Collision Avoidance Strategies for Small Fixed-Wing UAV with Flight Test Demonstration

Proposal for Master Thesis
in Aerospace Engineering

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Goals

This work addresses the safety enhancement of small fixed-wing UAVs, namely with regard to the collision avoidance manoeuvre that follows a detection of obstacles during flight. It is part of a comprehensive obstacle detection and collision avoidance system, representing a two-stage "sense" and "avoid" problem, being this work focused on the latter.

The Sense & Detect stage is responsible for the acquisition of the necessary information that enables to detect, based on estimation techniques, collision threatening situations with either fixed or moving objects. The Collision Avoidance stage is responsible for replanning the flight path so that the UAV avoids the previously identified threats, taking into account the UAV dynamic and performance capability, as part of an optimal control problem.

This work follows previous theses were the virtual models have been developed to find the optimal obstacle detection sensor configurations and the preliminary obstacle sensor hardware has been added to a flight controller. The main goal is to further develop the flight controller PX4 software to implement a set of different avoidance strategies for fixed-wing UAVs. In the end, different sense and avoidance solutions for small fixed-wing UAVs are validated in flight tests and a performance benchmark completed.

Tasks

To meet the goals proposed, the work should be composed of the following main tasks:

- Bibliography Review
  Literature research about obstacle detection and avoidance, in particular for application to small fixed-wing UAVs;
  Estimated time: 3 weeks.

- Problem Definition
  Overview of optimal control techniques applied to trajectory optimization. Real-time trajectory replanning strategies, both on-board and off-board implementations;
  Estimated time: 2 weeks.

- Collision Avoidance Algorithms
  Review and benchmark of trajectory replanning algorithms;
  Estimated time: 4 weeks.

- Characterization of Flight Controller
  Study of existing flight controller software and hardware. Identification of existing solutions and development of new proposed ones; Estimated time: 6 weeks.

- Collision Avoidance Implementation
  Implementation of the different obstacle avoidance strategies into an existing flight

control system software;
Estimated time: 12 weeks.

- Demonstration and Validation
  Demonstration of the obstacle avoidance solution in controlled laboratory environment. Validation of solution in flight tests;
  Estimated time: 4 weeks.

- Thesis Write-up
  Write-up of the dissertation thesis and corresponding oral presentation support material. The different technical topics covered should be described in detail, and a rigorous presentation is expected, both in visual and verbal terms, in a document logically structured.
  Estimated time: 5 weeks.

Requirements

The proposed work requires knowledge covered in courses such as:

- Programming
- Sensors and Systems
- Instrumentation and Measurement
- Flight control

The list mentioned is only illustrative of the scientific content of the work to be executed, it does not represent mandatory requirements. As such, the student that shows interest in this proposal is advised to previously discuss it with the supervisor.

Localization

IST (campus Alameda) or other location to be defined.

Observations

The student is strongly encouraged to start documenting his work since the first day. The recommended language for writing the dissertation is English.

Curriculum

- MEAer - branch of Aircraft
- MEAer - branch of Avionics

Calendar

The work to be developed has an estimated duration of six months, in accordance to the present curricular plan at IST. During that period, the student is expected to meet on a regular basis with the supervisor for follow up and discussion of ideas.

The student has full autonomy to manage his time in the way it suits him best, however a calendar is suggested according to the tasks described previously.

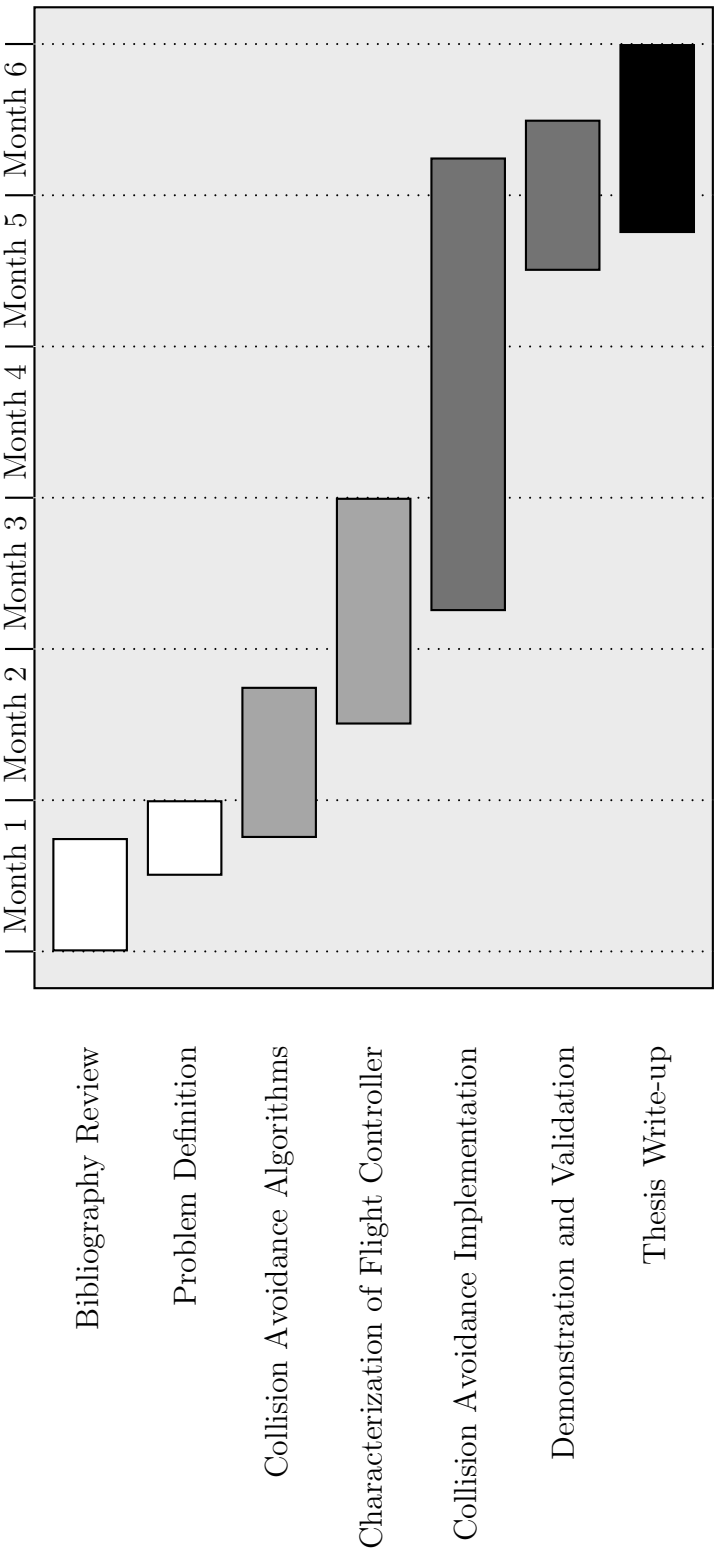

Table 1: Proposed Calendar