithms for autonomous indoor multicopters is of primary importance. It offers a secure and cost-effective setting for the testing and optimization of algorithms. This article considers and examines the currently used simulation options with regard to their suitability for the development of path planning algorithms for autonomous indoor multicopters. The use of autonomous multicopters represents an innovative solution to simplify the process of layout recording and inventories. This article focuses on the voxel-based simulation VSim, developed and named by the author. In light of the extant literature, the article elucidates the simulation environments that are most commonly utilized. Subsequently, a selection of simulations is compared with VSim. The time efficiency and resource usage of the simulation environments are examined based on more than 1,500 test runs. Furthermore, the observations of the test executions are described in detail, and finally, the simulations with all investigated parameters are compared. Additionally, the potential for parallelization is explored and discussed.

ThB4	Rm 265
Sensor Fusion (Regular Session)	
Chair: Kim, Dongbin	University of Hartford
Co-Chair: Amaral, Guilherme	INESC TEC - Institute for Systems and Computer Engineering, Technology and Science

14:00-14:20	ThB4.1

Data Fusion Approach for Unmodified UAV Tracking with Vision and mmWave Radar, pp. 801-808

Amaral, Guilherme	INESC TEC
J. Martins, João	INESC TEC
Martins, Pedro	INESC TEC
Dias, André	INESC TEC
Almeida, José Miguel	INESC TEC
Silva, Eduardo	INESC TEC

Knowledge of the precise 3D position of a target in tracking applications is a fundamental requirement. The lack of a low-cost single sensor capable of providing the three-dimensional position (of a target) makes it necessary to use complementary sensors together. This research presents a Local Positioning System (LPS) for outdoor scenarios, based on a data fusion approach for unmodified UAV tracking, combining a vision sensor and mmWave radar. The proposed solution takes advantage of the radar's depth observation ability and the potential of a neural network for image processing. We have evaluated five data association approaches for radar data cluttered to get a reliable set of radar observations. The results demonstrated that the estimated target position is close to an exogenous ground truth obtained from a Visual Inertial Odometry (VIO) algorithm executed onboard the target UAV. Moreover, the developed system's architecture is prepared to be scalable, allowing the addition of other observation stations. It will increase the accuracy of the estimation and extend the actuation area. To the best of our knowledge, this is the first work that uses a mmWave radar combined with a camera and a machine learning algorithm to track a UAV in an outdoor scenario.

14:20-14:40	ThB4.2

Enhanced UAV Navigation Systems through Sensor Fusion with Trident Quaternions, pp. 809-816

Incicco, Sebastian	Facultad De Ingeniería, Universidad De Buenos Aires
Giribet, Juan Ignacio	University of San Andrés
Colombo, Leonardo, J	Centre for Automation and Robotics (CAR)

This paper presents an integrated navigation algorithm based on trident quaternions, an extension of dual quaternions. The proposed methodology provides an efficient approach for achieving precise and robust navigation by leveraging the advantages of trident quaternions. The performance of the navigation system was validated through experimental tests using a multi-rotor UAV equipped with two navigation computers: one executing the proposed algorithm and the other running a commercial autopilot.

14:40-15:00	ThB4.3

A Framework for the Consistency Analysis of Relative Pose Sensors for Unmanned Aerial Vehicles (UAVs), pp. 817-824

Jung, Roland	University of Klagenfurt
Horyna, Jiri	Czech Technical University in Prague, FEE

Jantos, Thomas | University of Klagenfurt
Saska, Martin | Czech Technical University in Prague FEE
Weiss, Stephan | University of Klagenfurt

In autonomous multi-robot systems robot-to-{robot/object} localization methods can be utilized to increase the robustness and to achieve a precise and robust localization of the individuals. This paper investigates the performance of two promising systems: UVDAR, a vision-based mutual localization in the UV spectrum, which has shown to be effective in swarm formation and leader-following tasks, and PoET, which is a deep learning-based visual relative object pose estimator. To evaluate these methods, we collected datasets in a controlled indoor environment equipped with a motion capture system for precise ground truth measurements. Our evaluation considers two key aspects: the absolute error between measured and true relative poses, and the consistency of the provided measurement uncertainty estimates with the actual errors. We introduce a novel framework for evaluating the consistency of relative pose measurements. This framework supports various error definitions and leverages spline-based trajectory representations to generate smooth, C2-continuous reference measurements. Both the UVDAR dataset and the evaluation framework are made publicly accessible to foster further research and development in this field.

15:00-15:20 | ThB4.4

From Detection to Traversal: A Probabilistic Framework for UAS-Assisted Landmine Mapping and Circumvention, pp. 825-831

Steckenrider, J. Josiah | United States Military Academy
Kim, Dongbin | University of Hartford
Manjunath, Pratheek | United States Military Academy

This research presents a robust probabilistic framework for minefield localization, mapping, and avoidance, addressing a technological gap in the field of aerial countermine intelligence, while bypassing the well-established techniques of landmine detection. Our approach propagates the pose uncertainty matrix delivered by a drone's flight controller's Kalman filter to probabilistically estimate the location of detected mines. This probability map then seeds an artificial potential field path generator which creates a safe path for ground traversal by producing waypoints through the minefield. The system's performance is evaluated in simulations and validated through flight trials, demonstrating its potential to improve the efficiency and safety of UAV-assisted minefield navigation and threat avoidance.

15:20-15:40 | ThB4.5

Navigating the Underground: Tackling Localization Challenges for UAVs in Tunnels (I), pp. 832-838

González Marín, José Manuel | CATEC
Montes-Grova, Marco Antonio | CATEC
Perez-Grau, Francisco Javier | FADA-CATEC
Viguria, Antidio | FADA-CATEC

In this work a survey of the issues and difficulties for Unmanned Aerial Vehicles (UAVs) in underground environments, in particular tunnels, will be carried out. In addition to not having Global Navigation Satellite System (GNSS) signal or any other type of external positioning, this kind of environment will present a number of unique constraints that make a wide range of visual-inertial (VIO), or LiDAR-inertial (LIO),localization algorithms unusable. In addition, state-of-the-art algorithms will be validated with real flight data in a tunnel and possible solutions will be offered for achieving robust and reliable localization using only the on-board. In this way, the deployment of autonomous navigation tasks in these degraded environments will be pushed.

Friday, May 16

FrA1	Rm 340GHI
Advances in Aerial Robotics for Inspection and Maintenance (Invited Session)	
Chair: Caballero, Alvaro	University of Seville
Co-Chair: Loianno, Giuseppe	New York University
Organizer: Caballero, Alvaro	University of Seville
Organizer: Gonzalez-Morgado, Antonio	Universidad De Sevilla
Organizer: Ruggiero, Fabio	Università Degli Studi Di Napoli
Organizer: Loianno, Giuseppe	New York University

10:30-10:50 FrA1.1

Semi-Autonomous Interaction Framework for Contact-Based Operations with Commercial UAVs in GNSS-Denied Environments (I), pp. 839-846

Gonzalez-Morgado, Antonio	Universidad De Sevilla
Zhang, Qi	Tampere University
Damigos, Gerasimos	Lulea University of Technology
Cuniato, Eugenio	ETH Zurich
Hui, Tong	Technical University of Denmark
Sahin, Erdem	Tampere University
Nikolakopoulos, George	Luleå University of Technology
Siegwart, Roland Y.	ETH Zürich
Fumagalli, Matteo	Danish Technical University
Ollero, Anibal	Universidad De Sevilla
Heredia, Guillermo	University of Seville

Unmanned aerial vehicles (UAVs) are being increasingly established for autonomous contacted-based inspection of industrial assets, reducing the risk of errors by human operators. However, challenges remain in the navigation under unreliable Global Navigation Satellite System (GNSS) signals, or in the detection and interaction with the inspection surface, which limits the autonomy level of current UAV industrial technologies. This paper presents a semi-autonomous framework which combines automated target detection and interaction in GNSS-denied environments, with supervision commands by a human operator, to increase both safety and reliability. Our framework is composed of: (i) a camera-based onboard odometry solution for positioning the UAV in GNSS-denied conditions, (ii) a target-detection and filtering algorithm which estimates the orientation and position of the interaction target and (iii) a visual servoing strategy for approaching and contacting the target. The proposed framework is developed completely in ROS and can be used with any commercial UAV. The framework is validated through outdoor flights, where a UAV detects and contacts a target on a vertical pipe.

10:50-11:10 FrA1.2

Enhancing IMU Accuracy in MRAVs: A Theoretical and Experimental Approach to Vibration Damping (I), pp. 847-853

Balandi, Lorenzo	INRIA
Robuffo Giordano, Paolo	IRISA / INRIA Rennes
Tognon, Marco	INRIA

This paper analyses the problem of mechanical vibrations on Flight Controllers (FCs) of Multi-Rotor Aerial Vehicles (MRAVs) and proposes solutions based on vibration theory. First, we analyze the raw Inertial Measurement Unit (IMU) data obtained from real flights to understand the dynamical characteristics of a baseline damping configuration. We confirm that the motor-propeller units are the main source of vibration in these systems. We then develop two models used to understand how to effectively damp vibrations on IMU. We improve the baseline configuration using commonly available components placed according to a theoretical analysis and we discuss the experimental results. The new damping configuration greatly decreases the amplitude of vibrations on acceleration and angular velocity measurements.

11:10-11:30 FrA1.3

Simplifying Autonomous Aerial Operations: LUCAS, a Lightweight Framework for UAV Control and Supervision (I), pp. 854-861

Murillo Alvarez, Jose Ignacio	FADA-CATEC
Montes-Grova, Marco Antonio	CATEC
Zahinos, Raul	CATEC
Trujillo, Miguel Ángel	CATEC
Viguria, Antidio	FADA-CATEC
Heredia, Guillermo	University of Seville

This work introduces LUCAS, an open-source framework designed to control and monitor highly autonomous UAV systems. This framework is composed of two modules, the Control Manager Finite-State-Machine (FSM), an efficient and easily extensible state machine that controls the behavior of the robot during the mission, and the Cascade Controller, which handles the commands to the low-level autopilot. The methodology followed to develop the framework has been the use of C++ and a modularized implementation, to separate communications from core functionality and allow the use of diverse middleware, in this case, ROS and ROS2. The system can be integrated with other software nodes to form a complete autonomous setup, which has been successfully tested in a simulated environment and in a real scenario, where a quadrotor has to perform an indoor inspection in a building under construction.

11:30-11:50	FrA1.4

Intuitive Human-Drone Collaborative Navigation in Unknown Environments through Mixed Reality (I), pp. 862-868

Salunkhe, Sanket Ankush	Colorado School of Mines
Nedunghat, Pranav	New York University
Morando, Luca	New York University
Bobbili, Nishanth	New York University
Li, Guanrui	Worcester Polytechnic Institute
Loianno, Giuseppe	New York University

The widespread use of aerial robots in inspection, search and rescue, and monitoring has created a growing need for intuitive human-drone interfaces. These aim to streamline and enhance the user interaction and collaboration process during drone navigation, ultimately expediting mission success and accommodating users' inputs. In this paper, we present a novel human-drone mixed reality interface that aims to (a) increase human-drone spatial awareness by sharing relevant spatial information and representations between the human equipped with a Head Mounted Display (HMD) and the robot and (b) enable safer and intuitive human-drone interactive and collaborative navigation in unknown environments beyond the simple command and control or teleoperation paradigm. Our framework is validated through extensive user studies and experiments conducted in simulated post-disaster scenarios, with performance compared to traditional First-Person View (FPV) control systems. Multiple tests on several users underscore the advantages of the proposed solution, which offers intuitive and natural interaction with the system. This demonstrates the solution's ability to assist humans during a drone navigation mission, ensuring its safe and effective execution.

11:50-12:10	FrA1.5

Power Line Following Based on Measurements of the Magnetic Field (I), pp. 869-875

Vasiljevic, Goran	University of Zagreb
Martinovic, Dean	University of Zagreb
Bogdan, Stjepan	University of Zagreb

In this paper, we present a method to control the UAV to follow the power line with a specific position and orientation based only on the measurement of the magnetic field generated by the current flow in the power line. In this way, it is possible to localize the UAV with respect to the power line without the need for additional sensors, even in poor visibility conditions. The measurements from four magnetometers attached to the UAV are used to solve an optimization problem that involves determining the relative pose of the UAV with respect to the power line. Based on the relative pose, the UAV is controlled to follow the power line in a predefined position and orientation. Experiments in a test setup have confirmed that the method is applicable in a realistic environment.

12:10-12:30	FrA1.6

Aerial Transportation, Deployment and Retrieval of Dexterous Dual Arm Rolling Robot for Power Line Maintenance: Field Validation (I), pp. 876-881

Suarez, Alejandro	University of Seville
Caballero, Alvaro	University of Seville
Ollero, Anibal	Universidad De Sevilla

This paper presents the application of an aerial-deployable dual arm rolling robot developed for the realization of maintenance operations on power lines, validated through field tests in a real power line. The system consists of a quadrotor used as a carrier platform for the transportation, deployment and retrieval of a lightweight and compliant anthropomorphic dual arm system (LiCAS). The arms are equipped with a drive wheel that allows them to move along the cable to conduct the installation of devices while the aerial platform stays at the landing area. The proposed approach avoids the problems of operating while flying in terms of positioning accuracy and energy efficiency, reducing also significantly the load on the power line compared to the case in which the multi-rotor has to perch. The paper describes the mechanisms implemented for the deployment and retrieval of the arms on the power line and for the installation of a customized model of bird flight diverter on the power line, as well as the system architecture, reporting results and practical aspects derived from the experimental validation.

FrA2	Rm 200
UAS Applications III (Regular Session)	
Chair: Sanket, Nitin	Worcester Polytechnic Institute
Co-Chair: Maalouf, Guy	University of Southern Denmark

10:30-10:50	FrA2.1

Customized Design and Preliminary Testing of a Precision Spraying Drone for Vineyard Applications, pp. 882-889

Primatesta, Stefano	Politecnico Di Torino
Enrico, Riccardo	Politecnico Di Torino

Carreño Ruiz, Manuel | Politecnico Di Torino
Bloise, Nicoletta | Politecnico Di Torino
Guglieri, Giorgio | Politecnico Di Torino

Unmanned Aircraft Systems (UAS) for spraying plant protection products are an emerging technology aimed at enhancing the efficiency and sustainability of agricultural production. This paper presents the design and development of an innovative UAS-based spraying system for targeted and precise spraying applications in vineyards. The proposed solution introduces several innovations compared to state-of-the-art technologies. Nozzle positioning is optimized through Computational Fluid Dynamics simulations and wind tunnel tests to improve the control of sprayed droplets. The system reduces the sloshing effect, i.e. the oscillation of the onboard liquid, through a tank with internal baffles and with the adoption of a sloshing-aware control strategy. Precision spraying is further enhanced by a methodology for vineyard row tracking and following. Although the system is under development, this article outlines the architecture, the design methodology, and presents some preliminary results. The first prototype has been successfully developed and preliminarily tested, demonstrating the feasibility of the project and validating some of the key design concepts, while further developments are ongoing to implement all system functionalities.

10:50-11:10 | FrA2.2

A Semi-Autonomous UAV with Human Supervisory Control for Non-Destructive Inspections in Interaction with Concrete Structures, pp. 890-897

Marcellini, Salvatore | Leonardo S.p.A
Marolla, Michele | Leonardo S.p.A
Lippiello, Vincenzo | Università Di Napoli Federico II

Inspection and assessment of large concrete structures is the primary method to monitor their status and is conventionally conducted by trained inspectors and climbers with specialized equipment, which can be expensive and ineffective at times. Non-destructive inspection solutions emerge as a good candidate for facilitating such evaluations. In this article, we present a human supervisory control to fully automate both the approach and interaction stages of the measurement process employing a multirotor featuring tiltable rotors, characterized by a streamlined kinematic model. Our software seamlessly integrates with the PX4 autopilot firmware, thereby harnessing the complete capabilities of the flight controller. Furthermore, this integration enabled us to leverage all compatible tools such as QGroundControl, log review functionalities, and others, optimizing efficiency and functionality. Thanks to that, it has been possible to test our system without an experienced and/or certified drone pilot on the concrete pillars of a highway bridge, reducing the time and the costs needed to deploy and validate such a robot.

11:10-11:30 | FrA2.3

Analyzing Deep-Learning Methods for Power Line Component Detection in Unmanned Aircraft System Imagery with Few Data, pp. 898-904

Fourret, Guillaume | LIRMM, University of Montpellier, Drone Geofencing
Chaumont, Marc | LIRMM, University of Montpellier, University of Nîmes
Fiorio, Christophe | LIRMM, University of Montpellier
Subsol, Gérard | LIRMM, University of Montpellier
Brau, Samuel | Drone Geofencing

Due to the critical role of power lines in modern infrastructure, numerous automated methods have been developed for their inspection. Among these, Unmanned Aircraft Systems (UAS) have emerged as a valuable tool, offering rapid and precise inspections by capturing high-resolution aerial imagery of power lines. Drones enable access to hard-to-reach areas, reduce safety risks for workers near live wires, and significantly lower the time and cost associated with traditional inspection methods. In particular, deep learning techniques have been widely applied to automate the analysis of key components via the onboard camera. However, these methods typically rely on a first stage of detection based on large, annotated datasets focused on specific components, limiting their adaptability to new or unseen components. This paper investigates the application of two state-of-the-art algorithms of Few-Shot Object Detection (FSOD) for power line component detection: DeFRCN and CD-ViTO, alongside a modified Yolov8 detector of our own in which we integrated the modules of DeFRCN. We evaluate their performance using both public and proprietary datasets, analyzing unexpected outcomes and provide insights into the practical applicability of FSOD in real-world scenarios.

11:30-11:50 | FrA2.4

Insights into Safe and Scalable BVLOS UAS Operations from Kenya's Ol Pejeta Conservancy, pp. 905-912

Maalouf, Guy | University of Southern Denmark
Meier, Kilian | University of Bristol
Richardson, Thomas | University of Bristol
Guerin, David | IFATCA
Watson, Iain Matthew | University of Bristol
Schultz, Ulrik Pagh | University of Southern Denmark
Afridi, Saadia | Avy B.V
Rolland, Edouard George Alain | University of Southern Denmark
Jepsen, Jes Hundevadt | University of Southern Denmark
Njoroge, William | Ol Pejeta Conservancy
Jensen, Kjeld | University of Southern Denmark

Beyond Visual Line of Sight (BVLOS) operations of Uncrewed Aerial Systems (UAS) hold significant potential for transforming many sectors, but face significant regulatory, safety, and operational complexity challenges. This paper presents a framework

developed for planning and executing safe and compliant BVLOS missions in the context of wildlife conservation. While validated through a case study at the Ol Pejeta Conservancy, Kenya, this approach may also serve as a foundation for similar operations in other complex environments. Leveraging the widely adopted Specific Operations Risk Assessment (SORA), we developed an operational framework that addressed both air and ground risks. Key measures include strategic planning, coordination with local authorities, and the establishment of contingency volumes and operational procedures to ensure safety.

Field trials have demonstrated the practical challenges of ensuring airspace safety and highlighted the importance of close collaboration with Air Traffic Control (ATC) and the need for more robust, and redundant Command & Control (C2) solutions for long-range or remote operations. This study provides a replicable framework applicable to diverse BVLOS scenarios while offering insights specific to wildlife conservation. Documentation related to this work is publicly accessible: https://github.com/GuyMaalouf/WD-June24-BVLOS-Docs

11:50-12:10	FrA2.5

Heave Motion Estimation from IMU Measurements in Hybrid Aerial-Amphibious Drones and Horizontal Take-Off Window Prediction, pp. 913-920

Capuozzo, Andrea	University of Naples Federico II
Ruggiero, Fabio	Università Degli Studi Di Napoli "Federico II"
Lippiello, Vincenzo	Università Di Napoli Federico II

Employing hybrid aerial-amphibious drones, for activities in the marine environment, comes with a series of challenges that concern managing the interaction between the robot and the water surfaces, especially in the presence of waves. This paper focuses on the take-off transition from water to air, aiming to identify and predict those time windows in which the drone has a close to zero roll and pitch (horizontal attitude) and the propellers are the furthest from the water surface, thus optimizing the take-off. The proposed solution merges the measurement of the drone vertical displacement, due to the wavefronts, with the attitude data, returning a prediction signal that marks the best take-off windows in the immediate future. The idea has been validated through numerous simulated case studies.

12:10-12:30	FrA2.6

Data-Driven and Explainable Artificial Intelligence Modelling for Quadrotor Crash Area Prediction, pp. 921-928

Sivakumar, Anush Kumar	Nanyang Technological University
T., Thanaraj	Nanyang Technological University
Feroskhan, Mir	Nanyang Technological University

The advent of quadrotors has revolutionized applications such as surveillance, logistics, and disaster response, owing to their versatility and maneuverability. However, their nonlinear dynamics and sensitivity to actuator and propulsion failures pose significant safety risks. Additionally, the black-box nature of traditional artificial intelligence (AI) models hinders transparency and trustworthiness in safety-critical predictions. This paper presents a novel data-driven and explainable AI framework for predicting quadrotor crash areas under single actuator and complete power failure scenarios. The framework uses high-fidelity simulation data and the Feyn QLattice algorithm to model complex descent dynamics while offering an interpretable symbolic expression for external stakeholders. Comparative predictive evaluations with machine learning models, including random forests (RF) and extreme gradient boosting (XGB), reveal that the QLattice algorithm achieves competitive accuracy with RMSE and R2 values of 7.666 and 0.969, respectively. Validated through 5-fold cross-validation and hold-out testing, the framework demonstrates its potential to advance quadrotor safety by balancing accuracy, efficiency, and interpretability. Upcoming research will focus on integrating wind disturbances, investigating additional failure scenarios, and creating and refining interpretable algorithms to improve predictive performance.

FrA3	Rm 267
Regulations/Energy (Regular Session)	
Chair: Atkins, Ella	University of Michigan
Co-Chair: Pignaton de Freitas, Edison	Federal University of Rio Grande Do Sul

10:30-10:50	FrA3.1

Energy Aware Coverage Planning for a QuadPlane Small Uncrewed Aircraft System, pp. 929-936

Mathur, Akshay	University of Michigan
Atkins, Ella	University of Michigan

This paper describes flight planning for a Vertical Take-Off and Landing (VTOL) QuadPlane small Uncrewed Aircraft System (sUAS). Five Lift+Cruise sUAS waypoint types are defined and used to construct smooth flight path geometries and acceleration profiles. Accelerated coverage flight plan segments for hover (Lift) and coverage (Cruise) waypoints are defined. Carrot-chasing guidance shows a trade-off between tracking accuracy and control stability as a function of carrot time step. Experimentally derived QuadPlane aerodynamic and thrust models for vertical, forward, and hybrid flight modes are developed as a function of airspeed and angle of attack. The QuadPlane feedback controller supports a novel hybrid mode that combines multicopter and aircraft actuators to add a controllable pitch degree of freedom at the cost of increased energy use. Energy aware coverage planning results show fly-coverage cruise waypoints are most efficient given long inter-waypoint distances. Energy versus coverage Pareto fronts analyze waypoint type tradeoffs for closely spaced waypoint cases.

10:50-11:10	FrA3.2

Adaptive Optimal Path Following Guidance for Fixed-Wing Aerial Vehicles, pp. 937-943

Dodge, Andrew	University of Kansas
Baruth, Adam	University of Kansas

Keshmiri, Shawn | University of Kansas

A vast body of research exists on the guidance of autonomous unmanned aerial vehicles, with most approaches relying on geometric relationships and constant gains. While these methods can be optimized for predefined flight paths, they become suboptimal in dynamic scenarios requiring real-time guidance without prior knowledge, sharp turns, or significant variations in path length. This work introduces an optimal guidance algorithm with adaptive gains and inherent robustness to external disturbances. By defining the state weighting matrix as a function of cross-track errors, the proposed approach dynamically adjusts gains to minimize deviations. Additionally, incorporating an integral term into the state-space dynamic model ensures zero steady-state error. Lyapunov stability of the algorithm is demonstrated for all possible state weighting matrices. The algorithm is evaluated in a six-degree-of-freedom simulation environment and validated through real-world flight tests under high-wind conditions. Results demonstrate superior robustness and path-tracking performance compared to widely used proportional navigation methods, particularly in adverse environments.

11:10-11:30 | FrA3.3

Regulatory and Operational Integration of High Altitude Platform Stations (HAPS) Considering the Brazilian and the European Perspectives, pp. 944-951

Erotokritou, Chrystel | Access Partnership
Stellatou, Sofia | Access Partnership
Formenton Vargas, Isadora | Rossi, Maffini, Milman & Grando Advogados
Pignaton de Freitas, Edison | Federal University of Rio Grande Do Sul

With the advance of communication technologies such as the 5G/6G and the widespread Internet of Things (IoT) in many application domains, the need for supporting infrastructure is becoming an important concern. Traditional solutions either do not meet the requirements or are becoming too expensive. In this context, an emerging approach based on High Altitude Platform Stations (HAPS) is revealing itself as a promising solution. However, the legal and regulatory frameworks necessary to enable their large-scale deployment remain fragmented or underdeveloped in most regions. Despite the technical advances regarding the design and deployment of these platforms, important concerns are raised in terms of the legal framework to make it feasible. In light of this gap and observing the significance of the employment of these high-altitude unmanned platforms, this work provides a discussion on regulatory aspects involved in HAPS operation, with a particular focus on the recent advances in Brazil and in Europe. Finally, a prospective analysis of the steps that are coming in HAPS regulation is provided.

11:30-11:50 | FrA3.4

Regulatory Landscape of Unmanned Aerial Systems in the Selected Countries in European Union: An In-Depth Analysis and the Imperative for Harmonization, pp. 952-958

Chrostowska, Martyna | Uczelnia Łazarskiego
Osiecki, Mateusz | Lazarski University in Warsaw
Fortonska, Agnieszka | University of Silesia

In recent years, Unmanned Aerial Systems (UAS) have surged in popularity, promising transformative applications across diverse sectors. Nevertheless, their rapid and widespread adoption poses significant challenges in the realm of regulatory frameworks. This study undertakes a comprehensive examination of the legal norms pertaining to UAS at the European Union (EU) level, followed by a comparative analysis of domestic regulations in selected countries. The primary objectives are to meticulously assess these norms, identify commonalities, and delineate disparities. The findings unveil shared aspects, as well as divergent approaches to UAS regulation among individual member countries, accentuating the pressing necessity for enhanced harmonization of regulations at the EU level. Such an endeavor provides a profound understanding of the legal landscape surrounding UAS, ultimately contributing to the responsible integration of this technology across all sectors. In the complex and evolving skies of UAS regulation, this research serves as a guiding star, illuminating the path towards a unified and effective legal framework.

11:50-12:10 | FrA3.5

Privacy Rights in the Context of Public Drone Use in the United States, pp. 959-966

Fortonska, Agnieszka | University of Silesia

The article examines the Fourth Amendment to the United States Constitution, which guarantees protection against unreasonable searches and seizures. This is a foundation of the right to privacy for citizens. However, with the emergence of modern technologies such as drones, interpreting the regulations regarding the protection of citizens may encounter challenges. The article examines the impact of drones on the right to privacy in the context of their use by law enforcement and private entities. The author presents key court decisions and current regulations governing the use of drones in public spaces. In addition, she draws attention to the conflicts between the public interest and the privacy of citizens, as well as the need to create clear legal regulations. The article also indicates that the dynamic development of technology requires a new interpretation of the Fourth Amendment to effectively protect the right to privacy in the 21st century.

12:10-12:30 | FrA3.6

A Risk-Aware Mission Planning and Monitoring Methodology for UAS Operations, pp. 967-974

Primatesta, Stefano | Politecnico Di Torino

The increasing use of Unmanned Aircraft Systems (UAS) in critical scenarios raises the need for efficient mission planning and risk assessment methodologies. One of the main challenges in UAS operations is the regulatory approval process, which requires operators to prepare comprehensive and compliant documentation. In this paper, we propose a mission planning methodology designed to assist UAS operators in conducting a risk assessment aligned with SORA 2.5 and generating documentation that meets European regulatory requirements. Additionally, our methodology integrates a risk-aware path planning approach to compute low-risk flight routes. Another key aspect of our approach is a situational awareness module,

which enables real-time monitoring of risk and operational constraints during mission execution. If the initially planned route becomes unsafe, a re-planning algorithm dynamically adjusts the route, ensuring an adequate level of safety. Although the proposed methodology is still under development, this paper presents the essential requirements and features, as well as preliminary results on risk map generation and risk-based route planning and re-planning algorithms.

FrA4	Rm 265
Control Architectures/Swarms (Regular Session)	
Chair: Bradley, Justin	NC State University
Co-Chair: Rodriguez-Cortes, Hugo	Centro De Investigación Y De Estudios Avanzados Del Instituto Politécnico Nacional

10:30-10:50	FrA4.1

Control Barrier Function-Based Predictive Control for Close Proximity Operation of UAVs Inside a Tunnel, pp. 975-981

Mundheda, Vedant	Carnegie Mellon University
Kancharla, Damodar Datta	Chalmers University of Technology
Kandath, Harikumar	International Institute of Information Technology

This study introduces a control strategy for Unmanned Aerial Vehicles (UAVs) performing high-precision proximity tasks in restricted tunnel environments, enabling them to conduct detailed inspections and navigate through extremely narrow tunnel corridors. The primary challenge in these tasks lies in managing nonlinear aerodynamic forces and torques induced by the tunnel walls while ensuring safe and efficient UAV operation in close proximity to these boundaries. To tackle this issue, we propose a novel approach that integrates Model Predictive Control (MPC) with modified Control Barrier Function (CBF) constraints. This framework is designed to achieve dual objectives: ensuring a safe operational distance from walls to mitigate their aerodynamic effects, while simultaneously minimizing distance to the walls to effectively perform close-proximity operations. Our approach demonstrates significant improvements, reducing the safe hovering distance from walls by 37% and decreasing UAV power consumption by approximately 15% when flying near ground and ceiling surfaces. The efficacy of the proposed method is rigorously validated through comprehensive simulations, which evaluate various close-proximity UAV trajectories under realistically modeled aerodynamic disturbances induced by the tunnel boundaries.

10:50-11:10	FrA4.2

A Linear Complementarity Based MPC for Aerial Physical Interaction, pp. 982-987

Fuser, Riccardo	LAAS-CNRS
Nguyen, Hai-Nguyen (Hann)	RMIT Vietnam
Incremona, Gian Paolo	Politecnico Di Milano
Farina, Marcello	Politecnico Di Milano
Cognetti, Marco	LAAS-CNRS

This paper presents a general MPC-based control framework that includes the linear complementarity problem (LCP) for modeling the interaction forces of a mobile robot. To validate our approach, two case studies are considered: (i) an aerial robot that should reach a target point placed on a frictionless surface; and (ii) an aerial robot that should lift a cable-suspended mass, switching from a slack to a taut cable condition. The simulation results confirm the validity of our approach, and the ability of the LCP to model the interaction forces for an aerial platform.

11:10-11:30	FrA4.3

A Collision Avoidance Strategy for Commercial Quadrotors, pp. 988-993

Rodriguez-Cortes, Hugo	Centro De Investigación Y De Estudios Avanzados Del Instituto Po
Marco A., Martinez-Ramirez	CINVESTAV
Romero, Jose-Guadalupe	ITAM
Trujillo-Flores, Miguel	ITAM
Shao, Xiaodong	Beihang University

This article proposes a repulsive vector field-based collision avoidance for quadrotors performing position regulation tasks. The proposed strategy is evaluated by employing commercial drones that can be controlled through the body frame's translational velocity. The collision avoidance algorithm activates after a threshold distance between drones is exceeded. The regulation controller and collision avoidance strategy are experimentally evaluated when two drones switch their position in such a way that they cross each other close to the origin.

11:30-11:50	FrA4.4

UAV Resilience against Stealthy Attacks, pp. 994-1001

Amorim, Arthur	University of Central Florida
Taylor, Max	The Ohio State University
Kann, Trevor	Carnegie Mellon University
Leavens, Gary	University of Central Florida
Harrison, William L.	Idaho National Laboratory
Joneckis, Lance	Idaho National Laboratory

Unmanned aerial vehicles (UAVs) depend on untrusted software components to automate dangerous or critical missions, making them a desirable target for attacks. Some work has been done to prevent an attacker who has either compromised a ground control station or parts of a UAV's software from sabotaging the vehicle, but not both. We present an architecture running a UAV software stack with runtime monitoring and seL4-based software isolation that prevents attackers from both exploiting software bugs and stealthy attacks. Our architecture retrofits legacy UAVs and secures the popular MAVLink protocol, making wide adoption possible.

11:50-12:10	FrA4.5

Co-Regulated Hierarchical Reinforcement Learning for Uncrewed Aircraft System Swarms, pp. 1002-1010

Phillips, Grant	University of Nebraska-Lincoln
George, Jemin	US Army Research Laboratory
Bradley, Justin	NC State University

Deploying decentralized control strategies for outdoor multi-agent Uncrewed Aircraft Systems (UASs) is challenging due to timing variations, packet loss, and computing resource limitations. In this work we address robustness to these conditions through a novel co-regulated control strategy that varies the periodicity of control inputs and communication with other agents. Co-regulation is applied to a decentralized hierarchical controller consisting of a global component governing inter-group coordination to multiple targets while a local component governs intra-group coordination of the agents as they progress to the target of interest. The control gains are ``gain scheduled'' according to current conditions while a cyber controller schedules the control and communication tasks for execution based on swarm performance. The control gains are found via reinforcement learning and the entire algorithm is deployed on a swarm consisting of 7 custom agents. Our results show the impact of rethinking swarming algorithms with computation and communication resource limitations in mind and indicate we can provide exceptional swarm control utilizing fewer resources while also improving the quality of service or an onboard, anytime collision avoidance algorithm.

12:10-12:30	FrA4.6

Flocking Behavior for Dynamic and Complex Swarm Structures, pp. 1011-1018

De Rojas Pita-Romero, Carmen	Universidad Politécnica De Madrid
Arias Perez, Pedro	Universidad Politecnica De Madrid
Fernandez-Cortizas, Miguel	Universidad Politecnica De Madrid
Perez-Segui, Rafael	Universidad Politécnica De Madrid
Campoy, Pascual	Universidad Politecnica Madrid

Maintaining the formation of complex structures with multiple UAVs and achieving complex trajectories remains a major challenge. This work presents an algorithm for implementing flocking behavior of UAVs based on the concept of Virtual Centroid to easily develop a structure for the flock. The approach builds on the classical virtual-based behavior, providing a theoretical framework for incorporating enhancements to dynamically control both the number of agents and the formation of the structure. Simulation tests and real-world experiments were conducted, demonstrating its simplicity even with complex formations and complex trajectories.

FrB1	Rm 340GHI
Security/Swarms (Regular Session)	
Chair: Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo
Co-Chair: Negrao Costa, Andre	KTH

14:00-14:20	FrB1.1

A Systematic Review of GPS Spoofing: Methods, Tools, Tests, and Techniques in the State of the Art, pp. 1019-1026

Allão, Daniel	Universidade De São Paulo
Ferrão, Isadora	University of São Paulo
Marçal, Vitor	Universidade De São Paulo
Ribeiro, Lucas	Universidade De São Paulo
Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo

The integration of GNSS with UAVs enhances their ability to perform high-precision geospatial. However, as UAVs become increasingly reliant on these systems as the core of their navigation and operational capabilities, they are also more susceptible to GPS spoofing attacks. These attacks manipulate or counterfeit positioning signals and data, leading to navigation errors and potential mission failures. This paper presents a systematic literature review (SLR) aimed at categorizing and analyzing state-of-the-art GPS spoofing methods, tools, tests, and techniques, with the goal of enhancing the understanding of both the spoofing process and the systems involved in its execution. The study explores the classification of GPS spoofing attacks, their implementation, and the hardware/software tools used for both conducting and detecting them. Additionally, it reviews existing countermeasures and highlights critical challenges in GPS security research, such as the necessity for real-world validation, implementation costs, and the growing complexity of both attacks and detection techniques. By consolidating recent advancements, this review provides a structured reference for researchers and practitioners, supporting the development of more effective detection and mitigation strategies against GPS spoofing threats.

14:20-14:40	FrB1.2

Collaborative Intrusion Detection System for Network and Flight Security in Unmanned Aerial Vehicles Group, pp. 1027-1034

da Silva, Leandro Marcos	University of São Paulo
Ferrão, Isadora	University of São Paulo
Diniz, Beatriz Aparecida	University of São Paulo
Carciofi, Teodoro Prada	University of São Paulo
Zilio, Vicenzo D'Arezzo	University of São Paulo
Dezan, Catherine	Université De Bretagne Occidentale
Espes, David	Université De Bretagne Occidentale
Branco, Kalinka Regina Lucas Jaquie Castelo	University of São Paulo

Unmanned Aerial Vehicles (UAVs) have been gaining popularity in various areas, such as military, civil and commercial. However, these vehicles are exposed to cyber threats that can compromise their security and privacy and even result in physical damage. Such threats include signal interception, unauthorized access, data theft, and even remote control of the UAV. Therefore, UAV manufacturers and users need to be aware of these threats and adopt appropriate measures to strengthen the security and integrity of the systems. One of the defense strategies is the implementation of an Intrusion Detection System (IDS), which monitors the system for suspicious behavior. When an abnormality is identified, the IDS sends a notification to the control station, allowing appropriate decision-making. IDS aimed at UAVs often focus on detecting attacks on specific data sources, without considering the application in a group scenario. In this context, this paper presents a collaborative intrusion detection system for group security of UAVs. The system is capable of identifying threats both on the network and in-flight, using supervised and unsupervised learning. Attacks detected on the network include blackhole, gray hole, and flooding, while in-flight threats include GPS spoofing and jamming, with tests carried out using real UAVs. Federated learning is incorporated into the system to preserve data privacy and promote collaboration in training between UAVs. In addition, geographic and physical characteristics are considered to ensure that the IDS operates independently of the specific hardware of the UAVs. The development also focuses on implementing a lightweight IDS, ensuring efficiency and optimized operation.

14:40-15:00	FrB1.3

Performance Assessment of Counter-Drone Systems Using Bayesian Networks, pp. 1035-1042

Bertrand, Sylvain	ONERA
Gayraud, Lionel	ONERA
Durieux, Jerome	ONERA

This paper proposes a method to model and analyze the performance of a Counter-Drone System (CDS) using Bayesian Networks (BN). Quantitative performance indexes related to the sensor and the tracking algorithm used in the CDS are proposed. They are used in a BN which also accounts for CDS functions related to alert, localization and engagement of neutralization means. A case study is proposed to illustrate how performance of the CDS can be evaluated under various scenario conditions, including different types of drones and influences of the environment. To illustrate how the BN can also help for design considerations of a CDS, influence of the sensor location is also analyzed.

15:00-15:20	FrB1.4

UAV Audio Detection and Identification Using Short-Time Fourier Transform Spectrograms with Deep Learning Models, pp. 1043-1048

Lei, Helen	Cornell University
Gadgil, Ravi	San Jose State University
Amgothu, Sandeep Kumar	Texas A&M University-Corpus Christi
Kar, Dulal	Texas A&M University-Corpus Christi

Unmanned aerial vehicles (UAV), or drones, offer immense potential but also pose major security concerns due to their accessibility and misuse. Therefore, effective drone detection and identification are crucial to mitigate these risks. This study explores the application of different preprocessing techniques and deep learning models for the identification of drones and the detection of unknown drones by their acoustic signature. Specifically, We study the effectiveness of using a Short-Time Fourier Transform (STFT)-based approaches in generating audio spectrograms for deep learning multi-class classification. Our findings demonstrate the efficacy of deep learning models in achieving promising results for the audio identification of drones. We focus on Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), and Convolutional Recurrent Neural Networks (CRNN), analyze the performance of each for STFT spectrograms. STFT spectrograms consistently offer the best overall classification results. In conclusion, this analysis compares the varying potential of utilizing different acoustic features and deep learning algorithms for accurate, real-time UAV identification.

15:20-15:40	FrB1.5

A Control-Theoretic Framework for Voronoi-Like Space Partitioning in Multi-Agent Drone Systems with Second Order Costs, pp. 1049-1056

Negrao Costa, Andre	KTH
Ögren, Petter	KTH

We present a framework for space partitioning, where the Regions of Influence (ROIs) of the agents are defined based on proximity metrics derived from the cost of optimal control problems. Efficient space partitioning in multi-agent systems, particularly in Unmanned Aerial Vehicle (UAV) operations, is critical for coverage, load balancing, and task allocation. However, traditional methods, such as the standard Voronoi Diagrams (VDs) based solely on distances, often fail to account for the dynamic behavior and capabilities of UAVs. We generalize the VD concept by replacing distance-based metrics with transition costs obtained from optimal control formulations. This allows the resulting partitions to incorporate UAV dynamics, including initial states and control effort, in defining regions where one agent is more suitable than another for a given task. We show that for a broad class of problems with second-order optimal costs, the boundaries between ROIs are given by either hyperplanes or quadratic surfaces. This includes, as special cases, classical VDs based on distance, minimum-time problems for single integrators, the fixed-final-state (FFS) optimal transfer problem, and Linear Quadratic Regulators (LQR). Overall, the proposed framework bridges geometric and control-theoretic space partitioning, enabling dynamic and context-aware task allocation in multi-agent systems.

15:40-16:00	FrB1.6

Dynamic Space Partition Algorithm with an Archimedean Spiral for Wildfire Detection Using a Swarm of UAVs, pp. 1057-1063

Shi, Yinan	University of Bristol
Tzoumas, Georgios	University of Bristol
Hauert, Sabine	University of Bristol

Due to climate change in recent years, wildfires have become one of the most harmful hazards to the environment and society. In firefighting operations, the early stages are crucial to controlling wildfires successfully. In this paper, we propose an improvement to an existing dynamic space partition (DSP) algorithm by adding an Archimedean spiral to enable wildfire detection in large areas on the scale of California. Compared to the baseline DSP controller, the improved algorithm provides more efficient area coverage with the same number of robots in the simulation. With a swarm of 30 robots, the DSP algorithm with an Archimedean spiral (DSP-A) can identify 87.81% static fires. With the same configuration, the baseline DSP algorithm covered 79.77% of total fires. Furthermore, the DSP-A controller is resilient when the number of robots decreases. When the number of robots in the swarm drops from 30 to 10, the DSP-A algorithm can still cover 70% of wildfires, while the performance of the baseline DSP controller is reduced to 44%.

FrB2	Rm 200
UAS Applications IV (Regular Session)	
Chair: Carlson, Stephen	University of Nevada, Reno
Co-Chair: Sopegno, Laura	University of Palermo

14:00-14:20	FrB2.1

Vertical Dynamics of Flapping-Wing Flying Robot Facing Wind Disturbance: State-Dependent Riccati Equation and Equivalent Dynamics, pp. 1064-1070

Capobianco, Eleonora	Universidad De Sevilla
Gonzalez-Morgado, Antonio	Universidad De Sevilla
Rafee Nekoo, Saeed	Universidad De Sevilla
Ollero, Anibal	Universidad De Sevilla

Flapping-wing flying robots (FWFRs) are becoming a trend case study in the control field. The model of an FWFR in the gliding phase of flight is similar to an unmanned lightweight aircraft. By actuating the wings (flapping), a periodic motion disturbs the dynamics and, additionally, generates the lift and thrust forces. The actuation makes the traditional analytical dynamics complex and computationally heavy for simulations of control algorithms. In this work, the vertical dynamic of the FWFR is presented using the equivalent dynamic approach as forced base excitation. Then, a wind disturbance model is implemented to study the effect of wind gusts. The state-dependent Riccati equation (SDRE) method is applied to control the model for height regulation, exploiting its nonlinear-optimal capabilities on the nonlinear FWFR model and evaluating the system response to the wind disturbance. The SDRE results were compared with the linear quadratic regulator (LQR) controller. The SDRE mimics the LQR design and delivers a nonlinear version; hence, the LQR is a good candidate for comparing the results.

14:20-14:40	FrB2.2

RL-Based Control of UAS Subject to Significant Disturbance, pp. 1071-1077

Chakraborty, Kousheek	Saxion University of Applied Sciences
Hof, Thijs	Saxion University of Applied Sciences
Alharbat, Ayham	Saxion University of Applied Sciences
Mersha, Abeje Yenehun	Saxion University of Applied Sciences

This paper proposes a Reinforcement Learning (RL)-based control framework for position and attitude control of an Unmanned Aerial System (UAS) subjected to significant disturbance that can be associated with an uncertain trigger signal. The proposed method learns the relationship between the trigger signal and disturbance force, enabling the system to anticipate and counteract the impending disturbances before they occur. We train and evaluate three policies: a baseline policy trained without exposure to the disturbance, a reactive policy trained with the disturbance but without the trigger signal, and a predictive policy that incorporates the trigger signal as an observation and is exposed to the disturbance during training. Our simulation results show that the predictive policy outperforms the other policies by minimizing position deviations through a proactive correction maneuver. This work highlights the potential of integrating predictive cues into RL frameworks to improve UAS performance.

14:40-15:00	FrB2.3

VAPE: Viewpoint-Aware Pose Estimation Framework for Cooperative UAV Formation, pp. 1078-1085

Kim, Young Ryun	Korea Aerospace University
Jung, Dongwon	Korea Aerospace University

Accurate and robust vision-based pose estimation is essential for cooperative unmanned aerial vehicle (UAV) operations, particularly in formation flight and multi-UAV coordination, where precise relative positioning is critical to mission success.

However, many existing systems rely on active sensors, limiting their applicability in environments with communication constraints, GNSS denial, or stealth requirements. To overcome these limitations, recent studies have explored the use of passive sensors such as cameras. However, current methods, including marker-based and learning-based approaches, perform well under controlled conditions, but often struggle with viewpoint variability during dynamic maneuvers. To address these challenges, this paper presents the Viewpoint-Aware Pose Estimation (VAPE) framework, which enhances robustness across diverse viewpoints while operating with passive vision sensors. VAPE integrates viewpoint classification, robust feature matching using pre-trained models, and spatial feature distribution analysis to establish accurate 2D-3D correspondences without the need for specialized markers or extensive feature annotation. Ground tests simulating formation maneuvers demonstrate that VAPE maintains reliable tracking performance, achieving mean absolute position errors below 2.5% and angular errors below 5°, indicating its potential for real-world UAV coordination tasks.

15:00-15:20	FrB2.4

Automatic Identification of Safety Landing Points for VTOL UAVs Using Geodata, pp. 1086-1093

König, Eva	RWTH Aachen University
Voget, Nicolai	RWTH Aachen University
Hartmann, Max	RWTH Aachen University
Moormann, Dieter	RWTH Aachen University

This paper presents a concept for automatic identification of landing spots for safety landings applied for unmanned aerial vehicles (UAVs) with vertical take-off and landing (VTOL) capabilities. It utilizes open source geodata, consisting of land use data and an elevation model. With the growing deployment of UAVs across diverse applications, it is necessary to ensure operational safety in emergency situations. In such situations, the flight system must be able to safely abort its current flight mission by landing at a so-called safety landing point and thus minimize both air and ground risk. A systematic procedure for determining potential safety landing points using two data sources (elevation model and land use data) based on predefined criteria has been developed. The presented results demonstrate the effectiveness of using open-source data in UAV operations, thereby paving the way for more robust and safe flight operations in various environments.

15:20-15:40	FrB2.5

Transformer-Based Physics Informed Proximal Policy Optimization for UAV Autonomous Navigation, pp. 1094-1099

Sopegno, Laura	University of Palermo
Cirrincione, Giansalvo	MIS/UPJV
Martini, Simone	University of Denver
Rutherford, Matthew	University of Denver
Livreri, Patrizia	University of Palermo
Valavanis, Kimon P.	University of Denver

During the last two decades, Unmanned Aerial Vehicles (UAVs) have been employed for a wide range of civil and public domain applications, as well as in missions to Mars. In complex autonomous exploration scenarios, particularly in GPS-denied environments, the software integrated into the Guidance, Navigation, and Control (GNC) systems plays a critical role in ensuring UAV stability and autonomy. To meet these requirements and address the limitations of traditional navigation techniques, the development of Deep Reinforcement Learning (DRL) approaches to support decision-making tasks has gained significant traction in recent years. The goal of the paper is twofold: i) to present a comparison between the traditional Proximal Policy Optimization (PPO) and the augmented PPO with a transformer architecture, ii) to achieve smooth and efficient trajectories by designing a continuous physics informed reward function accounting for the Least Action Principle (LAP). The results demonstrate that PPO achieves significantly improved performance when integrated with the transformer, as well as high efficiency of the trained agent when simulating a specific flight path. This enhancement highlights the potential of transformer-based architectures to more effectively address complex decision-making tasks than traditional DRL methods.

15:40-16:00	FrB2.6

A Dynamic Soaring Algorithm for Powered Fixed-Wing UAVs in Marine Environments, pp. 1100-1108

Carlson, Stephen	University of Nevada, Reno
Papachristos, Christos	University of Nevada Reno

Dynamic soaring is a method used by seabirds or small aircraft to harvest energy from a wind gradient. This work shows an adaptive dynamic soaring controller algorithm implemented in a software-in-the-loop simulation of a common autopilot flight stack, commanding only the pitch rate, roll rate, and throttle setpoints. The algorithm smoothly transitions from low-wind to high-wind velocity gradients, using the aircraft propulsion system only as necessary, up to the point that the propulsion system is not employed given sufficient wind. Using this algorithm, a set of four unique fixed-wing UAVs are demonstrated to perform dynamic soaring in an oceanic environment simulation, showing the potential for energy-augmentation and unlimited cross-ocean flight in small fixed-wing UAVs.

FrB3	Rm 267
Autonomy (Regular Session)	

Chair: Willis, Andrew	University of North Carolina at Charlotte
Co-Chair: Von Moll, Alexander	Air Force Research Laboratory

14:00-14:20	FrB3.1

Synthesized Control for In-Field UAV Moving Target Interception Via Deep Reinforcement Learning and Fuzzy Logic, pp. 1109-1116

Xia, Bingze	Concordia University
Akhlaque, Mohammad Ahsan	University of Ottawa
Mantegh, Iraj	National Research Council Canada
Bolic, Miodrag	University of Ottawa
Xie, Wenfang	Concordia University

Uncrewed Aerial Vehicles (UAVs) are increasingly applied across various fields due to their strong mobility and high flexibility. Concurrently, the rapid development of Artificial Intelligence (AI) has unlocked new potential for autonomous learning and the evolution of robots. This synergy enables UAVs equipped with AI capabilities to perform complex tasks such as real-time path planning and swarm management more adeptly than traditional models reliant on pre-programmed algorithms. This paper builds on our previously proposed deep reinforcement learning and fuzzy logic-based multiple UAV dynamic target interception algorithm, introducing several improvements and innovations aimed at safe applications in the real world. Initially, several components of the original algorithm have been redesigned and improved; subsequently, an inter-platform simulation environment incorporating MATLAB, ROS, PX4 has been established. Finally, a programmable drone has been constructed. The improved algorithm has been validated through systematic phases of simulations and actual flight tests under complex and dynamic conditions, establishing a solid link from algorithm design to practical applications.

14:20-14:40	FrB3.2

Silent Drones: A Deep Learning Approach to Suppress Drone Propeller Noise, pp. 1117-1123

Rizvi, Syeda Warisha Fatima	Hamad Bin Khalifa University
Ahmed, Fatimaelzahraa Ali	Hamad Medical Corporation
Qassmi, Noof	Qatar University
Al-Ali, Abdulla	Qatar University

Unmanned Aerial Vehicles (UAVs) provide many benefits and opportunities across a range of sectors, including surveillance, humanitarian work, disaster management, research, and transportation. Due to their accessibility and affordability, they are now used more than ever, which also poses some challenges. This is the noise pollution produced by the motors and propellers that has been highlighted as a significant issue to people's health and the environment. To address this issue, this paper proposes using Generative Adversarial Networks (GAN) to produce an inverse sound signal based on the drone's acoustic signals and use that to cancel the noise produced by the drone. We synthesize training data spanning the acoustic diversity of drone noise: steady-state propeller tones, rapid throttle transitions (simulating ascent/descent), and superimposed broadband turbulence. The GAN model is capable of adapting to dynamic settings, learning from data, and adjusting to testing conditions accordingly. We compared our proposed solution with other techniques that can also be used for drone signal interference in order to suppress the drone noise. This research idea paves the way for the need to address the issue created due to drone noise and a solution in managing this problem for modern drone applications.

14:40-15:00	FrB3.3

A Reinforcement Learning Framework to Adaptively Schedule Controllers for UAVs Operating under Harsh Environmental Conditions, pp. 1124-1131

Albool, Ibrahim	University of California, Irvine
Willis, Andrew	University of North Carolina at Charlotte
Wolek, Artur	University of North Carolina at Charlotte
Maity, Dipankar	University of North Carolina - Charlotte

In this article, we present a hierarchical supervisory reinforcement learning (RL) framework for achieving precise trajectory tracking of UAV(s) operating in dynamic and complex environments. The UAV is equipped with multiple controllers, each controller tuned to provide a desired response under specific environmental conditions. Our objective is to dynamically schedule these controllers in response to abrupt environmental changes. To this end, we develop an RL-based framework for adaptive controller scheduling. We derive sufficient conditions for switching stability and validate our approach through extensive numerical simulations.

15:00-15:20	FrB3.4

Real-Time Mapping and Tree Measurements Using UAVs, pp. 1132-1137

de Almeida Pereira, Jean Nelson	UFSCar Universidade Federal De São Carlos
Duarte de Souza, Caroline Elisa	UFSCar Universidade Federal De São Carlos
Lidia, Rocha	UFSCar Universidade Federal De São Carlos
Kelen Cristiane, Teixeira Vivaldini	UFSCar
Boshi, Raquel	UFSCar Universidade Federal De São Carlos
Brandao, Alexandre Santos	Federal University of Vicosa

Precise tree measurement is essential for forest inventory and biomass estimation. Current methods often capture data only from the upper or lower parts of trees, resulting in incomplete or estimated measurement, bringing uncertainty to measurements. Some approaches fuse upper and lower tree data, but they require the alignment and merging of dense point clouds, making large-scale implementation challenging. This study presents an autonomous navigation and real-time data extraction method using an unmanned aerial vehicle (UAV) equipped with depth cameras and a LiDAR sensor. The system navigates autonomously and maps the environment around it, using a uniform voxel grid to segment and measure individual

trees. The results demonstrated that: (1) the UAV successfully navigates autonomously between trees, mapping the unstructured and unknown environment while performing real-time reconstruction; (2) tree trunk segmentation, measurement, and localization were achieved with a root mean square error (RMSE) of 0.22 m; and (3) tree height measurements obtained an RMSE of 0.05 m. The proposed methodology proved to be effective for forest inventory applications, providing accurate tree measurements with improved computational efficiency.

15:20-15:40	FrB3.5

One-Vs-One Threat-Aware Weaponeering with Basic Engagement Zones, pp. 1138-1145

Von Moll, Alexander	Air Force Research Laboratory
Milutinovic, Dejan	University of California at Santa Cruz
Weintraub, Isaac E.	Air Force Research Laboratory
Casbeer, David	Air Force Research Laboratories

In this paper we address the problem of 'weaponeering', i.e., placing the weapon engagement zone (WEZ) of a vehicle on a moving target, while simultaneously avoiding the target's WEZ. A WEZ describes the lethality region of a range-limited weapon considering both the range of the weapon along with the state of the target. The weapons are assumed to have simple motion, while the vehicles carrying the weapons are modeled with Dubins dynamics. Three scenarios are investigated and are differentiated in the assumptions that can be made about the target in the process of the vehicle control design: 1) no knowledge of target control, 2) avoid unsafe positions assuming the target's optimal control, 3) full knowledge of target's optimal control. The engagement is formulated as a stochastic optimal control problem with uncertainty in the target's control modeled using a noise parameter applied to the target's control input. After discretizing the Hamilton-Jacobi-Bellman equation, Value iteration is then used to obtain an approximate solution for the optimal vehicle control and time-to-go. Simulation results support usage of the first paradigm: assume no knowledge of the target's control.

15:40-16:00	FrB3.6

Fighter Jet Navigation and Combat Using Deep Reinforcement Learning with Explainable AI, pp. 1146-1151

Kar, Swati	University of Tennessee at Chattanooga
Dey, Soumyabrata	Clarkson University
Banavar, Mahesh	Clarkson University
Sakib, Shahnewaz Karim	University of Tennessee at Chattanooga

This paper presents the development of an Artificial Intelligence (AI) based fighter jet agent within a customized Pygame simulation environment, designed to solve multi-objective tasks via deep reinforcement learning (DRL). The jet's primary objectives include efficiently navigating the environment, reaching a target, and selectively engaging or evading an enemy. A reward function balances these goals while optimized hyperparameters enhance learning efficiency. Results show more than 80% task completion rate, demonstrating effective decision-making. To enhance transparency, the jet's action choices are analyzed by comparing the rewards of the actual chosen action (factual action) with those of alternate actions (counterfactual actions), providing insights into the decision-making rationale. This study illustrates DRL's potential for multi-objective problem-solving with explainable AI.

FrB4	Rm 265
Airspace Control (Regular Session)	
Chair: Keshmiri, Shawn	University of Kansas
Co-Chair: Kolios, Panayiotis	University of Cyprus

14:00-14:20	FrB4.1

Monotonically Weighted Nonlinear Model Predictive Control for Dynamics-Driven Visual Servoing of an Over-Actuated Quadrotor, pp. 1152-1159

Kamath, Archit Krishna	Nanyang Technological University
Sivakumar, Anush Kumar	Nanyang Technological University
Feroskhan, Mir	Nanyang Technological University

This paper presents a monotonically weighted nonlinear model predictive control (NMPC) strategy for dynamics-driven visual servoing of an over-actuated quadrotor. The proposed control framework incorporates a dynamics-driven formulation that explicitly accounts for the multirotor's over-actuated nature, enabling precise trajectory tracking and robust disturbance rejection. A key innovation is the introduction of a monotonically weighted cost function, which eliminates the need for terminal constraints while ensuring stability and computational efficiency. Additionally, an adaptive prediction horizon mechanism is developed to dynamically adjust the control horizon, enhancing real-time feasibility without compromising control performance. To evaluate the effectiveness of the proposed approach, four distinct maneuvering scenarios are considered, including pure translation, translation with rolling, translation with pitching, and full six-degree-of-freedom motion. Comparative simulations demonstrate that the proposed NMPC achieves improved tracking accuracy and reduced computational latency compared to state-of-the-art Tube MPC and Adaptive MPC approaches.

14:20-14:40	FrB4.2

On Cooperative Control of Two-Drones with a Slung Load, pp. 1160-1166

Aghaee, Fateme	University of Southern Denmark
Jouffroy, Jerome	University of Southern Denmark

Increasing the load capacity of drones can be effectively achieved by utilizing two drones. This paper introduces a novel

cooperative control strategy for the transport of a slung bar-shaped load using two drones. Our approach integrates differential flatness-based motion planning with filtering techniques to generate reference trajectories. This method does not require prior knowledge of the load mass or cable deflection angles and ensuring compatibility with a wide range of flight controllers. The proposed control scheme employs a super- twisting controller as an internal stabilizer to ensure robustness against model inaccuracies and external disturbances, providing precise stabilization around the preplanned trajectories. This methodology is particularly well-suited for practical applications requiring the cooperative transport of complex loads, such as wind turbine blades, where precision, robustness, and simplicity are critical.

14:40-15:00	FrB4.3

A Robust Flight Controller Design: Investigating Guidance Failures Near TSS Heliport in Challenging Wind Conditions, pp. 1167-1174

Kucuksayacigil, Gulnihal	University of Kansas
Keshmiri, Shawn	University of Kansas
Chrit, Mounir	University of North Dakota

With the imminent integration of Advanced Air Mobility (AAM) into the national airspace, ensuring the robustness of flight controllers in spatially congested metropolitan areas and in the presence of external disturbances is of paramount importance. The complex interaction between atmospheric turbulence and tall buildings further exacerbates the effects of wind disturbances, posing significant safety challenges to aircraft stability and trajectory tracking. This study employs the high-fidelity urban wind field model using Computational Fluid Dynamics (CFD) which captures wind variations in urban environments. This model quantifies wind shear intensity and vorticity distributions, which are critical factors affecting flight performance. The failure of an autonomous fixed-wing aircraft to maintain its intended flight path within permissible deviation limits under extreme wind conditions is investigated. To address these challenges, a robust flight control system is developed to enhance trajectory tracking performance and mitigate the adverse effects of wind on the path following. The proposed controller is designed to ensure reliable operation despite the unpredictability of urban wind fields, contributing to safer and more resilient autonomous flight operations in complex metropolitan airspaces.

15:00-15:20	FrB4.4

A Real-Time Autonomous Exploration Framework for Indoor 3D Environments Employing Multiple Unmanned Aerial Vehicles, pp. 1175-1182

Nikolaidis, Antonis	KIOS, University of Cyprus
Laoudias, Christos	University of Cyprus
Kolios, Panayiotis	University of Cyprus

In search and rescue (SAR) operations, rapid and comprehensive exploration of unknown indoor environments is critical for locating survivors and assessing structural integrity. This paper presents a novel multi-unmanned aerial vehicle (UAV) framework for autonomous exploration in GPS-deprived indoor environments, leveraging advanced sensing technologies and algorithmic strategies. The proposed methodology integrates LiDAR and 3D simultaneous localization and mapping (SLAM) for real-time environment reconstruction, coupled with a weighted frontier-based exploration strategy and Dijkstra's algorithm for collision-free path planning. This combination enables UAVs to prioritize unexplored regions systematically while minimizing redundant coverage. The system's efficacy was validated through high-fidelity simulations in RViz and Gazebo, replicating multi-floor damaged buildings. Performance metrics, including total travel distance and percentage of unvisited areas, demonstrate the framework's ability to achieve near complete 3D coverage (exceeding 90% in tested scenarios) while significantly reducing exploration time compared to manual methods. These results highlight the framework's potential to enhance the safety and efficiency of SAR missions by reducing human exposure to hazardous environments and accelerating critical decision-making.

15:20-15:40	FrB4.5

Deep Neural Network-Based UAS Transport, pp. 1183-1189

Rastgoftar, Hossein	University of Arizona
Zahed, Muhammad Junayed Hasan	University of Arizona

The paper develops a deep neural network- (DNN-) based mass transport approach to cover a distributed target in a decentralized manner by Uncrewed Aerial Systems (UAS). This is a new decentralized UAS transport approach with time-varying communication weights that can be achieved by solving the following three sub-problems: (i) determining the DNN structure, (ii) obtaining communication weights, and (iii) ensuring stability and convergence guarantee. By proposing a novel algorithmic approach, the DNN is structured based on the agent team initial formation with an arbitrary distribution in the motion space. To specify communication weights for a team of 펵 multicopters, we use the DNN to obtain the initial communication weights, based on the agents' initial positions, abstractly represent the distributed target by 펵 points, considered as the final positions of all agents, and obtain the final communication weights. The third sub-problem is to prove the stability and convergence of the UAS transport.

15:40-16:00	FrB4.6

Vision-Based Collision Avoidance and Path Planning for UAVs Using Bearing and Pixel Area, pp. 1190-1197

Liu, Jen-Jui	Brigham Young University
Evans, Curtis P.	Brigham Young University
Beard, Randal W.	Brigham Young University

This paper presents an innovative collision avoidance and path planning framework for unmanned aerial vehicles (UAVs) using minimal camera-based inputs. The system leverages visual data to predict the future trajectories of nearby flying objects and compute low collision risk paths while maintaining progress toward designated targets. This solution extracts only two essential parameters from the visual feed--bearing and pixel area--enabling practical obstacle detection and avoidance. Furthermore,

our approach avoids the target observability problem without relying on extensive ownship maneuvers, allowing collision avoidance with minimal movement. Designed for UAVs operating in shared airspace with manned aircraft, the proposed framework emphasizes autonomous decision-making to improve operational safety. Simulation results demonstrate the system's capability to effectively plan avoidance maneuvers and generate feasible routes in complex and dynamic environments.

ICUAS '25 Key Word Index

ICUAS ’25 Author Index