UAS/UAM capacity management in U-SPACE

Universitat Autònoma de Barcelona

Previous report of the end of studies theses

By:

Johanna Fernandez Lubary – 1527482

Supervised by:

Marsel Omeri

Thesis overview

With the anticipated increase of commercial Unmanned Aircraft Systems (UAS) applications and the emerging Urban Air Mobility (UAM), enabling high density operations, especially in low altitudes is a key challenge for stakeholders such U-space in Europe, and UTM in the USA as well [1][2]. Considering all the potential flying traffic in dense urban regions, it may cause airspace capacity congestion, which directly effects the efficiency and safety of the operations. While the safety is strictly related to Conflict Management (CM), Capacity Management (CaM) is seen as means to facilitate the "work" of Traffic Management. Essentially, it would have the similar functions as Air Traffic Flow and Capacity Management (ATFCM) in manned aviation. In Europe, such a service is expected to be achieved at U3 stage and is referred to as Dynamic Capacity Management (DCM) [3]. A possible DCM service for U-space is shown here [4], which comprises three main threads: demand (flight planning), capacity (dynamic airspace configuration, conflict management) and demand-capacity balancing.

In this work, we want to focus on **U-Space capacity** and its relationship with **safety** and **complexity**. It is acknowledged the non-linear relationship between density and conflict probability [5], affecting in consequence the capacity. Therefore, performance of conflict resolution (CR) methods are a key factor to determine the thresholds up to which the U-SPACE would be considered operable (ie. safe and efficient).

In order to optimize this value, we propose to model the air traffic as a graph which gives us the benefits of graph theory (such as defining complexity as graph connectivity [8]) and use Multi-Agent Reinforcement Learning (MARL)and Graphical Neural Network techniques to solve multi-UAS/UAM conflicts in dense air traffic scenarios.

Objectives

The main objective of this work is to evaluate the impact of CR methods on U-SPACE capacity. In a more detailed approach, this objective spans on the following points:

1. Regulating traffic density by optimizing conflict resolution (CR) methods [6][7]
    a. CR is seen as a Multi-Agent Reinforcement Learning problem to achieve scalability and robustness or air traffic (UAM/UAS)
    b. By solving efficiently more conflicts, we increase the density and consequently capacity of the U-SPACE.
2. Evaluating traffic complexity, and taking it in consideration the CR method [8]:
    a. Increasing capacity by reducing traffic complexity

Note that the scope of this thesis is not to propose different U-SPACE configuration or new capacity definitions. These concepts will be based on the sate of the art of UAM/UAS airspace capacity management.

Research Plan

The duration of the project is expected to be 6 months. We have, therefore, devised the following research plan for the project:

1st month: During the first month, the student will undergo a thorough literature review on UAM/UAS capacity management and conflict management. At the same time, it is expected to get familiar with the necessary literature in machine learning, particularly MARL methods. Moreover, in this project we will use the open-source simulator BlueSky. Therefore, the student will have to get familiar and gain hands on skills for testing existing models and implementing new ones, in the coming months. At the end of this month the method to measure the U-SPACE capacity will be discussed.

2nd and 3rd month: During the second month, the student will test existing conflict resolution methods, in high density scenarios. The goal here is to understand scalability performance given the expected future air traffic demand. Furthermore, the student will test different approaches to reduce air traffic complexity. The goal is to tune the model used here [8] for UAM/UAS operations and generate synthetic data for the flight trajectories. Since there is no open data for UAM/UAS, trajectory profiles will have to be identified in the literature review and then implemented in BlueSky.

4th month: During this month, the student will show preliminary results and show the correlations between capacity and safety (CR) and air traffic complexity. By this point, we will have statistically significant data to show that by optimizing CR methods and reducing complexity, airspace capacity can be increased.

5th and 6th month: In this period, we expect to validate the best performing model on real traffic data, which will be provided by CRIDA. As such, a period is foreseen to fine-tune the model to this new data. Finally, the student will write the thesis and prepare any required dissemination of results.

Risks

In order to successfully follow the research plan, some risks must be taken into consideration such as medical emergencies that may incapacitate me which does not have a palliative measure, lacking of knowledge, troubles during the simulations, etc.

In order to palliate these risks, there will be a constant reviewing of articles in order to enhance my knowledge and keep in touch with the supervisors to solve the problems in the simulations, etc.

References

[1] UAM Vision Concept of Operations (ConOps) UAM Maturity Level (UML) 4 - NASA Technical Reports Server (NTRS)

[2] Microsoft Word - vol2_ver3.docx (sesarju.eu)

[3] “European ATM master plan: Roadmap for the safe integration of drones into all classes of airspace,” SESAR JU, Tech. Rep., 2018.

[4] Yiwen Tang, Yan Xu, Gokhan Inalhan & Antonios Tsourdos .“An integrated approach for dynamic capacity management service in U-space” (14th Seminar Papers)

[5] M. Janic and V. Tosic, "En route sector capacity model," Transportation Science, vol. 25, no. 4, 1998