A Self Leraning Robotic Arm

AUTHOR

Harshvardhan Vala
BTech Computer Science and Engineering
IIT Gandhinagar

AFFILIATIONS

INTRODUCTION

Robotics is changing the world rapidly around us. Automated systems have become a huge part of our life and are widely being used across the industries. A robot that can learn movements and sense and react to its environment in order to complete certain tasks, can achieve a major breakthrough that will further help us realize larger goals in future.
This project deals with working out with an algorithm that will help a robot to self learn. The project was mainly related to two types of controller- Model Based Iterative Learning Controller (MBIL) and a Reinforcement Learning based controller.

OBJECTIVE

The main objective of this project was to perform extensive simulations on a 2R robotic manipulator using a model-based iterative learning controller (MBIL) and RL controller. We also want to analyze its behavior by introducing perturbations, and changing the various parameters of the controller and the environment around the robot. We also want to check whether the controller is able to demonstrate basic human qualities such as retention, savings and generalization. At the end, after implementing the same task in RL controller, we want to compare the performance of the RL and MBIL controller.

METHODOLOGY

The MBIL controller was based on 8 basic controller equations. There were mainly six parameters whose affects we wanted to analyze and check their effect on retention, savings and generalization. There were also environment related parameters that we wanted to analyze. We introduced various types of perturbation environments to see how the 2r robotic arm adapted to the situation for a simple reaching task. We introduced fixed force perturbation as well as velocity based perturbations. We also tried to implement an RL based controller in python using DDPG algorithm as well as in MATLAB simulink.

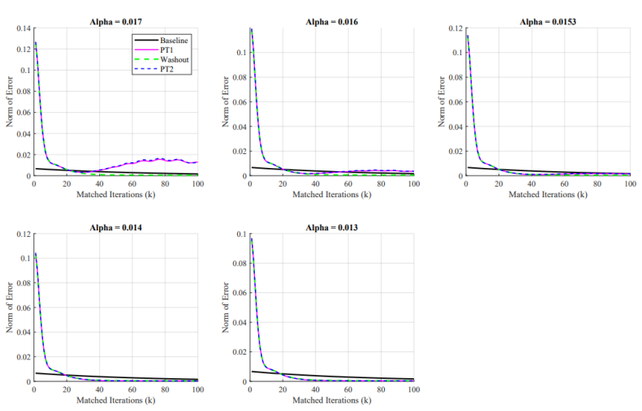
RESULTS

The MBIL controller showed retentions, savings and generalization. The simulation results were very similar to the results that showcased human behavior. These results however were quite sensitive to change in those parameters. We also successfully implemented an RL based controller without any dynamics involved. However, it was difficult to implement it by introducing dynamics and actuator controls. After successful implementation of the RL based controller using MATLAB Simulink, we were able to compare the two controllers' performances.

ANALYSIS

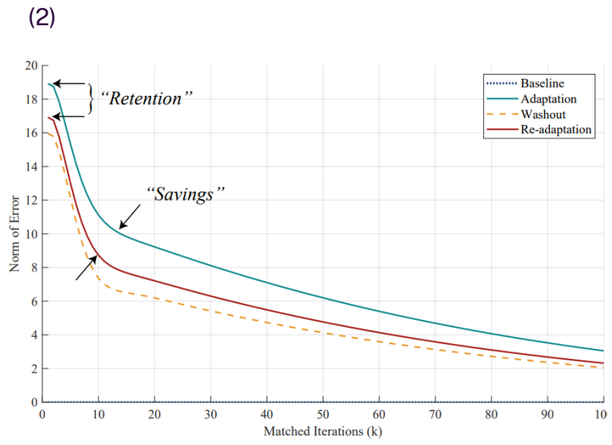
Figure 1 is one of the analysis done for varying 'alpha' parameter. Two more similar graphs were plotted for the same parameter. A total of three graphs were made for each parameter of the controller as well as force field controlling parameters. Figure 2 and Figure 3 are similar plots plotted for MBIL controller and the RL controller for comparing their performance. We can see savings and retentions aren't seen much for the RL controller. Again other similar analysis were performed for comparing the RL controller with the MBIL controller.

(1)



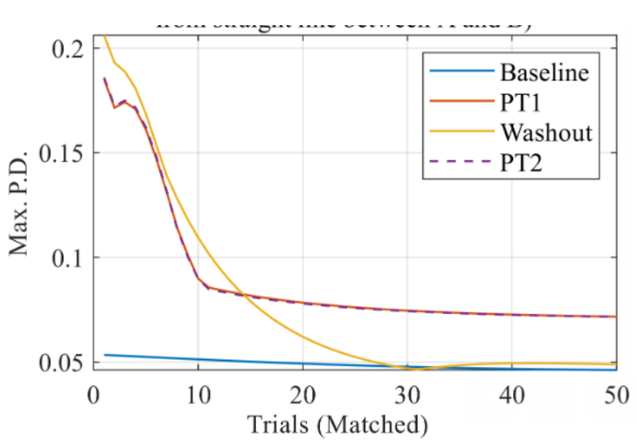
(MBIL Controller)

(2)



(MBIL Controller)

(3)



(RL Based Controller)

CONCLUSION

The Model Based Iterative Learning Controller, is able to depict human behavior for a simple reaching task under fixed force perturbations. The entire behavior of the 2R robotic arm manipulator is very sensitive to all the parameters. On comparing the RL based controller with the MBIL controller, we realize that RL controller is unable to show features like savings and retention as is the MBIL controller.

REFERENCE

1. Kadam, S. D., Jadav S. V., and Palanthandalam-Madapusi, H. J., 2022, "A Model-based Feedforward and Iterative Learning Controller With Human-like Learning Properties Exhibiting Human-motor-learning Features" (under review, IEEE Transactions on Cognitive and Developmental Systems, January 2022)