Event-Driven Control for Low-Torque Servomotors

Carlos Rosero, Gabriela Verdezoto, Diego Terán and Cristina Vaca
Universidad Técnica del Norte, Av. 17 de Julio 5-21, 100105 Ibarra, Ecuador
{cxrosero, gaverdezoto, dfteran, cvaca}@utn.edu.ec

***Abstract*—This article discusses the design and testing by simulation of an event-driven control scheme for low-torque servomotors. The control objective is to minimize the error between the current position and a pose provided through a setpoint; the controller has the ability to locate the servomotor in any angular position within its operating range, and keep it stable in this. This is accomplished while decreasing the use of computational resources, concurrently maintaining at least the same performance as that obtained through a time-driven controller. The servomotor was subjected to a unit step test both undisturbed and with stochastic disturbances. Simulation results show that the scheme significantly decreases the resource utilization while ensuring control performance tailored to the needs.**

I. Introduction

Servomechanisms are devices that automatically correct their state by reducing the error between a reference and a current fed back state. A widely used servomechanism in mechatronics engineering is the servomotor, which has the ability to locate in any position within its range of operation and remain stable in it. Due to their low inertia, servomotors are used in applications where starts and stops are fast and accurate, for instance in computer numerical control machines and robotics for precise positioning of end effectors [1].

The current trend in servomotors aims to replace analog control strategies with digital ones, taking care also to use the minimum possible energy and to obtain the maximum performance and flexibility [2]. In the classical technique for digital control through microprocessors, sensing the state, calculating the control action and executing the latter, are still implemented in a time-triggered fashion (time-driven). Its performance has been widely analyzed: time-driven control leads to over-utilization of resources, causing for example increased power consumption and the need to use more complex processors [3], [4]. Thus, it is not necessary to execute the control task at each period in order to guarantee a desired closed-loop performance [5].

Therefore, grouping many strategies proposed in the literature, see a review in [5] to know some of them, the event-driven control stands out. This control scheme considers a non periodic sampling pattern in such a way that the processor load is reduced by decreasing the amount of control updates. There are two approaches framed within event-driven control, being the event-triggered control [6], [7], and the self-triggered control [8]. In both approaches the control law has two fundamental parts: a feedback controller to calculate the control action, and a triggering engine to estimate when the control action should be updated. The basic difference between them is that in the event-driven a condition is continuously verified, which triggers the control task when becomes true; the self-triggered works pre-calculating one update-time ahead, when the next update-time will take place.

Simulations and experiments on event-driven control lead to results indicating that both event-triggered and self-triggered, are capable of maintaining satisfactory closed-loop performance while reducing the number of executions of control tasks. However, there are no relevant applications with a few exceptions such as those found in [9] and [10], which show the practical advantages of these control techniques. Thus, it is important to validate in practice these strategies in addition to show their benefits and to support the construction of a complete theory about them, which is not yet mature.

The present article focuses on applying an event-driven technique for designing a controller for low-torque servomotors. In particular, the optimal-sampling-inspired self-triggered control in [11] and [12] has been chosen due to its simplicity of application; recent works show clear information for its evaluation and implementation [13].

The purpose of this research is to validate the promise of the approach in [12] to reduce processor load. Moreover, this work establishes the relation between the reduced number of control updates and the processor load. Both a time-driven as well as a self-triggered controller are implemented on a simulation setup for a low-torque servomotor driven by a DC-motor. Data obtained from simulations is used to test the assumptions made in [12].

The rest of the paper is organized as follows. In Section II the formulation of the event-driven control scheme is introduced. Section III provides an illustrative numerical example and Section IV comes up with simulation results. Conclusions and future work are summarized in Section V.

II. Formulation of the Event-Driven Control Scheme

A. Servomotor model

B. Time-driven scheme

1) Sampling pattern:

C. Event-driven scheme

1) Sampling pattern:

2) Optimal-sampling controller:

III. NUMERICAL EXAMPLE

IV. SIMULATIONS

A. Simulation setup

B. Simulation results

V. CONCLUSIONS AND FUTURE WORK

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