Richert

Learning and imitation in heterogeneous robot groups

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Learning and imitation in heterogeneous robot groups

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Abstract

As robots become increasingly affordable, they are used in ever more diverse areas in order to perform increasingly complex tasks. These tasks are typically preprogrammed by a human expert. In some cases, however, this is not feasible – either because of the inherent complexity of the task itself or due to the dynamics of the environment. The only possibility then is to let the robot learn the task by itself. This learning process usually involves a long training period in which the robot experiments with its surroundings in order to learn the desired behavior. If robots have to learn a shared goal in a group, the robots should imitate each other in order to reduce their individual learning time. The question how this can be done in a robot group has been considered in this thesis, i. e., how robots in a group can *learn* to achieve their shared goal and *imitate* each other in order to increase the performance and the speed of learning by spreading the learned knowledge in the group.

To allow for this intertwined learning and imitation, a dedicated robot architecture has been developed. On the one hand, it fosters autonomous and self-exploratory learning. On the other hand, it allows for manipulating the learned knowledge and behavior to account for new knowledge gathered by the imitation process. Learning of behavior is achieved by separately learning at two levels of abstraction. At the higher level, the strategy is learned as a mapping from abstract states to symbolic actions. At the lower level, the symbolic actions are grounded autonomously by learned low-level actions.

The approaches of imitation presented in this thesis are unique in that they relieve the requirements that governed multi-robot imitation so far. It enables robots in a robot group to imitate each other in a non-obtrusive manner. The robots can thus increase their learning speed and thereby the overall performance of the group by simply observing the other group members without requiring them to stick to a certain communication protocol that would provide the necessary information. With the presented approach, a robot is able to infer the behavior that the observed demonstrator is performing and to replay the beneficial behavior with its own capabilities.

In addition, the presented approaches allow the robots to apply imitation even if the group is heterogeneous. Normally, the performance of a group degrades if robots with incompatible capabilities imitate each other. Capability differences arise if robot morphologies differ in a robot group. This is the case if different robots from different manufacturers form a robot group that has to achieve shared goals. This thesis presents an approach that is able to determine similarities or differences between robots. This can guide the robots in a heterogeneous robot group in order to determine those robots for imitation that are most similar to themselves.

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