Improving Robotic Assistance with Reinforcement Learning for Motor Learning

Background:

The interest in using robotic systems to improve motor skills has significantly increased in the last years (e.g. in sports training and neurorehabilitation). One of the most popular ways of providing robotic assistance for motor skill training is haptic guidance.

Figure 1: An example task designed, interacted via Delta.3 from Force Dimension.

In conventional haptic guidance strategies, motions of subjects are constrained to static pre-defined paths by applying forces. Although this strategy allows subjects to practice tasks/movements beyond their capabilities, it has been found to be inefficient in some cases. Constantly constraining the motions to a static path might reduce participants' effort and prevent them from exploring different (and maybe more efficient) ways/paths to accomplish a given task. Furthermore, as the complexity of the motor task increases, it becomes extremely hard to implement a haptic guidance which is helpful for the task.

In this project, we would like to use Reinforcement Learning methods to learn how to assist the subjects in a complex motor task. The first part of the project is to choose or design a motor task that is complex, yet meaningful for clinical use. The second part is to come up with a flexible yet effective parameterization for the haptic guidance mathematical model (e.g. attractive radial basis functions). Later, you will use Reinforcement Learning methods with a suitable value function (e.g., neural networks) to learn the optimal parameter values of the haptic guidance by both using simulated data and real human data taken with the robot. Once the learned haptic guidance method is working effectively, it will be compared with a conventional haptic guidance method on healthy human subjects.

Outline:

1. Literature research: Motor tasks and Reinforcement Learning methods.
2. Implementation: Implementation/integration of the task, and the controllers.
3. Improving the implemented haptic guidance controller with Reinforcement Learning.
4. Comparing the new haptic guidance with conventional haptic guidance.
5. Scientific reporting: Scientific reporting of the methods and results.

Materials and Methods:
Virtual game environment (Unity3D, C#), haptics for the robot (Delta.3, C++).

Requirements:
Python and basic C++ skills. Basic motion control knowledge, and high motivation to learn machine learning (mosty reinforcement learning).

Supervisor:
Prof. Dr. Laura Marchal-Crespo, Özhan Özen
Institutes:
Motor Learning and Neurorehabilitation Lab at ARTORG Center (UniBern) and Department of Neurology, Inselspital

Contact: laura.marchal@artorg.unibe.ch