Velocity and acceleration estimation for optical incremental encoders using time stamping

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1 Introduction

Optical incremental encoders are widely used to apply feedback control on motion systems where the position is measured at a fixed sample frequency. The accuracy is limited by the quantized measurement of the encoder. Velocity and acceleration information from incremental encoders can be obtained using only the position information [1], thus disregarding the variable rate of occurrence of the encoder events, or using model based methods such as observers [2].

This research employs the time stamping concept, in which both encoder counts and their time instants are used for the position estimation [3]. To obtain accurate velocity and acceleration estimations, the time stamping concept is extended with a skip option.

2 The skip option in time stamping

The time stamping concept stores encoder events (t_i, x_i), consisting of the encoder positions x_i and the time instants t_i the transition occurs, captured at a high resolution clock. Position information is obtained using polynomial fitting through n encoder events and extrapolation to the desired time instant.

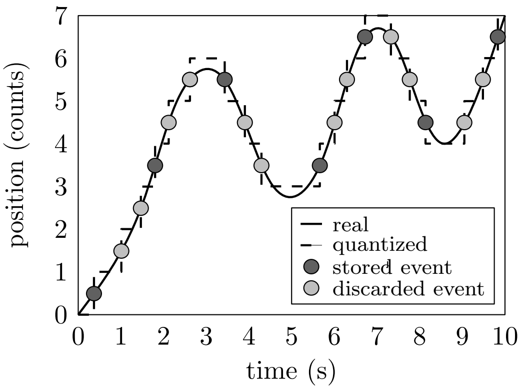
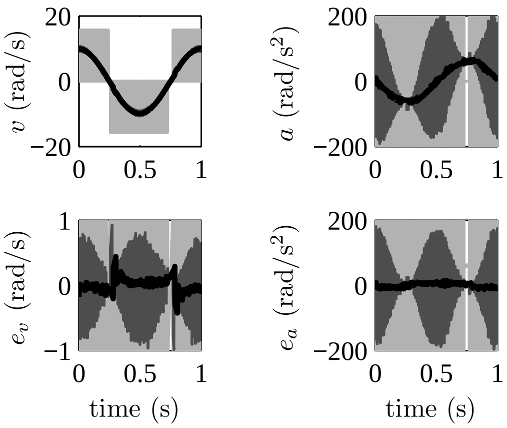


Figure 1: Visualization of the skip option for σ=2 counts.

The encoder events suffer from errors due to encoder imperfections, which act as a disturbance on the position estimation. The errors are amplified in the velocity and acceleration estimations. A skip option is proposed to skip σ events in between two stored events. This extends the time span covered by the events in the fit without the need for more events. The skip option is shown in Fig. 1 for $\sigma = 2$ counts.

3 Experimental results

The velocity and acceleration estimations of time stamping without skip and with $\sigma = 3$ are shown in Fig. 2 for a sinusoidal reference signal $r(t) = \pi/2 \sin(2\pi t)$. The estimation error of the velocity (Fig. 2(a)) with $\sigma = 3$ is 74% more accurate than without skip, i.e. $\sigma = 0$. For the acceleration, the estimation with $\sigma = 3$ is 92% more accurate than with $\sigma = 0$.



(a) Velocity estimation (b) Acceleration estimation

Figure 2: Experimental results, quantized measurement (light grey), σ=0 (dark grey) and σ=3 (black).

References

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[3] R. H. Brown and S. C. Schneider. Velocity observations from discrete position encoders. *IEEE conf. of the Industrial Electronics Society*, pages 1111–1118, 1987.