INTELLIGENT CONTROL OF EXOSKELETONS THROUGH A NOVEL LEARNING-FROM-DEMONSTRATION METHOD

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Abstract

We present a novel concept that enables the intelligent and adaptive control of exoskeletons through exploiting our state-of-the-art learning from demonstration (LfD) method, namely Conditional Neural Movement Primitives (CNMPs) [1], on our integrated system of a soft suit and a robotic exoskeleton [2]. Learning of complex locomotion trajectories is aimed to be achieved first by learning from demonstrated trajectories of healthy walking human subjects, next by refining the skills using Reinforcement Learning (RL) methods taking into account the balance and energy consumption of the exoskeleton system, and finally by realizing feedback-based control that enables robust execution in the face of external unexpected perturbations. To the best of our knowledge, LfD and RL based exoskeleton trajectory control is new in the field where existing ones are limited to trajectory generation without taking into account the exoskeleton-human interaction dynamics. Our LfD method can extract the prior knowledge directly from the training data by sampling observations, and uses it to predict a conditional distribution over any other target points. CNMPs specifically learn complex temporal multi-modal sensorimotor relations in connection with external goals, produce movement trajectories, and execute them through a high-level feedback control loop.

To react to unexpected events during action execution, CNMP can be conditioned with sensor readings in each time-step. To transfer learned knowledge from human demonstrations to control of our exoskeleton that has different physical properties, we extend CNMPs with state-of-the-art RL methods emphasizing generalization.

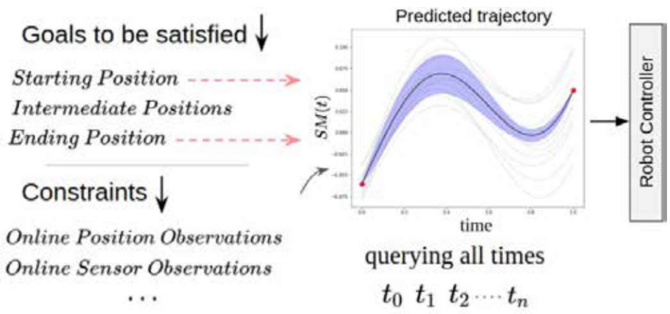

Figure: A number of potential motion trajectories are provided to the system, and a new trajectory is generated.

References

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Short Biography

Evren Samur is currently an Associate Professor of Mechanical Engineering at Bogazici University. In 2010, he received his Ph.D. in Robotics from EPFL, where he specialized in haptic interface development and evaluation. This work was supported by the Scientific and Technological Research Council of Turkey (TUBITAK 118E923).

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