Model Based Friction Compensation in a DC Motor

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1 Introduction

Friction modeling and identification is a prerequisite for the accurate control of electromechanical systems. In the literature, identification of friction in a motor system usually considers only classical friction models, such as Coulomb and Viscous friction. Presliding motion, which is apparent in many friction investigations, is usually neglected. The presliding regime is taken into account in some advanced models, such as LuGre model and the most recent Generalized Maxwell-Slip (GMS) model. Unfortunatelly, LuGre does not accommodate the unique behavior of presliding faithfully. The GMS model manages to overcome those difficulties by modeling friction as a Maxwell-Slip model where the slip elements satisfy a certain, new state equations [1,2].

Once the friction models have been optimized, position control incorporating friction compensation is performed [1,3]. For this purpose, the inertial force and friction behavior are compensated for using a feedforward control, while a simple (PID) feedback part is included to track set-point changes and to suppress unmeasured disturbances.

2 Modeling and Results

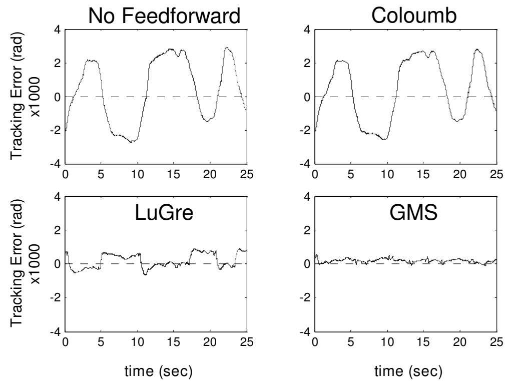
Experimental identification of friction in a DC motor was performed on an ABB motor type M19-S, with maximum rated torque of 0.49 Nm/amp and armature inertia of 0.001 kgm^2. To allow a straightforward position and velocity data collection on the motor, an incremental angular encoder was connected to the shaft through a toothed belt and two pulleys. The pulleys give reduction ratio of 1:3 to increase the sensitivity of the encoder, whose resolution is 5000 pulses per revolution. These signals were applied through a dSPACE-1104 acquisition card to the servo amplifier. The real current input to the motor, which is assumed to correspond to the torque was measured and recorded using the same acquisition unit.

A special command signal was used for the identification purpose. The signal is composed of a band limited random signal with cutoff frequency of 4 Hz, and enveloped by a rectangular signal in order to emphasize the behavior of presliding friction in the experiment. By means of a nonlinear regression process, the optimized sets of parameters in each model are obtained.

In order to validate the friction compensation, a different reference position signal was employed. The signal contains a filtered random signal with a small stroke. This signal was generated using a random signal generator, which is passed through a low pass, 4^{th} order digital Butterworth filter with 1 Hz cutoff frequency.

The tracking error of each friction compensation model can be seen in Figure 1 (All these results were obtained with the same PID controller parameters).

Figure 1. The tracking errors for random reference input



without FF compensation and FF compensation using Coulomb, LuGre and GMS model.

3 Conclusions

The superiority of GMS model is the ability to estimate the friction behavior in presliding regime, while it does not lose its ability to estimate the friction in sliding regime.
The nonlinear effect of friction in a high load torque DC motor is successfully compensated for in a feedforward-based control experiment. In the validation cases, GMS model yields by far the best results.

References

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