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**DOCTOR OF ENGINEERING SCIENCES**

of  

Elahe Bagheri

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**IMPROVING HUMAN-ROBOT INTERACTION THROUGH EMPATHY AND TRANSPARENCY**

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Abstract of the PhD research

The number of robots that are in direct interaction and close proximity with humans is increasing. In most of these interactions, the robot tries to help the human partner, however, the types of the provided help are different. Some are for providing emotional support for the human partner, e.g., robots in elderly houses, and some others are for reducing the human’s workload, which is mostly seen in industrial areas. Although the types and purposes of these interactions are different, the more the interaction is natural and smooth, the more the human partner accepts the robot and is willing to continue the interaction with it. Thus, the main goal of this thesis is to develop a framework that enhances the interaction between humans and robots, including both social and collaborative robots, by providing human-like characteristics, e.g., empathy and transparency, for robots.

While social robots are centered in more domestic and public social environments like hospitals, schools, and hotels, collaborative robots are mostly used in workshops and industrial environments. Therefore, the strategies to improve their interaction with humans are different. Since the former robots are used in social environments to interact with different groups of society, it is useful to enable them to establish an interaction that considers humans’ feelings and emotions too, since humans usually evaluate and adjust their behaviors based on their interactant’s feelings, which is also called “empathy”. Studies showed that expressing empathy by robots helps them establish friendly, caring, and trustful relationships with humans. Therefore, this thesis proposes an empathy model for robots that enables them to adapt their behaviors according to the personality and emotional state of the human they are interacting with, to improve their interaction. The proposed empathy model contains two main modules, i.e., an emotion detection module, which enables the robot to detect six different emotional states, and a learning module, which enables the robot to learn the most appropriate empathic behaviors based on the human’s personality type and emotional state.

Further, humans are also working with collaborative robots in industrial environments. While humans benefit from robots’ precision in repetitive tasks, they need to supervise them and perform the mentally demanding parts of the shared task. In this condition, one important aspect of working with a collaborative robot is being able to trust that it performs the assigned task correctly. One characteristic that can lead to such trust is transparency since through transparency the robot is able to explain the rationality of its actions. Thus, this thesis proposes two transparent assembly models through which robots are able to learn new assembly tasks and generate explanations about the strategy they take to accomplish the task. In this manner, if human partners are not sure whether the robot’s action is correct or not, they can ask the robot about the reason for its action, and the robot can clarify and justify its action, which not only prevents some potential conflicts between them but also enables the human partner to supervise the robot and speed up the learning phase. The proposed transparent model has two main modules, i.e., a learning module, which applies a reinforcement learning model to enable the robot to learn its task, and an explanation generation module, which enables the robot to explain the rationale behind its actions.