Simulation of backlash on rack-and-pinion axes for condition monitoring purposes

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Rack-and-pinion drives are one of the most commonly used drive types in large machine tools. Due to manufacturing tolerances and to avoid component wear, there is usually a backlash between the rack and the pinion [1]. In non-high precision machine tools, some amount of backlash is tolerated. However, large changes in the size of the backlash often indicate defects or problems in the machine axis. Therefore, monitoring this amount of backlash can be useful [4].

In this work, a simulation model of a machine tool with rack-and-pinion drives is used to investigate how backlash affects the dynamic behavior of the machine and measurable signals in order to develop methods for automatic backlash determination. For this purpose, a suitable modeling of backlash is presented [3]. By comparing the simulation results with measured data, the model is adapted and individual parameters are optimized. This is performed using a single drive train model and subsequently extended to the simulation model of an entire machine tool with multiple axes [2]. Using these simulation models, a method for the automatic determination of backlash is validated and the influence of different axle conditions and model parameters on the estimation quality is studied. It can be shown that with the help of a suitable simulation model, failure modes like too much backlash can be systematically analyzed and algorithms for fault detection can be developed. This is a great opportunity, especially in the field of condition monitoring or predictive maintenance, as it enables to evolve new functions without damaging physical machines and even to generate large amount of artificial data for the development of ML algorithms.

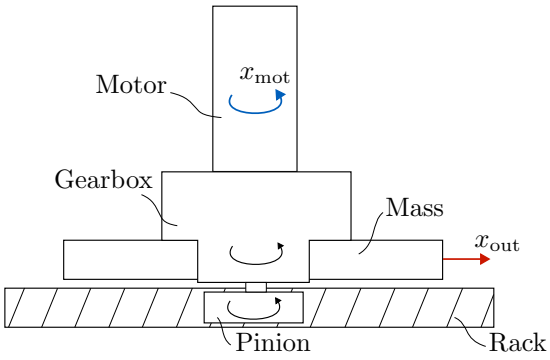

Figure 1: Sketch of a rack-and-pinion drive.

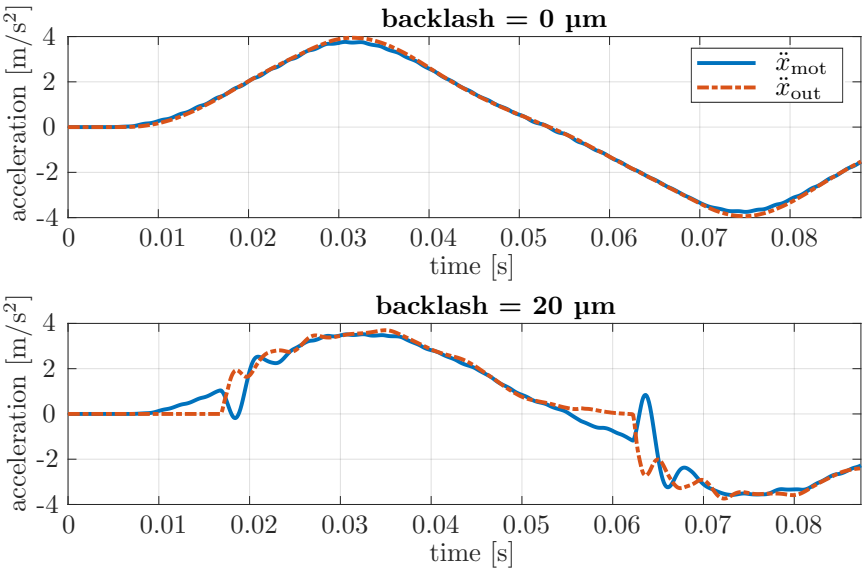

Figure 2: Simulated acceleration curves of the motor (mot) and the moved mass (out) during a positioning step with and without backlash.

References

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