Dynamic Simulation of Manipulation & Assembly Actions

To grasp and assemble objects is something that is known as a difficult task to do reliably in a robot system. Yet humans are able to quickly learn how to manipulate and assemble objects based on previous experience. Most learn to do these tasks as infants and the knowledge from previous experience allows solution of new similar, but different, tasks intuitively. In the dissertation dynamic simulation is seen as a necessary tool to allow robots to get the same intuition for solving manipulation and assembly tasks. By virtual modelling of the task, simulation will allow robots to reason about the optimum strategies without complex programming by highly skilled specialists.

In the dissertation, a different paradigm is proposed for performing dynamic simulation in the context of tight-fitting assembly. A new physics engine is developed for this purpose. It focuses very much on the geometric aspects of contact generation and temporal coherence between contacts. This allows enhanced possibilities regarding modelling of the interaction between bodies in contact. Regarding development of robust control strategies for assembly, it is important to have a simulated environment that is realistic compared to the real environment. The problem with simulation of tactile sensors is that they lead to redundancy in the mathematical formulation of the dynamical system. In this dissertation, we present a method that includes an objective for distributed force measurements in the case of redundancy, and we show that this objective causes simulated force measurements that are more realistic and more ideal for control strategies.

The main purpose of the work performed in the dissertation is to make an engine which is easily extendable, well-documented and also has interfaces that makes it transparent what happens step-by-step during execution. An assembly simulation framework is presented with the purpose to create a unified way of defining assembly actions and results. This also forces the user to write control strategies that are reusable in both simulation and the real world.

Different comparisons are performed in order to qualitatively illustrate the benefits from using the newly developed engine for manipulation and assembly. This shows that our approach to dynamic simulation is viable and that, even though it adds some complexity to contact management, it is still very efficient in the tight-fitting assembly use case, while at the same time allowing detailed modelling of the interaction.