Exercises for 31390

Unmanned Autonomous Systems 31390

Department of Electrical Engineering • Technical University of Denmark

PURPOSE:

The purpose of this project assignment is to practice the topics learned in the Unmanned Autonomous System course 31390 on a realistic unmanned aerial vehicle application.

INTRODUCTION:

In this course we will have a combination of lectures, exercises, self-study material, and we aim at a final demonstration of your skills and competences gained, using a simulated Crazyflie-2.1 quadrotor UAV. The UAV is a nano quadcopter that weighs only 27g. This has many advantages, including that it is ideal for flying inside a lab, office, or your living room without damaging or harming. Even though the propellers spin at high RPMs, they are soft and the torque in the motors is very low when compared to a brushless motor. In any case, when you work with the hardware, we recommend you to use safety precautions as described in the practical exercise document.
Even if in this course you are expected to complete all the predefined theoretical and practical exercises and prepare a small demonstration, we do not want you to spend too much time on reporting, rather we prefer you use your extra time for self learning. We have prepared a scoring system to get an idea whether what you are reporting on is enough or not to pass the course (see later) and we encourage you to use any extra time to perform self-study activities and additional competence development using the available systems and infrastructures.

ABOUT THIS MATERIAL:

This paper describes a project assignment tasks that consists of 7 parts, denoted 'Part 1' to 'Part 7', available in the material on DTU Learn. The parts are a mixture of basic problems on the different aspects constituting the foundations of the course (these problems will help you refreshing previously studied topics), and more advanced exercises that focus on reaching the learning objectives of the course. Furthermore, Part 6 and Part 7 will give you hands on experience on the course topics through simulation and real experiments.
We recommend you to complete the assignment using Matlab and Simulink.

CONTENTS:

Part 1 - Rotations focuses on refreshing your knowledge on 3D rotations and minimal representation. You will solve problems related to angle representation using several approaches, from Euler angles to quaternions.
Part 2 - Modeling focuses on refreshing your knowledge on kinematics and dynamics modeling. You will end up with a dynamic model of a quadrotor UAV.
Part 3 - Control focuses on refreshing your knowledge on control theory. You will control a non-linear dynamic system such as a quadrotor UAV.
Part 4 - Path Planning focuses on testing and comparing several path planning algorithms that you will need to find the 3D path of a UAV from a starting point to a target one.
Part 5 - Trajectory Planning focuses on defining time-dependent trajectories that allow the UAV to generate commands leading to the goal.

Part 6 - Simulation Exercises simulations will give you hands on experience and an excellent starting point to test your knowledge and implementation, before you use the real system.
Part 7 - Experimental Exercises this is the hands-on part of the course.

A GROUP WORK APPROACH:

We believe that group work is beneficial for your personal learning as you are required to plan, communicate, monitor and evaluate your work together with other students who might have different views, or even a different background. We recommend a group to have (not more and not less than) 4 members. Groups will be defined on Day 1 by filling the group table available online[1].
When doing group work, it is necessary to kick in the work by sharing personal motivations and expectation from the self and your colleagues. Make sure that you discuss how are you going to work together, identify potential risks and think of mitigation well in advance. We encourage you to write down how much (in percentage) everyone has contributed to solving the exercises and making the report. This value will be used to differentiate the grades if needed, so please make sure that everyone in the group agrees with the differentiation (if any) and let the whole group sign the report.

SOLVING AND REPORTING THE PROJECT ASSIGNMENT:

There are many exercises, which will help you develoing the knowledge needed to excel in this course. However, we do not expect you to report on all of them, as this may require a lot of your time! To ensure that you gained the competences expected by this course, while reducing the time that you spend on reporting, we have prepared a scoring system that you can use to report only what is sufficient for you to pass the exam.
The scoring system gives you an idea whether you have collected enough material in your report to pass the course. For each exercise, a maximum score is available. This score represent the score that you would get IFF the exercise and the description of your solution are correct and very well explained (meaning that you can demonstrate that you have gained the knowledge required to solve the specific exercise). In practice, this means that if the result is incorrect, or if the description of your solution is minimal, not clear, etc., you may get a score that is lower than the maximum score associated to that particular exercise.
You must report at least one exercise per part. The exercise that we want you to report on is indicated in the scoring table in Blue, as well as in this document by a $\star$ symbol.
We will have a demo day in the last day of the course. If you are able to demonstrate successfully your algorithms, your scores in part 7 will double.
You will need a minimum of 100 points to pass the course.
A demonstration video for part 6 and 7 should also be submitted and it will be used as a record for the evaluation.

The report is assessed as a whole based on the quality of the explanatory text and the correctness of the answers. The last page of the report should be signed

[1] ttps://docs.google.com/spreadsheets/d/1JB7U5rlhMGGmrCdlhxWqZEjJbMQ1QPtXML8THM_A66k/edit?usp=sharing

by the participant(s). Remember your 'study registration number'. The project assignment needs to be carried out by team of two or three persons, the individual contribution to the project work must be clearly indicated contributions to the answer for each of the problems presented in the 5 parts of the project assignment report. Specify the work contribution each problem by the percentage scale, e.g. example Elisabeth 30% / Peter 30% / Jack 40%.

DEADLINES:

The project report and demonstration video must be submitted on DTU Learn by each of the group members, NO LATER THAN the midnight of July 7th, current year.