MA1 projects at SAAS – Academic year 2016-2017

1. Temperature control with the world smartest radiator valve – in collaboration with the start-up OTREMA (2 students)

Supervisors: Laurent Catoire and Michel Kinnaert

Presentation of the context of the work by OTREMA

OTREMA, a Brussels based start-up, has been developing an innovative radiator valve based on Bluetooth Low Energy. It has state of the art features such as machine learning, presence detection, USB charging and much more in a compact and beautiful design. We need your support to develop a reliable thermal regulation algorithm. We plan a kickstarter.com campaign soon to launch the product, and we offer you to be part of the adventure…for a greener and smarter world.

More info on www.otrema.eu

Description of the work

1. Programming of the controller (Arduino-like) in order to be able to control the valve and to export measurements
2. Modeling of the thermal behavior of a room
3. Design of the controller, validation in simulation
4. Implementation of the controller in the valve
5. Comparison of various controllers both in simulation and experimentally (robust or adaptive controller)

2. Dynamic modelling and experimental validation of a tele-operated robotic system

Supervisors : Christophe LABAR (Christophe.Labar@ulb.ac.be), Michel KINNAERT (Michel.Kinnaert@ulb.ac.be) and Laurent CATOIRE (Laurent.Catoire@ulb.ac.be)

Context of the work

Tele-operated robotized surgery is more and more used as it improves the surgeon's accuracy.

In this configuration, the surgeon does not directly act on the patient. He moves a so-called master robot, that can be seen as a sophisticated joystick. A slave robot, equipped with the surgical tools, reproduces his actions on the patient.

The SAAS department designed and manufactured a 4-degree of freedom slave robot (Figure 1). In previous works, controllers were designed to make the slave robot follow the trajectory imposed by the master. Up to now, the dynamics of the robot is not used in the control strategies. Although the results obtained are satisfactory, the knowledge of the robot dynamics would enhance the tracking accuracy.

Description of the work

1. Derivation of the dynamic model from the existing Catia files
2. Step-by-step validation of the model on the experimental set-up
3. Identification of the friction acting on the different joints of the robot (… if time left)

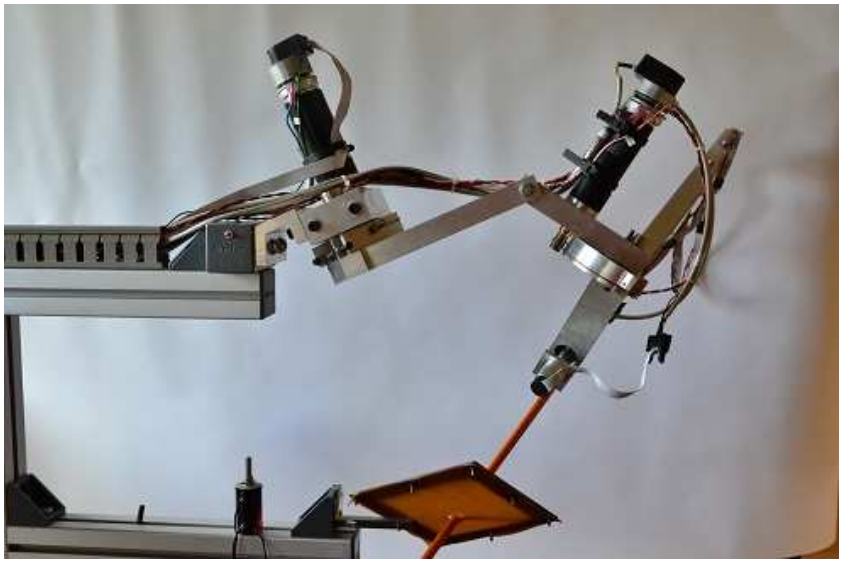

Figure 1: Experimental Set-up

3. Lithium-ion battery modelling for the design of a battery management system

Supervisors: Luis Daniel Couto and Michel Kinnaert

A battery-management system (BMS) is a supervising unit used aimed at improving battery lifetime and performance. It is based on a mathematical model of the behavior of the battery. The two main approaches to develop a battery model for a BMS are: equivalent circuit model (ECM) and electrochemical model (EChM).

The ECM uses electric circuits to predict the internal states of the battery. The simplest ECM is the internal resistance model (Rint) which consists of an ideal voltage source and an ohmic resistance, that represent the open-circuit voltage (OCV) and the internal resistance of the battery, respectively. Both OCV and resistance are functions of battery state of charge (SOC), state of health (SOH) and temperature.

The student is asked to develop and compare several ECMs, starting from the basic Rint model and progressively adding RC pairs and fitting parameters in order to improve it. Introducing temperature effects in a suitable way will be pursued. The circuit component values have to be found via parameter identification techniques. Computation of SOC and SOH from the considered ECM will also be performed and compared.

4. Battery Pack Reconfiguration via Switches Control

Supervisors: Luis Daniel Couto, Laurent Catoire and Michel Kinnaert

Context of the work

A *battery-management system* (BMS) is a supervising unit aimed at improving battery performance and lifetime. It is based on a mathematical model of the behavior of the battery. The idea of this project is to connect several battery cells in series/parallel arrangements in order to achieve specific voltage/power requirements, while studying suitable reconfiguration mechanisms based on the control of switches.

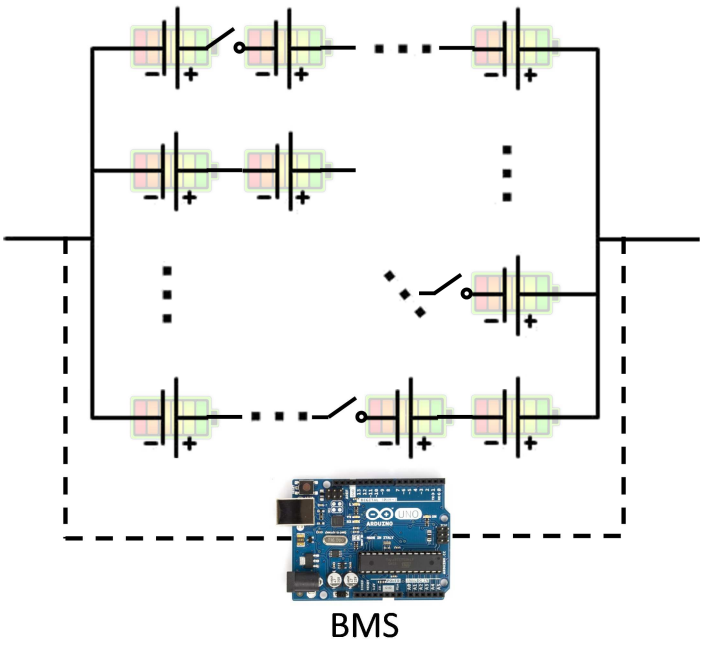

Figure 1 Battery pack comprised by series/parallel battery cells arrangement, with switches and a BMS monitoring/controlling the system.

On the one hand, the student is expected to build an experimental test bench resembling a typical battery pack. On the other hand, the student has to study and develop control strategies to reconfigure the battery pack via switches. This will allow finding the most suitable reconfiguration mechanisms to achieve load demands and balance the charge throughout the battery pack

Requested skills

Basic knowledge in programing and control theory.

5. Pitch control for mechanical load reduction upon grid disconnection

Supervisors: Sandra Paola Vasquez Rodriguez and Michel Kinnaert

Mitigating extreme mechanical loads in wind turbines is of paramount importance in order to reduce maintenance costs. Previous work has shown that pitch control may be useful to reduce extreme mechanical loads that are observed upon occurrence of faults in the network that induce abrupt turbine disconnection. However, the considered studies do not take into account the backlash in the gear. The aim of this project is to take into account this phenomenon in the controller design and to study how it affects control performance.

6. Control of a magnetic levitation process

Supervisors: Laurent Catoire and Michel Kinnaert

The student is asked to design (modeling, actuator and sensor selection), build and control a magnetic levitation process. A prototype has been built during a former project (see below) but it has to be optimized, notably concerning the actuator (winding of the coil and ball size), the sensor and the controller.

7. Realization of an Inverted Pendulum Controlled by a Cart and an UAV

Supervisors: Tam Nguyen, Laurent Catoire and Emanuele Garone

Context of the work

The *Inverted Pendulum* controlled by a cart is a well-known control problem, where the cart must move so as to maintain the beam in the upright position. The idea of this project is to connect the beam to an Unmanned Aerial Vehicle (UAV) so that the ground and aerial vehicles can collaborate to stabilize the beam.

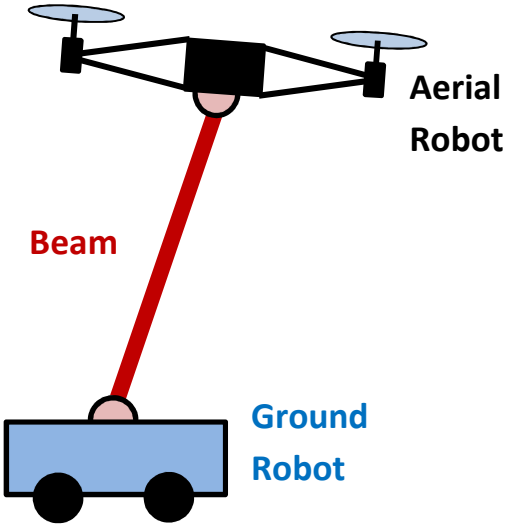

Figure 1 left : A ground robot and an aerial robot collaborating in the transportation of a beam ; right : experimental setup

The objective of this project is to finalize the experimental testbed that has been developed during a former project. It will be used to test various collaboration control strategies.

Description of the work

The student is asked to finalize the prototype. In particular, he/she has to develop the command of the UAV motors from Matlab. Moreover, the student will be required to validate and improve the collaboration control strategies between the two robots using the experimental testbed.

Requested skills

Basic knowledge in programing and control theory.

8. Friction Observer/Reference Governor Implementations on a Cart Actuated by a Worm Drive System

Supervisors: Tam Nguyen, Laurent Catoire, Emanuele Garone, Michel Kinnaert

Context of the work

The control of a cart actuated by a worm drive system presents two fundamental problems:

1) The identification of the non-constant dry friction along the trajectory;
2) The safe management of the actuator constraints of the cart;

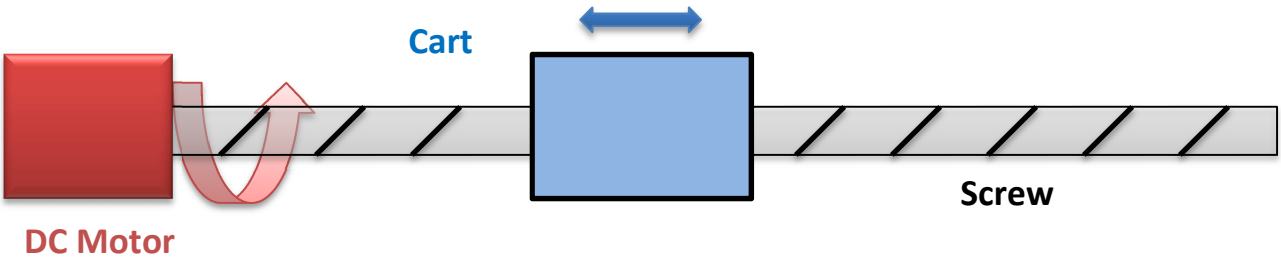

Figure 1 Cart actuated by a worm drive system

The objective of this project is to implement a friction observer and a Reference Governor scheme to the system using Matlab. The effectiveness of the solutions will be tested using a Proportional-Integral-Derivative (PID) and repetitive control laws.

Description of the work

The student is requested to implement a friction observer for the identification of the dry friction along the trajectory. To safely manage the actuators saturations, the Reference Governor scheme will be implemented, using bisection to perform the optimization of the parameters. For validation purposes, a PID and a repetitive control law will be implemented.

Requested skills

Basic knowledge in Programming and Control Theory