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Building, Verifying and Validating a Collision Avoidance Model for Unmanned Aerial Vehicles

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Abstract

This paper documents verification and validation of a multi-rotor aircraft emulator in a collision avoidance simulation scenario by comparing its behaviour during a specific flight plan against a "live" hexacopter following the same flight plan. Positional data is collected using telemetry downlink with the precision of onboard global positioning sensors.
Scenario described above is part of an ongoing research project to create a cooperative collision avoidance system for small unmanned aerial vehicles with a specified reliability level.

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Keywords: unmanned aerial vehicles, remotely piloted aircraft, collision avoidance, unregulated airspace, simulation, model

1. Introduction

Present day commercial UAV technology does not provide solid, reliable collision avoidance mechanisms (Lancovs, 2015). However, there are alternatives to using on board sensors, such as using broadcast transponders. An example is ADS-B technology used in manned craft, but it does not transfer well to small UAV craft.

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An alternative system was proposed, similar to ADS-B, but designed specifically for small, low flying commercial UAVs that do not require to enter controlled airspace (Lancovs, 2016). Such system needs to comply with strict safety regulations, especially if such craft would ever be used autonomously in urban areas – in no small part because it could be the only collision avoidance system on board.

As potential for human injury or death exists in case of failure, this system would be classified as “Class A” in manned aviation, posing strict reliability requirements (Won KeunYoun *et al.*, 2015). Parameters of this system need to be determined to adequately cover all possible use scenarios, while maintaining a specific reliability level in each case.

Since these parameters are interdependent, a stepwise approach to designing such system was proposed (Lancovs, 2016). At each subsequent step new internal or external factors are introduced, while parameters are updated to maintain reliability. This approach relies on modelling collision avoidance at each step.

This article develops the proposed approach. A model needs to be created to simulate UAVbehaviour during collision avoidance. Such model would consist of a specific flight plan and rely upon an “emulator”, a program that simulates behaviour of an actual craft with specified parameters. The flight plan should imitate manoeuvres during collision avoidance, while the emulator acts as the aircraft performing these manoeuvres.

U|g|CS mission planning and flight control software (SPH Engineering, 2016) supplies multi-rotor and fixed-wing aircraft emulators, and is therefore used for aircraft modelling and flight control purposes. However, supplied emulators need to be verified and validated before they can be used.

2. Collision avoidance model

Collision avoidance model is required to fulfil the research goal of designing a collision avoidance system, as presented during 3rd Conference on Sustainable Urban Mobility (Lancovs, 2016). Aforementioned system is to function in a real environment, consisting of a narrow band of airspace below regulated airspace, as seen in Fig.1.

Such airspace presents its own hazards, including stationary obstacles, such as buildings and trees, but those can be dealt with using initial path planning and quality sensors. The issue of avoiding collisions with similar craft in a highly saturated airspace is more complex, since craft are too small to be detected reliably by on board systems. A cooperative approach was proposed by author, similar to ADS-B, used by manned craft.

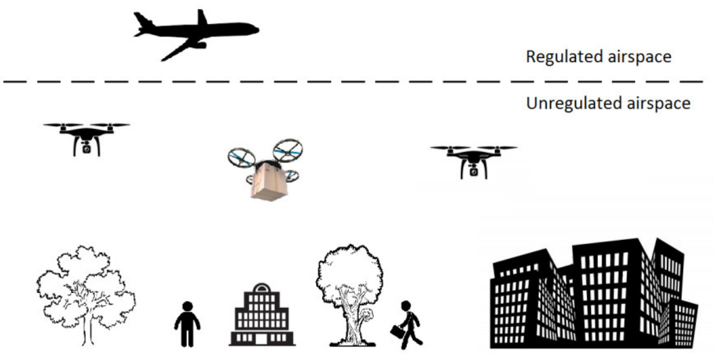

Fig. 1. Operating environment (Lancovs, 2016).

The system in question has two important functions to fulfil – provide broadcast of craft location to other participants of aerial traffic within the same airspace, and provide reception of this information coming from other craft. The system is operating in a real-life environment, and is made of real-life components, each having a set of limitations. Safety requirements, however, dictate that all these factors are taken into account when providing its main collision avoidance functions at a specific level of reliability.