Cutting-Surface-Aware Object-Shape Manipulation for Removal Processes

Name: Takumi Hachimine

Laboratory's: Robot Learning Lab.

Supervisor's: Takamitsu Matsubara

Abstract (should be within 1st page)

Shaping methods include two types: deformation processes, which shape objects by pressing, and removal processes, which shape objects by removing unnecessary material from the base stock. Shape change has high degrees of freedom and is high-dimensional. Deformation processes have been automated by modeling shape deformation using data-driven approaches. However, applying such approaches to removal processes is difficult due to the high cost of data collection, the generation of removal resistance depending on process conditions, and the uncertainty of target shapes arising from unknown internal structures. In this dissertation, we propose a novel automation approach for object shaping by removal processes. We focus on the removal process performed by local surface contact between the tool surface and the object, and formulate shape transitions as a *cutting-surface* model that geometrically splits the shape. This model can be applied to various shape because it requires no learning. Based on this model, we propose automation frameworks for grinding and internal part extraction tasks. For grinding, we propose (1) a real-world-data approach, which compensates for removal resistance caused by process conditions by treating it as deviations of the cutting surface; and (2) a sim-to-real approach, which constrains actions to suppress removal resistance and reduces the reality gap between the cutting-surface model and the real world. For internal part extraction, we collect observations of the cutting surface for diverse internal structures using a simulator with the cutting-surface model. From these data, we build a model that estimates the internal structure from the observed cutting surfaces and propose a method that plans cutting positions based on the estimated structure. We evaluated the proposed automation approaches through real-robot experiments and simulation experiments.