# Teaching Multiple Robots Using Tools Based on Robots Capabilities

# 論 文 の 内 容 の 要 旨

論文題目

Teaching Multiple Robots Using Tools Based on Robots Capabilities

**(ロボットの性能を考慮した，ツールによる複数ロボット教示)**

氏　　名　　フィゲロア　エレディア　ホルヘ　ダビド

In past decades, we humans, have begun to incorporate robots into our lives in order that they assist us in tasks with different purposes. However, it is difficult to pass the information related to how to do a task for robots, this due to the complexity of human tasks we are able to do, according to our capacity, mentally and physically (mobility, managing our strength, etc.).

To overcome the limitations that exist between the robot capabilities with respect to human capabilities, the use of multiple robots has been adopted and successfully implemented in various fields and in an extensive range of tasks. The information of how to perform each particular task, has traditionally been transmitted to multiple robots by programming robots in advance, the robotic actions that each robot has to do are assigned and programmed by a human with programming background to successfully realize the task.

To better exploit the potential of systems that use multiple robots, a method that enables a human to transmit / teach information related to how to do tasks to robots is required.

The most practical way for humans to teach how to do a task is by demonstration, therefore, it is required that the proposed method is capable of extracting information during the demonstration of the task by a human, and decide how to analyze and distribute this information among multiple robots. However, it is important to consider how to deal with the gap in capabilities between robots and humans, in this study a method for teaching multiple robots by a human in where the robots limitations are respected is proposed.

Most of the tasks that the human does, involve the manipulation of objects. Based on this assumption, the design and use of a tool during task demonstration by a human is proposed. The design of the tool is based on the capabilities that tools to manipulate objects mounted on robots have. Thus, by restricting the mobility of human, limitations of capabilities of robots can be considered while the experience of humans in manipulating objects is involved, the generation of information during the demonstration can be carried out more easily with the use of various sensors incorporated in the designed tool.

In the first stage of this study, the focus is on allowing one human teach one robot by using a tool on how to grasp objects from specific positions. The design of the tool is intended to mimic the mechanism of the tool mounted in one particular robot, the human movements are restricted to thereby respect the limitations of robot capabilities, and be able to transmit information generated to the robot, in a more direct way. To extract and build the program for the robot, a system composed of several devices and sensors supported by a GUI which

guides the human during the teaching process is proposed.

In the second stage, the study focuses on teaching multiple robots by a human who used a tool to demonstrate tasks which involve different styles of manipulation of objects. Considering the experience in the previous stage, another tool that could not only mimic the mechanism of the manipulation tool mounted on one robot, but mimic the tools mounted on several robots is designed. The level of restrictions on the movements of humans while using the tool were also decreased, thus the range of tasks human can teach increases. An approach where the extracted data are used to first classify the type of style of manipulation used in the task intended to be teach is proposed, then, it is proposed to use a series of heuristic rules to determine the type and number of robots that human requires to teach. Finally, robot programs are generated by a process in which humans teach robots how to perform human actions into robotic actions. The realization of each step that integrates this approach is carried out by a human interaction with the system through several graphical user interfaces (GUI).

The method that allows a human to teach robots how to perform tasks needs to guarantee safety for robots and humans. In this context, the trajectories assigned to robots, as well as the rate for sending robotics commands inside the current programs might be not the ideal. Therefore, robots should be able to adapt their behaviors based on their hardware capabilities and the knowledge acquired after executing the basic program taught by a human.

Through modification of the trajectory and acceleration or deceleration of the

speed when executing basic robotic behaviors, it is proposed an approach that allows to refine programs taught by a human, so that robots can minimize the execution time of tasks.

The proposed approaches are evaluated and based on the experimental results, the proposed methods proved to be efficient to teach multiple robots quickly using tools designed based on the characteristics of robots to used.