Proposal for Final Year Project

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Objective

This final year project (FYP) will build on the outcomes of my third-year research placement. For the placement I conducted a research project in the summer of 2018 under the supervision of Professor Jeff Shamma of RISC Lab at the King Abdullah University of Science and Technology. The goal of the earlier project was to devise a decentralized control algorithm for autonomous cooperative transportation of a payload (CPT) by two unmanned aerial vehicles (UAVs). The proposed algorithm relied on one UAV as a 'leader' agent and the second UAV as a 'follower' agent. Over the course of the placement I formulated a mathematical model of a simplified CPT system (constrained to motion in two dimensions) and simulated its operation using MATLAB and Gazebo.

For the FYP I wish to build on this previous work by developing a more complex CPT system. Extensions that I could pursue include:

1. Executing motion control in three dimensions
2. Including more followers to reduce loading per agent
3. Transportation of payloads with complex features (asymmetry, fragility, non-rigidity, non-homogeneous composition)
4. Safely managing hardware failures
5. Obstacle avoidance, or tracking
6. Integration of humans as ad-hoc leader agents
7. Increasing the robustness of the system to environmental conditions
8. Finding a less-computationally intensive means of navigation and localization than motion capture feedback

I am particularly interested in tasks 1 and 6, hence I propose to focus these two tasks for the final year project. It may be overambitious to pursue both ideas sequentially, hence I am willing to discuss limiting the remit of the project further.

Technical Contacts

My local supervisor at KAUST was Professor Jeff Shamma (Jeff.Shamma@kaust.edu.sa), Director of RISC Lab, KAUST. I would also like to seek the advice of Dr Petar Kormushev (P.Kormushev@imperial.ac.uk) of the Robot Intelligence Laboratory at Imperial College, London.

Proposed Method

1. Meet with academic supervisor and FYP coordinator to determine a tentative list of objectives and scope of the project.

Depending on the outcome of preliminary discussions with my supervisor, I could pursue one or both of the following tasks:

2. Implementing three-dimensional motion control:
    a. Conduct a review of literature on CPT schemes using UAVs (surveyed as part of the summer research placement) and reflect on findings
    b. Review the previous system design (including sensor type, sensor placement, cooperation scheme) and update the mathematical model accordingly

    c. Conduct a visual simulation of system operation using ROS overlaid with Gazebo.
    d. Construct a hardware demonstrator for observation of user experience
3. Integrating a human as a leader agent:
    a. Conduct a literature survey on human-UAV interaction
    b. Review previous system design and update mathematical model
    c. Conduct a visual simulation of system operation
    d. Construct a hardware demonstrator for observation of user experience

Proposed Equipment and Estimated Costs

For simulations:

- Access to a PC
    - CPU must be at least 2.50 GHz, with at least 32 GB of RAM
    - GPU must have superior performance than the AMD Radeon R4 series
    - Must have Ubuntu Linux, ROS Kinetic Kame, Gazebo and PX4 installed (freeware), MATLAB 2018 (Imperial College has an academic licence)

Some of the hardware and infrastructure that I used during the research placement on the RISC Lab appears very expensive or difficult to operate without a dedicated space. This may not be an issue if Imperial College's Aerial Robotics Lab has the equipment.

- Optitrack motion capture system (56,325 GBP)
- Drone flight cage (3 x 5 x 7 m)

The drone architecture used was custom-built from mostly off-the-shelf parts; prices listed below exclude taxes.

- Quadcopter frame (Happymodel HMF Totem Q250, **8.42 GBP**)
- Power distribution board (**4.49 GBP, out of stock**)
- 4 ESC modules (20A Mini ESC with BEC 'Afro Race Spec'**, 7.99 GBP each**)
- 4 brushless DC motors (EMAX 'MT 2204 II', **11.18 GBP each**)
- 4 composite 2-blade 5" propellers (**1.55 GBP each**)
- 1 LiPo battery (Turnigy Multistar 3000mAh 3S 11.4V, **17.54 GBP, out of stock**)
- 1 remote controller (Spektrum DX8, **183.75 GBP**)
- 1 serial receiver module (Spektrum HK608X, **19.14 GBP**)
- Pixhawk flight controller (**110 GBP**)
- 1 universal battery eliminator circuit (ReadyMade RC 5A UBEC-S 6V6-32V in, 5V-6V out, **3.25 GBP**)
- 1 ODroid XU4 single-board computer (**47.44 GBP**) and Wifi module (**14.36 GBP**)

Subtotal of drone parts, excluding taxes: **491.27 GBP**

It would be easier and faster to source an off-the-shelf drone for hardware testing, but the selected model may not be compatible with the Pixhawk flight controller.

I also anticipate difficulties in sourcing an affordable angular encoder that can communicate with a ROS server running onboard the ODroid XU4 computer.

Due to these concerns I would like to discuss the viability of and option for hardware testing with my proposed supervisor and the FYP coordinator.

Proposed Schedule

Stage	Task	Deadline
Preliminary Scoping	Meet with academic supervisor to settle research topic	Week 1, Autumn
Reflection	Inception report	Week 6, Autumn
Literature Review	Review literature on CPT schemes using UAVs	Week 5, Autumn
	Summarize findings of literature survey	Week 8, Autumn
System Design	Review and update system design	Week 10, Autumn
	Update mathematical model of system proposal	Week 11, Autumn
Simulation	Create a visual simulation of the updated system proposal	Week 2, Spring
Reflection	Interim report	Week 4, Spring
Hardware Testing	Construct and refine hardware demonstrator	Week 5, Spring
Reflection	Final report	Penultimate week, Summer
	Presentation of results	Penultimate week, Summer

The precise details of the task sequencing (including whether to pursue 3D motion control, human interaction, or both topics) will need to be discussed in the preliminary meeting with my academic supervisor and the FYP coordinator.

Proposed Supervisor

I would like to be supervised by Professor Yiannis Demiris (Y.Demiris@imperial.ac.uk), Professor in Human-Centered Robotics at the Personal Robotics Laboratory.