論 文 の 内 容 の 要 旨
Abstract

論文題目　Research on Affordance-Focused Learning and Generalization through Observation of Proper Handovers and Object Usages in Robot-Human Interactions
(ロボットと人のインタラクションにおける適切な手渡し動作と物体操作の観察に基づくアフォーダンスに着目した学習と一般化に関する研究)

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Object handover is a common task arising frequently in many cooperative scenarios. Therefore, it is crucial that robots perform handovers well when working with people. However, determining the proper handover method for an object is a difficult problem since it varies depending on each object's affordances. Towards enabling effective human-robot cooperation, this thesis contributes a framework that enables robots to automatically determine handover methods for various objects by observing human handovers and object usages.

This thesis first documents a user study conducted to characterize and compare the handover orientations used by humans in different conditions. It puts forth the novel idea of object affordance axes for identifying patterns in handover orientations, and a distance minimizing method for computing mean handover orientation from a set of observations.

Next, this thesis presents an object grouping and classification method based on observed object usage for generalizing learned handover methods to new objects. Until now, a demonstrated method for generalizing handover methods

to new object has been lacking. The presented method focuses on a set of action features extracted from the movement patterns and inter-object interactions observed during usage. An experiment demonstrates the effectiveness of the method on grouping objects and then classifying new objects and computing proper handover methods for them.

The described framework for learning and generalizing handover methods is implemented onto a Kawada Industries HRP2V robot, and this thesis also documents the verification experiments. The implementation in this thesis overcomes the robot perception challenge of identifying a held object's pose at handover by detecting the object at the pre-occluded state and tracking its pose using a sequential Monte Carlo method. Results show that the framework allows robots to learn handover methods from demonstrations and compute proper handover methods for new objects. This is the first demonstrated system capable of automatically learning and generalizing handover methods from observations. Finally, integration into a household service robot application shows how this work this can enhance the capabilities of robots working in the real world by enabling them to work effectively with humans.

Through enabling better human-robot object handovers, this thesis contributes towards improving the interaction between humans and robots, thus, allowing safer, more natural, and more efficient human-robot cooperation.