A study on gestures at a hands occupied situation for manually controlling a helping hand robot

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SUMMARY OF Ph.D. DISSERTATION

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Title

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Abstract

A helping hand robot is one of the main focuses in human robot collaboration (HRC) research and has high potential in both modern industry and daily living usages. The helping hand robot could be considered as an extra hand that gives helps when both hands of a user are occupied by a task. A multimodal interaction between a human and a robot is an important requirement in HRC because robots are usually working and interacting closely with a user, it is essential to find natural and intuitive user interfaces between a user and a robot in various usage scenarios.

From many usage scenarios and multiple interaction possibilities, this thesis studied the use of nonverbal interaction such as hand and body gestures for controlling basic movements (forward/backward, up/down, and left/right) of an end effector of a helping hand robot. We focused mainly on a scenario when both hands are occupied and manually control is needed, therefore explicit gestures such as a waving hand(s) gestures cannot be easily performed by a user.

To get an idea about the suitable natural gestures for controlling the movements of an end effector, we conducted a pilot study with laboratory members and found that gestures those the members were asked to freely perform vary substantially. With this cue, we (1) set up a video based experiment to survey gestures for controlling movements of the end effector and (2) developed a real helping hand robot system for evaluating the discovered gestures.

To allow the participants to freely use any gestures which they feel suitable, we used a guessability study methodology for extracting gestures from the participants in the gesture surveying experiment. The experiment showed the ``effects" of gestures (a set of pre-recorded videos of an end effector movements) to participants and asked them to think about the ``causes" or gestures (e.g. tilting body) which they thought suitable and intuitive. Although results from this methodology depend on the background and experiences of each participant, the results led to a set of common gestures which were generic and intuitive for most participants.

By conducting the video based experiment with 19 voluntary participants, we captured and categorized 152 gestures. Our findings showed that a hand was a part of body used most often for gesture articulating even when the participants were holding tools and objects with both hands, that gestures for a pair of opposite movements such as up/down were consistently performed by most participants, and that the participants rarely care or aware of using one- or two- handed gestures interchangeable. From 152 gestures, we also found that there were many alternative gestures such as pursing lips, tilting head, and so on which could be useful for other situations such as a use for the handicapped persons.

By using results from the gesture surveying experiment, we implemented a helping hand robot using a small industrial robot for validating the discovered gestures. We used Microsoft Kinect sensors for sensing user's hand, and body movements. We implemented a gesture recognition algorithm using a state machine that checks distances of hands, arms, and body from their initial positions. The gestures that were a combination of hand, arm, and body movements could effectively be used to control movements of the helping hand robot by the participants.

With the implemented system, we conducted the second experiment with eight participants that used a real robot as a helping hand for a soldering task. The results showed that the selected hand and body gestures were easily accepted by the participants. The outcomes aligned with our expectation on the two most performed gestures from the video based experiment. However, in the real robot experiment, the body gestures were preferred over the hand gestures. This finding was unexpected but helped us confirm our intuition from the pilot study and the need of the real robot system implementation in the human robot interaction study.

Our findings could be useful as a guideline for acquiring natural gestures for controlling robots as a complementary for the multimodal interaction with a robot in HRC.