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Dynamic modelling of a screw actuator for improved locomotion control on various terrains

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Different types of terrains can be encountered in mining environments, varying from hard rock bottom to mud, including gravel and sand. In our research we are investigating the usage of Archimedean screw actuators for locomotion in mining environments, as they are mechanically robust and can work on various substrates. The limitations on using screw locomotion in autonomous robotics include its inherent property of slippage that varies depending on the type of terrain. Moreover, the dynamic model of an Archimedean screw depends on variables such as shear stress or sinkage, which are difficult to measure with the onboard sensors. To accurately model and later control such robots, we focus on the dynamic modelling of the screw-ground interaction based on real experiments. In this work, we approximate the dynamics of an Archimedean screw to those of different tire models available in the literature. The proposed models are used to; (1) Simulate the ground-screw interaction with several types of grounds. (2) Estimate the robot pose based on odometry. (3) Design adaptive controllers able to control the robot in grounds with varying properties. We validate the proposed dynamic models based on experimental force measurements, and we evaluate the accuracy of the derived odometry models based on visually measured ground truth data.