AUFRANDE ENAC UNSW SYDNEY

Position Description

1. General Information

Name of the position	**Contributions to aircraft trajectories anomaly detection and hyperbolic routing**
Foreseen enrolment date	From 1 July 2024
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • École Nationale de l'Aviation Civile (ENAC) • University of New South Wales (UNSW)
Research Host	École Nationale de l'Aviation Civile (ENAC)
PhD awarding institutions	ENAC & University of New South Wales
Locations	Primary: Toulouse, France Secondary: Sydney, Australia
Supervisors	Prof. Emmanuel Lochin (ENAC) Prof. Jean-Philippe Condomines (ENAC) Prof. Aruna Seneviratne (UNSW) Dr. Deepak Mishra (UNSW)
Group of discipline	Computer Sciences, Telecommunications, AI, Networking, Applied Mathematics

2. Research topics (only one of these projects will be funded)

Project 1: *Differentiating bird flight from UAS flight*
Unmanned aircraft systems (UAS) are widely used for recreating, safety or video surveillance. They provide key information and reduce the risks associated with human operators. While UAS traffic nearly doubles yearly, the risks associated with UAS also increase. The concept of Urban Air Mobility, to autonomously fly people over cities, is currently addressed. Considering the exponential growth in UAS traffic, the risk of collision and privacy issues are also increasing. The Single European Sky Air traffic management Research Joint Undertaking (SESAR-JU) has developed the concept of U-Space, a set of services to enable the safe, secure and environmentally friendly use of drones. To support U-Space, an efficient method to detect and/or track UAS is essential for air traffic safety, and there exist several proposals attempting to overcome this challenge. Unfortunately, several of these schemes fail at differentiating birds from UAS. The objective of this project aims to develop an algorithm capable to both detecting a UAS and identifying it against birds. The objective is to subsequently enable countermeasures against UAS. The proposed system will identify a UAS through a variety of methods, including Wavelet Linear Methods and Deep Learning. Once a UAS is detected, a

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countermeasure can be used with the tracking system. The final objective is to keep malicious or harmful UAS away from restricted or residential areas.

Currently available technologies will be reviewed for their suitability at fulfilling the performance requirements in terms of the ability to provide coverage at low levels, very low-level detection, and tracking together with the ability to correctly classify small drones from other targets (e.g. birds/manned aircraft/vehicles/people). The technology gaps will be identified, the ability to enhance key performance areas such as detection sensitivity of UAS in the presence of strong ground clutter), tracking and robust classification methods will be assessed, and an enhanced concept will be developed.

Supervisors:

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Prof. Aruna Seneviratne (UNSW), Dr. Deepak Mishra (UNSW)

Frederic Barbaresco (Thales Group)

Research Fields: Computer Sciences, AI, Applied Mathematics

Project 2: *Detecting abnormal flight drift using deep learning*

The radar traces carried within the ATM (Air Traffic Management) system allows civil aviation controllers to perform air traffic control and thus ensure the safety of aircraft and their passengers. However, the recent emergence of attacks from the Internet world with the high criticality of these data challenges the integrity of radar data. Furthermore, if we let aside the data, detecting a bypass drift of an aircraft flight from an abnormal/suspicious drift is also a challenging problem. Although state-of-the-art proposes some solutions to protect against flooding or potential man-in-the-middle attacks, the anomaly prediction schemes currently used in the world of IP networks cannot be transposed to avionics systems and radar traces. In addition, despite the criticality characterising radar exchanges, detecting anomalies related to these data has been little studied until now.

Using novel approaches in Deep Learning combined with Wavelet Linear Methods, this project aims to propose an algorithm able to predict the long-term behaviour of a flight radar trace and classify an abnormal route flight drift weighted by confidence intervals. The idea is to provide an algorithm that is generic enough to be applied to any context to analyse any suspicious vehicle drift on land, air or sea.

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Research Fields: Computer Sciences, AI, Applied Mathematics

Project 3: *Routing over LEO megaconstellations using hyperbolic geometry*

Satellite constellations have become an essential means of communication since private companies deploy several thousand satellites in low earth orbit (LEO), such as SpaceX with Starlink, Amazon with Kuiper or Eutelsat-OneWeb. The main objective of these massive constellations is to provide global terrestrial coverage. This increase in connectivity reduces the digital divide and allows new connectivity offers, such as those proposed by OneWeb for airliners.

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The communication within a constellation is established in the following way. First, the signal from a ground station is sent to a satellite that sends the signal back to another ground station and so on, before reaching the final destination. Then, to establish communication between the ground stations, a path must be established on which the IP packets will be relayed. A routing protocol is then used within the constellation, specifying for each satellite the next hop to reach the destination satellite. However, routing in these constellations remains a complex and open problem. In recent years, many scientific publications have proposed new routing paradigms or improvement algorithms. This project aims to explore a new method of path establishment based on the principle of hyperbolic geometry and, more particularly, by applying some properties of the Poincaré disk. Many distributed routing schemes, such as LEO routing, rely on greedy algorithms. Among these routing techniques, the simplest ones are based on geographic coordinates. This is called "greedy routing" because nodes always forward their messages to the neighbour closest to the destination in Euclidean distance. However, this type of algorithm can go wrong when there is a node closer to the destination than all its neighbours without being the destination. This node is referred to as the minimum local, and packets passing through this node will not reach the given destination. To avoid local minima, another solution is to define an overlay or graph embedding. An overlay is a graph embedded in a network with its own notion of distance between elements. An overlay is said to be greedy if and only if the greedy routing is always valid and state-of-the-art, proving that any finite connected graph has a greedy overlay in the hyperbolic plane. The goal of this project will be to study the possibility of obtaining a greedy overlay that would allow a more efficient routing than the traditional short path based on the Floyd-Warshall algorithm commonly used for LEO routing.
Supervisors: Prof. Emmanuel Lochin (ENAC), Prof. Jean-Philippe Condomines (ENAC) Prof. Aruna Seneviratne (UNSW), Dr. Deepak Mishra (UNSW) Nicolas Kuhn (Thales Alenia Space)
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3. Employment Benefits and Conditions

The École Nationale de l'Aviation Civile (ENAC) offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). There is a 2-month probation period and the total working hours per week is 35h.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 29,604 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,982 EUR per month (before income tax). However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association.
- Access to all the necessary facilities and laboratories at ENAC (University of Toulouse) and UNSW as well as the Lab Seminars.

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- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events.
- 10,000 EUR allowance to cover flights and living expenses for up to 12 months in Australia.
- Possibility to choose between 2 work cycles.
- Paid holiday leave including extra day off related to statutory reduction in working hours (number depending on the work cycle).
- Sick leave.
- Parental leave.
- Subsidy for the school cafeteria.
- Access to on-site social, cultural and sports activities.
- Tuition fee waiver at ENAC and UNSW.

4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

Applicants must hold a Master's degree or another qualification conferring the status of Master (5 years of higher education).

Applicants must demonstrate an English language proficiency equivalent to an overall IELTS score above 6.5 and no band below 6. Note that the test needs to be completed no more than two years before enrolment. For more information about the tests accepted and scores required, visit:
https://www.unsw.edu.au/study/how-to-apply/english-language-requirements

More information on ENAC's requirements

Visit the website: https://www.enac.fr/en/phd-enac-0

More information on UNSW's requirements

Visit the website: https://research.unsw.edu.au/higher-degree-research-programs

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