Trading control performance for processor load[1]

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1 Introduction

Various papers (see e.g. [1], [2] and [3]) present the use of asynchronous controllers to create a trade-off between the processor load and the control performance. Many controllers do not require the same high sample frequency at every moment in time to guarantee a required performance. Lowering the sample frequency at certain moments, should decrease the processor power needed for the controller algorithm. In [3] we analyze event-driven control structures with the sample frequency relative to the absolute value of the measured error.

The purpose of this research is to investigate the relation between the reduced number of control updates and the processor load, while applying event-driven control in stead of time-driven control. For this purpose, both a time-driven as well as an event-driven controller have been implemented on a test-setup of a copier paper path, driven by DC-motors. Measurement data from the experiments is compared with simulation data to show the validity of the assumptions made in [3].

2 Controller Design

The plant we need to control consists of a Maxon RE25 20 Watt motor. Its axis is coupled to a pinch that drives the sheets of paper through the paper path. To the other end of the motor axis, a 500-slit rotary encoder is connected.

To control the angular velocity of the motor axis, a discrete-time PI velocity control algorithm was designed. The controller sample frequency is 100 Hz. The closed-loop bandwidth of the system is 30Hz. When the error, i.e. the difference between reference velocity and measured velocity, is smaller than a pre-determined value e_T, we do not execute a control update. This means that the controller computations are not carried out and the actuator signal is held at the same value as at the previous sample.

3 Main results

In figure 1 the results are plotted for multiple simulations and experiments of the event-driven and time-driven controller. The motor has to track a reference velocity profile for 10 seconds, comparable to the one used in [3]. From the figure it can be seen that the number of control updates decreases as the value of e_T increases, while the maximum error e_{max} increases as well. This shows the intended trade-off. The simulation results are very similar to the experimental results.

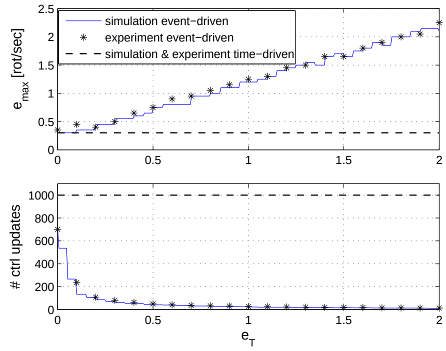

Figure 1: e_T versus e_{max} and the number of control updates.

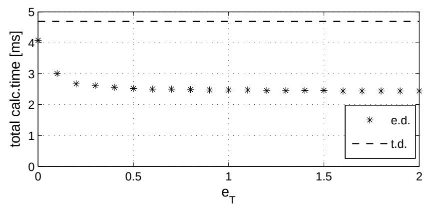

Figure 2: e_T versus the total computation time.

In figure 2 the cumulative processing time is plotted for 20 experiments of 10 seconds. From the figure, we see that indeed the processing time decreases at increasing values of e_T. Note however the offset in comparison with the relative decrease in the number of control updates. This is mainly caused by the overhead of the event-generator part of the controller that compares the error with e_T. The straight dashed lines in the above figures show the results for the time-driven controller (which are not related to e_T).

References

[1] Årzén, Karl-Erik (1999). A simple event-based PID controller. *Preprints 14th World Congress of IFAC*. Beijing, P.R. China.

[2] Doff, R. C., M. C. Fatten and C.A. Phillips (1962). Adaptive sampling frequency for sampled-data control systems. *IRE Transactions on Automatic Control*, vol. AC-7, pp. 38-47.

[3] Sandee, J.H., Heemels, W.P.M.H., Bosch, P.P.J. v.d. (2005). Event-driven control as an opportunity in the multidisciplinary development of embedded controllers. *Proc. American Control Conference*, Portland, Oregon, USA, pp. 1776-1781.

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