EXPLORING THE DOMAIN OF APPLICABILITY OF SIMULATED 2D RIGID BODY DYNAMICAL SYSTEMS

By

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ABSTRACT

In many common robotic manipulation tasks, the manipulation of nominally rigid bodies is a primary goal. Establishing a stable grasp of an object between two or more fingers is a common scenario in grasping applications. Other tasks that involve pushing, pulling, or caging of objects are also typical tasks in robotic manipulation. Often, such tasks as these fail due in part to a lack of understanding of the system's dynamics.

One approach to increasing the success rate of manipulation tasks involves executing a dynamical simulation of a manipulation trajectory before attempting it. Once simulated, the simulated system may provide useful information regarding the degree of success of the manipulation trajectory. If the simulation represents the dynamics of the physical system accurately, it may be used to reliably design successful manipulation actions.

In this thesis, I will be nominally focused on exploring the space in which a planar physical system composed of rigid bodies may be accurately simulated by a state-of-the-art planar rigid body simulator to within a certain tolerance. We will denote this space as the *domain of applicability*. This realm represents the space of system conditions in which the simulated system may be used to provide useful insight into the dynamics of the physical system it represents, without conducting physical experiments. We will conduct this search with heavy emphasis on *grasping* scenarios; i.e. scenarios in which our bodies represent a hand and object being manipulated.

To investigate this space, we will first determine the optimal set of model parameters for a set of physical experiments. This is formulated as an optimization problem, in which our objective function is an error metric defining the difference between simulated and experimental system trajectories for one set of system parameters. We will refer to this process as *calibration*. Once found, we calculate the error between our simulated and experimental results using this set of optimal parameters. If the error is less than a certain threshold for all the experiments in

this set, we conclude that the space covered by the set of experiments is a subset of the domain of applicability. We repeat this procedure iteratively, until the error for one experiment in the set exceeds this threshold, indicating that we have reached a boundary in our domain of applicability.

The results of this work provide evidence toward establishing tolerance bounds on the physical correspondence between a planar simulator and a physical planar system. Also, contributions to the calibration process, 2dgad database design, and planar testbed system were made as a result of this work. In addition, a large amount of planar experiment data that may be used for further analysis was introduced to the 2dgad database.