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Tutorial: "Under-Control: A Control Theory Introduction for Computer Scientists"

May 8, 2024

General Information

- Tutorial webpage: <https://control-for-computing.gitlabpages.inria.fr/tutorial/intro.html>
- Tutorial introduction slides: <https://inria.hal.science/hal-04460285/>
- Previous sessions: <https://control-for-computing.gitlabpages.inria.fr/tutorial/sessions.html>
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Short Abstract

This tutorial aims to introduce to the attendees the basis of Control Theory applied for the online management of computing systems through a practical example. This tutorial is composed of two parts. In the first part, we present the motivation and classical tools (PID controllers) of Control Theory. During the second part, the participants will experiment with the concepts presented in the first part through *interactive* documents. Attendees will need a computer with an internet connection and a "recent" web browser (which support WebAssembly)

Abstract

Computing systems are more and more complex. The softwares are being stacked on and executed on increasingly complex hardware. The behavior of application is thus impossible to predict or model correctly. There is thus the need for an *online* management of the systems to yield guarantees on the Quality of Service for the users. One approach could be to find a model of a theoretical model of a system and to design a complex algorithm based on this model.

However, such an approach is limited by the quality of the model. An exhaustive modeling which includes all the possible behaviors and corner cases is cumbersome and error-prone. A different approach to regulate the behavior of a system consists of frequently taking measurements of the state of the system with sensors, and to adapt its inputs to meet high level requirements. This approach is described as a "*Feedback Loop*" and is the main focus of the Autonomous Computing community. Numerous strategies exist to adapt the inputs of the systems based on its sensors. For example, one can use simple ad-hoc strategies based on arbitrary rules, or AI. However, these strategies do not yield any proven guarantees on the behavior of the closed-loop system. On the other hand, the tools of Control Theory have been mathematically proven and used on physical systems for decades. Unfortunately, the use of Control Theory technics on computing systems has only been recent and limited.

We believe that numerous computing systems or applications would benefit from a Feedback loop architecture coupled with tools from Control Theory that provide interesting guarantees. This tutorial aims to initiate the attendees to the application of Control Theory methodology and tools to computing systems through a practical and interactive example.

At the end of the tutorial, the attendees would have:

- understood the motivations, methodology, and basic tools (PID Controller) of Control Theory
- performed an "identification" of a system
- designed a Proportional (P) Controller for this system, and understood the limits of the controller
- designed a Proportional-Integral (PI) Controller for the same system.