University of Stuttgart

Institute for Adaptive Mechanical Systems

Master's thesis
Term paper

Teaching a Muscle-Driven Robot Arm to Write

Topic Areas:	Hardware Implementation, Optimal Control, Machine Learning
Advisors:	Sven Schepp (IMSB) sven-robin.schepp@imsb.uni-stuttgart.de
	Nikola Velimirović (IAMS) velimirovic@iams.uni-stuttgart.de
Responsible Professor(s):	Prof. C. David Remy, Prof. Syn Schmitt
Prerequisites/Prior Knowledge:	Matlab / Python, MPC, Machine Learning (DNN)

Bioinspired robotics is a rapidly advancing field that draws inspiration from biological systems. This approach holds immense potential for innovative developments, including the design of more efficient and adaptable robots. For this thesis, the institutes IMSB and IAMS collaborate to advance the field of bioinspired robotics, and to research the construction and control of robots that employ innovative actuation concepts with the aim of understanding underlying principles such as morphological computation and inherent compliance.

The subject of this project is a robotic arm that is actuated by pneumatic artificial muscles (PAMs), which are driven by industrial valves and controlled by an Arduino (Figure 1).
We aim to investigate whether our robot is capable of dexterous movements, including writing letters or drawing simple images. In a first step, basic trajectory following should be realized by applying well-established techniques in data-driven system identification and optimal control. Specifically, an empirical system model must be found, which informs a MPC controller (see Figure 2) tasked with determining which actions the robot should perform given a predefined trajectory.
Afterwards, these results can be compared to end-to-end data-driven control techniques, such as reinforcement or deep learning controllers.
Passion for working with software and hardware, as well as the motivation to improve technical skills are essential for successful participation in this project. Basic knowledge of supervised/ unsupervised machine-learning techniques and previous experience in solving optimal control problems are helpful.

The overall scope of this project can be adjusted based on the thesis type.

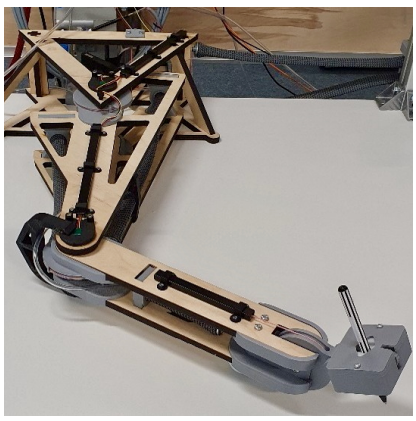

Figure 1: Robotic Writing Arm Setup

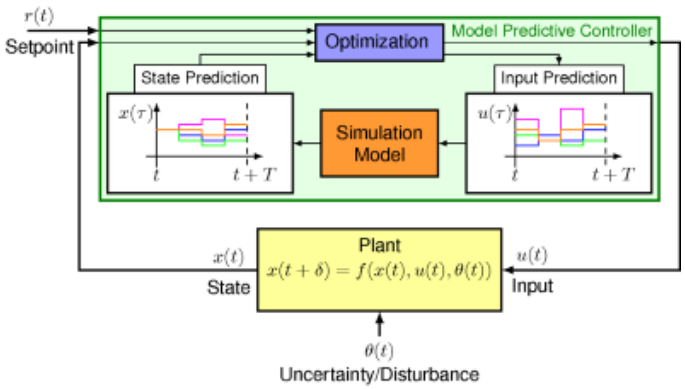

Figure 2: Illustration of MPC Scheme (IST)