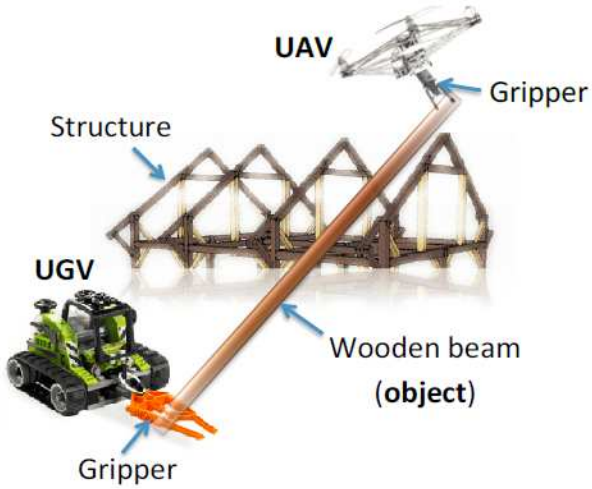
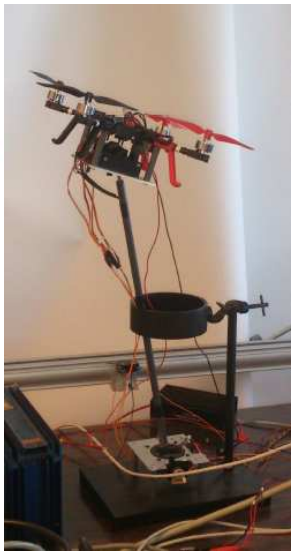
Control of a quadrotor manipulating a beam (2 projects available)





Supervisor: Emanuele Garone (egarone@ulb.ac.be), Tam Nguyen, Laurent Catoire

General Goal: The goal of this project is to complete from a theoretical and from an experimental viewpoint a system composed of a quadrotor manipulating a beam (see Photo). Two possible projects are available in this field, depending on the background and motivation of the student

Project 1: (theoretically oriented) The main goal of this project is to prove the stability of the system quadrotor + beam controlled through a control law already developed in previous studies. For this path is require a competitive student, highly motivated, with a good mathematical background, and with a research oriented mindset. Working adequately it is very likely that the result of this work will lead to a real scientific publication. The student will be also involved in the experimental validation of the control law .

Project 2: (application oriented) The main goal of this project is to evaluate the feasibility of the experiments with the current setup and the possible needs to modify it. The starting point will be the theoretical models and the control laws developed in previous projects. The first steps that will be carried out concerns the identification of the parameters of the existing model. Further elements will be added to take into account actuators dynamics, sensor characteristics and the main effects not present in the theoretical model used so far. The goal is to build a realistic simulator that can be used to test the existing control law and understanding if the current paramenter configuration (mostly the length of the beam) is adequate. If not a dimensioning phase will be required, on the basis of which the experimental setup will be changed. After this preliminary phase, the project will focus on the tuning of the control law on the experimental setup to experimentally demonstrate its effectiveness.

Selection Procedure and Development: If interested contact as soon as possible Prof. Garone to discuss the project and your motivations. Since it is a project with an important experimental part it cannot be rushed through “last minute”. Accordingly the student is required to start working on it on November 2016 at the latest. The timely begin of the project is also needed to ensure that all the needed material is available.

Control of an Indoor Airship (1 project available)

Supervisors: Emanuele Garone (egarone@ulb.ac.be), Laurent Catoire

Context of the work: Airships (such as zeppelins and blimps) are lighter-than-air vehicles that remain airborne due to Archimedes' principle. The high energy efficiency of these vehicles allows them to be used for time-consuming operations such as the automatic patrolling of large indoor environments.

Description of the work: In this project the student will be asked to complete the construction and control of an autonomous blimp started with a Master Thesis. This includes the following aspects:

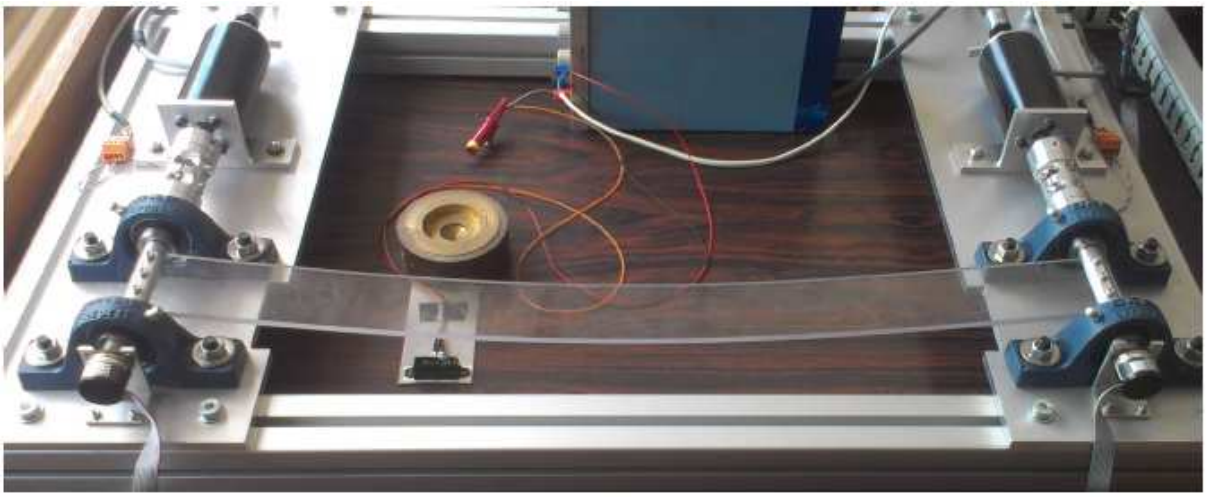
- Interface of the vision system developed with the radiocommand (mostly already done, only minor issues remaining)
- Some minor construction aspects on the blimps
- Identification of the model
- Simple Control Strategy

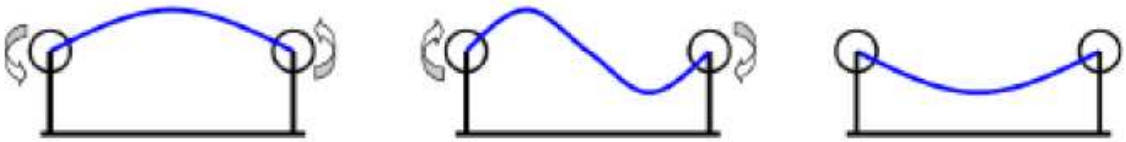
In case of a very motivated student, it is possible to think about implementing and studying advanced control strategies.

Requested skills: Basic knowledge in control theory, programming skills in C++.

Selection Procedure and Development: If interested contact as soon as possible Prof. Garone to discuss the project and your motivations. Since this project is mainly experimental it is very important to start early, possibly in November 2016 at the latest, in order to be robust to possible needs of purchasing new hardware

Experimental Parameter Identification, Model Validation and Control of a bi-stable buckled beam (1 project available)





Supervisors: Emanuele Garone (egarone@ulb.ac.be), Laurent Catoire

Context of the work: The project concerns the analysis and the control of a well-known multistable structure: the bi-stable buckled beam. The beam is subjected to end-shortening conditions which cause the buckling. Two motors are placed at both ends of the beam and apply a torque on the extremities. This may cause the snapping of the structure. The transition between two stable states will be studied and tried to be planned. The dynamic of the transition will be studied as shown on the figure 1.

Description of the work: In a previous master thesis the equation of motion of the beam in buckling has been studied, a reduced model proposed and a series of control law proposed. This MA1 project will be mostly experimental, the goal is to identify and experimentally validate the model and to experimentally demonstrate some control laws allowing to do the transition between the two stable equilibria trying to minimize the torque used

Requested skills: Basic knowledge in control theory

Selection Procedure and Development: If interested contact as soon as possible Prof. Garone to discuss the project. Since this project is mainly experimental it is very important to start early, possibly in November 2016.

Attitude sensing for the application of flapping wing robot

(1 Project Available)

Supervisor: Emanuele Garone (egarone@ulb.ac.be), Ali Roshanbin

Problem: To stabilize flapping wing robots, the estimation of the attitude is a fundamental aspect. The fundamental sensor to perform this estimation is the Inertial Measurement Unit (IMU) which is composed of gyroscopes and accelerometer. The use of flapping wing configuration leads to a large amount of vibrations, which causes more severe attitude estimation problems if compared to what is normally experienced in classical fixed wing or rotary wing aircraft. Vibrations introduces drifts in the robot's attitude measurement Figure 1 is the structure of a sample filter to compute angle and its rate from the accelerometer and gyro incorporation.

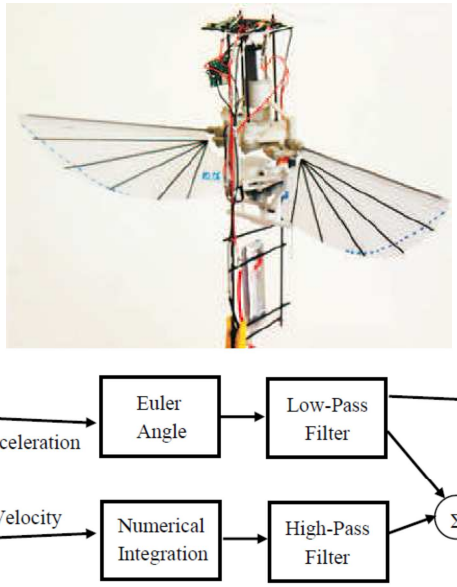


Figure 1: The Robotic Hummingbird and the Block Diagram of the Complementary filter

Description of the work: In this project the student will be asked to compare the implementation of different types of filters (such as Kalman filter and complementary filter) to the MPU6059 sensor in order to extract the attitudes for the application of flapping wing robot. The appropriate filter should be designed to extract Euler angles to minimize the drift measurement. The final design should be compared with the DMP (Digital Motion Processing Unit) available by MPU6050 to show the improvement of the proposed filter. One robot would be available for the experiment. The student needs to get familiar to the robot in order to be independent enough to prepare the robot for the experiment.

Requested skills: Knowledge in signal treatment, programming skills in C++.

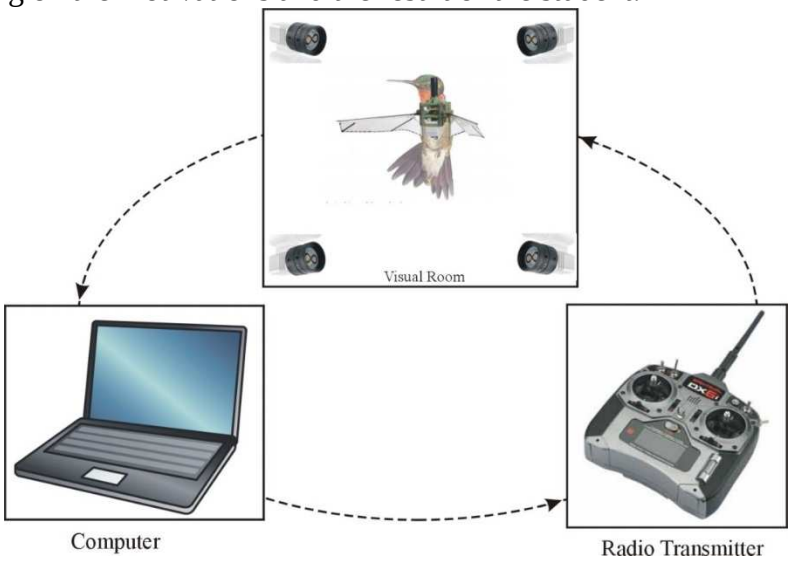
Selection Procedure and Development: If interested contact as soon as possible Prof. Garone to discuss the project.

Flight Arena – Flapping Wing Robot Communication Interface

(1 Project Available)

Supervisor: Emanuele Garone (egarone@ulb.ac.be), Ali Roshanbin

Project Description: The purpose of the project is to interface the flight arena present at SAAS composed of a motion-capture camera with a flying object. Both the use of a radio transmitter or of the Bluetooth Module of the flight control board will be explored. A flight demonstration will be carried out on a robotic bird hummingbird (or on a simpler flying object) depending on the motivations and the result of the student.



Description of the work:

The first part of this project will study different possibilities of interfacing a flying robot with the flight arena currently present at SAAS. A number of preliminary results are available. In particular the project will focus on the interface between the flight arena and a prototype of robotic hummingbird equipped with the Micro MWC Flight Control Board DSM2 and a Bluetooth Module SPBT2632C2A, as well as a Spectrum DSM2 radio transmitter for transmitting the command to the robot. Two possible ways of communication (and their advantage and pitfalls) will be considered:

1) The possibility of transmitting position and velocity measurements through the Bluetooth module, with a characterization of the transmission delays introduced
2) The possibility of directly transmitting velocity and thrust references to the radio modules, with a characterization of the resulting control bandwidth.

The evaluation of the control bandwidth and of the possible delays will be carried out taking into account the goal of controlling the aerial robot position. The second part of the project will focus on demonstrating the proposed solution on a real flying object. Accordingly, depending on the results of the student and of the hardware availabilities, the student will control the position loop of a real aerial robot (either on the robotic hummingbird or on a more standard flying vehicle)

Requested skills: Programming skills in C++ (for the interface), Basics of Control (for the control of the robot)

Selection Procedure and Development: If interested contact as soon as possible Prof. Garone to discuss the project. Since this project is mainly experimental it is very important to start early, possibly not later than November 2016.

Motion Tracking for a set of Ping Pong Balls
(1 Project Available)

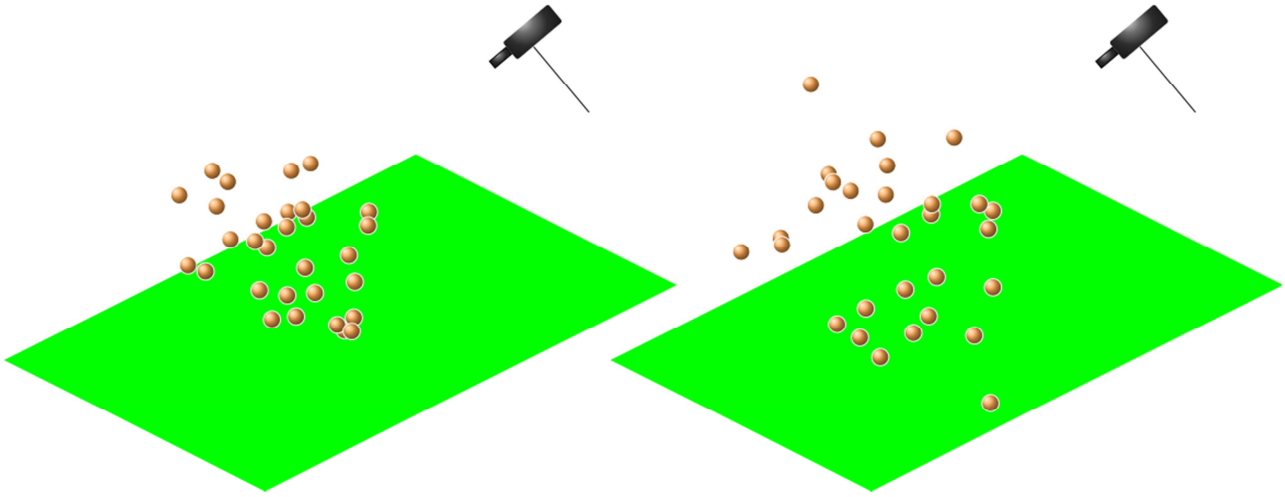


Fig 1. The problem of determining each ball position between two consecutive frames.

Supervisor: Emanuele Garone (egarone@ulb.ac.be), Raffaele Romagnoli (rromagnoli@ulb.ac.be), Laurent Catoire (Laurant.Catoire@ulb.ac.be).

Goal: The goal of the project is to develop a system that is able to track the motion of a set of homogeneous ping pong balls using information generated by a camera system.

Context: A set of balls with the same size and colour represents, under the image point of view, a set of indistinguishable points. The motion of this set, which is captured by a camera system, admits the problem of determining each point position from one frame to the next one (Fig.1). By introducing the dynamics of each point, i.e. a ping pong ball, an algorithm can be developed to solve the above mentioned problem using Kalman and/or particle filters.

Description of the work:

The student has to develop

- An algorithm for retrieving the position of each ball from the images.
- An algorithm to detect each ball and assigning it its trajectory.

Selection Procedure and Development: If interested contact as soon as possible Prof. Garone to discuss the project.