Predictive HVAC Control of a chicken-sized model building

Thesis proposal, 10.09.2019

We are looking for a motivated and excellent master's or bachelor's student at the chair for internet of things for smart buildings with **expertise and interest in control engineering** and building technology for a **theoretical and experimental thesis**.

Your task will be to **assemble a simple building model** ($45l$) including a simple heating, ventilation and air conditioning **(HVAC) system** with an invertible Peltier element as its actuator. A Peltier element is an electrothermal device that creates a temperature difference between its two sides when a current is applied and can be inverted to switch from cooling to heating. It is commonly used in space applications, where size and weight are constraints. For our experimental setup it is a great actuator as it is cheap, safe to work with and can be used for cooling and heating.

You will use a **microcontroller (Pycom LoPy4) to drive the Peltier element** as well as to gather and process temperature measurements. It is your task to set up an appropriate circuit and program the microcontroller (in **micropython**). We do not expect profound knowledge of electrical or computer engineering as this is more of a "DIY application" with excellent documentation available online.

After this preliminary work, your task will be **to perform a system identification** of the model building. It should be possible to derive the system dynamics from first principles and use the experimental setup to obtain system parameters. Alternatively, you may investigate any black-box identification approach, such as the Eigensystem Realization Algorithm (ERA) or even Deep Learning.

For controlling the model building you will be applying **Model Predictive Control (MPC)**. MPC is a highly efficient optimization-based control strategy that can incorporate future knowledge (e.g. future set-points or ambient temperature) as well as input and state constraints in an explicit way. Our chair has a strong focus and expertise in this field which allows you to build on existing MPC implementations.

One disadvantage of MPC is the computational cost of repeatedly solving an optimization-problem. In fact, the limited hardware capabilities of the microcontroller prohibit the direct execution of MPC on the device. It is therefore required to **compute the control inputs remotely** (on a regular PC) and to **exchange measurements and inputs with the microcontroller via LoRa communication**. LoRa stands for Long Range and is an open and emerging IoT communication standard.

Laboratory of Internet of Things for Smart Building
Technische Universität Berlin
Einstein Center Digital Future
Einsteinufer 17, Raum EN 148

Felix Fiedler (M.Sc.)
felix.fiedler@tu-berlin.de
www.iot.tu-berlin.de
Tel.: +49 30 314 22972

Finally, you might be wondering **why the box is chicken-sized**? It turns out that the supplier of the Peltier element advertises the product as:

- You can make cooling system for yourself, easy and funny.
- Great idea **for pet cooling in hot summer, such as chicken**, little dog.

Neither do we have a chicken at our chair nor do we know why we should cool it, but I guess the box would have the right-dimensions. So, there is that.

On a side note (in case it isn't clear): No animals are involved in this thesis.

Suggested skills

We advice you to have at least some of the skills mentioned below. Especially, some background in control engineering is desirable. However, we also consider highly motivated students who want to extend their knowledge.

- **Fundamentals of control theory**
  - System Identification
- Multivariable control in time domain
  - State-space models
  - Optimal control
  - (Model predictive control)
- Fundamentals of thermal systems
- Fundamentals of electrical engineering
- Python programming
- Wireless communication technologies

Please direct applications to felix.fiedler@tu-berlin.de .

Laboratory of Internet of Things for Smart Building
Technische Universität Berlin
Einstein Center Digital Future
Einsteinufer 17, Raum EN 148

Felix Fiedler (M.Sc.)
felix.fiedler@tu-berlin.de
www.iot.tu-berlin.de
Tel.: +49 30 314 22972