Data-based velocity observer using encoder time stamping

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1 Introduction

In motion systems, position measurements are often obtained using optical incremental encoders. The position accuracy is limited by the quantized position measurement of the encoder. Velocity and acceleration signals obtained by numerical differentiation are dominated by high-frequency content due to the quantization. In literature, several methods have been proposed to improve the position and velocity estimations using position measurements at irregular time instants [1, 2]. These methods often require a system model to be available or are not applicable in real-time experiments.

The research focuses on the development of a fully data-based observer. The observer can be applied in real-time and is based on the time stamping concept.

2 Time stamping

The time stamping concept uses the time instants of encoder transitions \( t_i \) together with their position \( x_i \) as shown in Fig. 1.

![The time stamping concept.](image)

The pair \((t_i, x_i)\) is called an encoder event. The proposed observer uses a number of stored encoder events to estimate the position, the velocity and the acceleration signals.

3 Signal estimation

The position estimation is performed by fitting a polynomial of order \( m \) through \( n \) encoder events by the least squares method \((m < n)\). Extrapolation of the fitted polynomial with coefficients \( p_0,...,p_m \) at time instant \( t_e \) results in the estimated position \( \dot{x}_c(t_e) \)

\[
\dot{x}_c(t_e) = \sum_{j=1}^{m} p_j t_e^j + p_0.
\]

The estimated velocity \( \dot{x}_e \) and acceleration \( \ddot{x}_e \) at time \( t_e \) are obtained by differentiation of the polynomial (1).

4 Experimental results

The estimated position \( \dot{x}_e \) does not exhibit quantization effects. The estimated velocity and acceleration signals of the time stamping concept are much smoother than the differentiated encoder measurements, see Fig. 2.

![Position, velocity and acceleration signals.](image)

Figure 2: Position, velocity and acceleration signals obtained by the quantized and differentiated encoder measurements (solid) and by the time stamping concept (dashed).

References
