Chapter 23

Design of a Controller with Time Response Specifications on STM32 Microcontroller

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ABSTRACT

The basic idea of this chapter is to implement a fixed low order controller on an electronic system using the STM32 microcontroller. The principal aim of this controller is to guarantee some time response specifications as the settling time and the overshoot. The controller parameters are obtained by minimizing a non-convex optimization problem while taking into account the desired closed-loop performances. Accordingly, the resolution of this sort of problem with classical optimization method may lead to a local solution and the achieved control law is not optimal. Hence, with an aim of obtaining an optimal solution that will be able to satisfy the desired specifications, the use a global optimization method is recommended. In this chapter, the Generalized Geometric Programming (GGP) method is exploited. The practical implementation, on a fast electronic system, of the designed control law and a Proportional Integral (PI) controller illustrates the effectiveness of the proposed algorithm.

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INTRODUCTION

Nowadays the use of microcontroller miniature devices is becoming remarkable. In fact, a microcontroller can be described as a computer on a chip thanks to the features that it contains. Indeed, it has the features of a computer such as central processor, non volatile and volatile memories, input and output ports with special particularities like serial communication, analog to digital conversion and, recently, signal processing. This device is employed in several industrial applications such as medicine, automotive systems and transportation, aerospace, etc. Indeed, the progression of microcontrollers and the features that they combined with their speed, allow them to be more suitable for a wide variety of control applications. There is some works that have used fast devices to implement control algorithms (Ling, Yue & Maciejowski, 2006; Jayaraman & Ravindran, 2008; Ling, Wu & Maciejowski, 2008). One example of the advancement in the embedded technology field is the apparition of STM32 microcontrollers. In fact, they combine several advantages such as low cost, low consumption and good performance. It is in this context that is made in this work which consists on the implementation of a linear system control algorithm on a STM32 microcontroller. There are some works that used the STM32 microcontroller in the control field. Zhen and Yan (2013) proposed a control law of the temperature for the hot runner system. So, they used the STM32 microcontroller to implement their fuzzy PID (Proportional Integral Derivative) control algorithm. They concluded and affirmed that the fuzzy PID controller presents the features of high anti interference and an acceptable adaptability. The STM32 processor was also employed by Lian (2011) as a component of sending frequency control code in a drill hole depth measurement system for coal mines. Wang, Li, Liu, and Ning (2011) proposed the application of STM32 microcontroller in the design of mine DC electrical prospecting instrument. Zhang and Kang (2013) designed an embedded signal acquisition system based on a STM32 microcontroller depending on the mechanical failure appeared with high frequency in the rotating machines. A Radio Frequency (RF) data acquisition system based on STM32 and FPGA was designed by Zhang and Zhao (2011) in order to collect the RF signal in high speed. In the present work, the STM32 microcontroller is used in order to implement a control law that will be used with a real electronic process. Indeed, this control law is obtained by discretizing a continuous time controller. The controller parameters are obtained by resolving a non convex optimization problem. In point of fact, the optimization is found in several real problem solving processes. For that reason, the resolution of optimization problems has gained the attention of eminent researchers in various fields. With an aim of find the global minimum Toksari (2009) proposed an Ant Colony Optimization (ACO) algorithm. The author has tested his proposed algorithm on some standard functions and he has also compared it with other algorithms. The Practical Swarm Optimization (PSO) was used by Zhou, Xiao, Wang, Liang and Hassanien (2013) in the control algorithm with the purpose of allowing robots to navigate towards remote frontier after exploring the region. Abu-Seada, Mansor, Bendary, Emery, and Moustafa Hassan (2013) have also employed the PSO method in order to find an optimal tuning of PID controller parameters for an automatic voltage regulator system of a synchronous generator. With the aim of solving unconstrained optimization problems, Toledo, Oliveira, and França (2014) have used the Genetic Algorithm (GA) with hierarchically structured population. Mamdoohi, Abas, Samsudin, Hisham Ibrahim, Noor Hidayat, and Mahdi (2012) proposed the implementation of GA in an embedded microcontroller based polarization control system. The controller measures the signal intensity. These measures will be used to estimate the genetic value. The GA controls this process. To achieve optimum performance, the best genetic parameters optimize the code such that the fastest execution time can be obtained. Valdez, Melin, and Castillo (2014) presented a hybrid approach for optimization combining.
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