9 - Needle's Eye: A drone to find the last ones

In February 2023 thousands of people passed away in the aftermath of a tragic earthquake that happened in Turkey and Syria. Most people did not die immediately after the earthquake. This was primarily due to the inability of Search and Rescue (SAR) teams to advance quickly enough. Collapsed buildings were often too difficult or too dangerous to enter for SAR teams. Due to these significant challenges, their ability to perform their duties effectively was hindered. In similar situations like explosions, fires and building collapses drones could be of significant help in locating victims and saving lives.

Mission Objective

The main objective of the Needle's Eye project is to design a small, energy-efficient SAR drone that can localise victims while flying autonomously within collapsed buildings.

System Design

After an extensive trade-off between various design options, a design was created: a ducted quadcopter drone with tracks. This design proved to have superior stability and propulsive efficiency characteristics. Next to that, the tracks ensure that the drone can move in confined spaces where flying is extremely hard.

Up until now, we have been working on designing and proving our concept. We have identified nine subsystems, namely: propulsion, power, structure, tracks, communication, sensors, data handling, navigation and stability & control. For each subsystem, we have worked on different methods to verify that our concept is valuable for the SAR use case.

For propulsion analysis, two methods were utilised: Computational Fluid Dynamics and Blade Element Analysis. For power, a battery, a power distribution board and an electronic speed controller were selected so that the drone is operable for 20 minutes which is the expected SAR time per building. Then, for the structure of the drone, a force analysis was performed which influenced the thickness and weight of the structure. This was validated using Finite Element Methods. Next to the structure of the drone, the tracks were analysed by looking at the maximal traction they can offer. Additionally, simulation software RecurDyn was used to validate results and test terrain conditions that can be encountered during SAR operations. Next, for the communications subsystem, various antennas were identified and analysed. From this analysis, components were chosen and an in-depth analysis of the limits of the communication systems was performed concluding in a possible transmission up to 0.9 m of concrete. Then, for the sensors subsystem, a combination of two 2D LiDARs, an optical and IR camera was selected for the mission of localising and identifying victims and flying autonomously. In data handling, the process of integrating the data from all sensors within a single system is defined. In the navigation subsystem, a method combining the 2D LiDAR data with path-finding algorithms is proposed in order to cover all grounds, fly autonomously, return to base and map its surroundings. For the stability & control subsystem, a model was created in order to simulate the behaviour of the drone. Since the drone is intrinsically unstable a control loop was created in order to track and change attitude, position and trajectory.

The algorithms, control systems and detailed analyses are finalised in the coming weeks. Following this, the design is concluded and constructed in CATIA. To conclude, this drone project will improve SAR operations by decreasing the time to find and rescue victims.