MECHANICAL ENGINEERING STUDENT SEMINAR

Wednesday, Jun 07 2023 at 13:30, D. Dan and Betty Kahn Building, Auditorium 1.

Locomotion dynamics of an underactuated wheeled three-link robot

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The wheeled three-link snake robot is a well-known example of an underactuated system which is modelled using non-holonomic constraints, preventing lateral slippage of the wheels. These types of systems are called underactuated since their locomotion is generated by changing their shape, rather than directly controlling the body variables. A kinematically controlled version assumes that both joint angles are directly prescribed as phase-shifted periodic input. In another version of the robot, only one joint is periodically actuated, while the second joint is passively governed by a visco-elastic torsion spring. Our work extends the previous studies both theoretically and experimentally. We constructed the two versions of the wheeled robot and conducted motion experiments under different actuation inputs, measuring the influence of input frequency on the motion, both in asymmetric input gaits, and symmetric ones that cross singular configurations. Motion measurements for the kinematic shape-actuated configuration revealed significant influence of actuation frequency on the mean speed and displacement, which cannot be explained by the kinematic equation of nonholonomic constraints based on no-slip conditions. This effect is caused by non-negligible lateral slippage of the wheels, due to inertial effects, as well as nearing singularities. To account for slippage, and to avoid non-smoothness and numerical sensitivity incurred by Coulomb-type friction, we incorporated linear viscous damping friction forces for each axle into the model. In addition, rolling resistance of the wheels was also represented as linear damping for each wheel. After calibration of the roll/slip damping coefficients, we obtained good quantitative agreement with the experimental results. For the semi-passive configuration, the model predicts dependence on actuation frequency, even with no-slip constraints, and the effect of slip dissipation is increased for symmetric actuation which passes near singular states. This illustrates the importance of incorporating slippage and friction into the system's model.

Note: the seminar will be given in Hebrew

Seminars Coordinator: Assoc. Prof. Matthew Suss.