

Abstract

Deploying collaborative robots for assembly processes has a huge potential to support companies in reducing the lead time on new products. However, assembly processes can be challenging to automate, e.g., due to part complexity, variability, and validation requirements. There are two main challenges when programming robots for a robust assembly process. First, a kinematic assembly trajectory needs to be found. This trajectory specifies the robot assembly movements in Cartesian space. However, this is often insufficient to realize the desired product quality. Hence, a second task is often needed: finding an optimal compensation strategy in response to inaccuracies and fluctuating uncertainties. Robot programming for product assemblies is often done through a kinematic virtual simulation. Even though this is sufficient for obtaining the kinematic trajectory, it can be insufficient for programming and finding a suitable compensation strategy, since this requires simulating dynamic interactions. Dynamic simulation tools for robot programming exist; however, achieving efficient and accurate simulation of dynamic interactions in a tight-fitting assembly process is an ongoing challenge. Dynamic simulation engines are often based on discrete surface representations, such as polyhedral approximations, which can lead to excessive contact points that can affect the quality of the simulation. Simulations that are based on smooth surface representations do not have these flaws. Finding contact points between smooth surfaces is typically more computationally expensive, but once a contact point is found, it can be tracked efficiently.

This thesis investigates robot programming for assembly processes via simulation. First, simulation approaches for programming kinematic trajectories are studied in the context of automated generation of the assembly motion. The study presents approaches for programming kinematic trajectories in a simulation and demonstrates them on an industrial assembly task. Second, dynamic simulations of compensation strategies are studied. Specifically, tight-fitting assembly processes are studied, and a simulation tool is presented with a collision module based on smooth surface representations. Finally, it is demonstrated that the tool can replicate the behavior of a compensation strategy implemented on a real robot.