Presentation of the system

We want to optimize the thermal regulation of a student dorm room, while minimizing the energy bill!

From a preexisting modeling work, one has already proposed the following second order model:

$$\begin{cases} C_{res}\dot{T}_{int}(t) & = & \frac{1}{R_i}\left(T_s(t) - T_{int}(t)\right) + \frac{1}{R_f}\left(T_{ext}(t) - T_{int}(t)\right) + 10\ \left(Q_{res}(t) + Q_{unk}(t)\right) \\ C_s\dot{T}_s(t) & = & \frac{1}{R_i}\left(T_{int}(t) - T_s(t)\right) + \frac{1}{R_0}\left(T_{ext}(t) - T_s(t)\right) + Q_s(t) \end{cases} \tag{1}$$

With the time unit being 1 hour, the parameters of this models are:

Parameters	R_f	R_i	R_o	C_{res}	C_s
Valeurs	5	2.5	0.5	5	8

Table 1: Value of parameters

In this hourly model, $Q_{res} \in [0, 1.5]$ is the control of the heating system in kilowatts. $Q_{unk} \geq 0$ is an unknown disturbance inputs.

Q_s is the external solar flux.

T_{ext} is the outside temperature.

T_{int} is the indoor temperature, which is supposed to be measured.

Global Objectives

The objective of this work is to **exploit the knowledge of the room occupancy** and to **exploit the knowledge of the price of energy** to make energy savings, without degrading the thermal comfort for the student.

The data available are: Indoor temperature sensor (T_{int}). You will have to choose what kind of predictors would you need (Expected energy price, expected indoor temperature, expected outdoor temperature, expected solar radiations, ...) with the associated prediction length.

You will have to design a controller that ensures good performances, as cheap as possible, easy to tune from a room to another room and you will have to convice other student that your solution is better than the others.

This work is organized in 4 parts. Part 1 is a straight application of the course. Parts 2 and 3 are open questions where you are free to try what you want ... This will lead to a competition between all the teams! Part 4 consists in a presentation of your work to the other groups. At the end, you will need to convince that your solution is the best!

Part 1: Classic MPC implementation

In this part, you will have to design a controller, following the classic MPC implementation : quadratic cost to track the expected reference. You can first neglect the disturbance input in your controller ($Q_s = 0$; $T_{ext} = 0$).

You can provide analysis on the required length for the prediction horizon, choice of the sampling time, ...

Many studies can be done in Matlab, but this first controller should also be implemented in the Simulink Environment.

Part 2: Smart Advanced Controller - Optimization of active costs

The main problem with the conventional approach is that it does not distinguish between periods of presence and periods of absence of the occupant. This then generates discomfort, despite the anticipation.

One idea to exploit is to change the optimization criterion to take into account only periods of occupancy.

Another idea that can also be exploited is to make the price of energy directly explicit in the criterion. This can be done by defining a linear criterion.

Another way of thinking may be on the necessity (or not) to integrate a more or less precise model of future disturbances (solar irradiation, outside temperature, ...).

You will have to discuss with your supervisor about the technical details of your solution, and provide a short synthesis of your solution. This can be done in LiveScript.

Your solution should also be developed in Simulink, in which the performance of your controller will be compared (privately) with the proposition of the other students.

Part 3: Improving the insulation - Optimization of passive costs

In this part, and based on the previous results (Part 2), we want to have an investigation on where to put the money to improve the eficiency of you house. You have two main options for that:

- Change the heating system, with a more powerful one, whose upper bound is 2kw: Price : 500 euros.
- Improve the house insulation: this can be modelled by increasing the value of R_0 and R_f, depending on the thickness of the insulation you provide. This thickness, denoted with e, has the following impact:
  - On the price: 48(100+e) euros, with $0 \leq e \leq 100$ in mm.
  - On the resistance R_f: $R_f = 6 + 20 * e$
  - On the resistance R_0: $R_0 = 1 + 10 * e$

How many euros will you invest, and what is the time of return on investment of the solution you propose?

The methodology and the results you are going to develop will need to be validated with your supervisor.

Part 4: Presentation

The final objective is to prepare a short presentation of your work in order to convince other students that your solution is the best. Without going into too much technical detail, you will have to present both the controller you develop and the solution you propose to improve the efficiency of the room. Why should I buy your solution? Will everyone be able to install it at home or will they have to use your service?

This presentation should last a maximum of 7 minutes, and will be followed by 3 minutes of questions.