Proposal

A novel robotic handwriting-learning system based on Dynamic Movement Primitives (DMP)

PI: Matthew Gombolay
Student: Jing Wu, Qian Luo

PROJECT DESCRIPTION

1 Introduction

In this project we will design a robot learning system which could imitate human's handwriting based on a few samples. Considering most handwriting-learning robots learn from handwriting images without considering human's motion [Kul+12] , we can compare and combine this method with image recognizing method further. Our robotic system can accurately record data of human's writing action(demonstration) use the collected data to perfect the performance of learning process and apply the learned algorithm for a real robot arm to generate trajectory. Therefor, the robot arm could write letters in a similar way as human teachers, which is a case of 'Learning from Demonstration'. We will generate variable movement patterns (handwriting trajectories) mainly based on dynamic movement primitives (DMP) algorithm. The purpose of this project is to modify the original DMP algorithm and apply a new method to reproduce the target trajectory with higher accuracy regarding both the position and the velocity information.

2 Methods and Objective

The platform we use to locate the position of our pen is a motion capture equipment, which consists of eight laser emitters and a laser reflection sensor on the pen. We use this set of equipment for collecting data as our 'target trajectory', which is the way human teachers write. To generate the trajectory, we will test on modified DMP, such as DMP+ [Ruo+16] and combine DMP with other liable algorithms to improve the performance. Given a certain letter and create a new trajectory using certain method, we can produce certain parameters from certain human teacher. After we get learned and modified parameters, we can apply it to the robot arm to generate a trajectory which does not occur in previous data to prove the correctness of the parameters and the upper limit of DMP algorithm. For the data-set part, we will invite about 15 people to write down different letters and record their movement data. If this algorithm (DMP) works well, we plan to use different frameworks to reproduce the trajectory and compare different learned algorithms in the simulation environment or in real world. The final outcomes (letters written by robot arm) are expected to be similar with the ones written by corresponding human teachers.

3 Timeline

10.08—finish project proposal.
10.18—finish collecting basic handwriting data via motion capture equipment and use basic DMP to reproduce trajectory.
10.28—try to modify DMP to enhance the accuracy of the trajectory and do some basic analysis.
11.04—project update. At least accomplish high accuracy imitation of handwriting trajectories in the simulation environment.
11.14—get familiar with the control of the real robot arm and apply the method to create robot handwriting trajectories.
11.24—collect final samples of demonstrators and analyze the data.
12.12—finish the paper and prepare for final presentation.

4 The Heilmeier Catechism

4.1 What are you trying to do?

Articulate your objectives using absolutely no jargon. We will design a robot learning system which could imitate human's handwriting.

4.2 How is it done today, and what are the limits of current practice?

Many handwriting robots nowadays could imitate the trajectories accurately. However, they usually learn from handwriting images without considering human's motion (3D scale)

4.3 What is new in your approach and why do you think it will be successful?

We have a more accurate way to get the data and our imitation of 3D trajectory would be more significant in imitating handwriting process.

4.4 Who cares?

This method is worth-trying for exploring the possible algorithm for robots to write like humans even when the specific trajectory is not inserted in the robot's memory.

4.5 If you are successful what difference will it make?

If working, it will be a progress for produce robots that can help people who cannot write with personalized writing style.

4.6 What are the risks?

There might be imprecise imitation because the trajectory might be quite complex comparing to 2D scale.

4.7 How much will it cost?

Currently, it will cost zero because the fetch robot and motion capture equipment are borrowed from another lab in the RIM.

4.8 How long will it take?

About 2 months.

4.9 What are the mid-term and final "exams" to check for success?

We have a project update in the mid-term to show our progress, and the final "exams" are our paper and final presentation.

Bibliografia

[Kul+12] T. Kulvicius, K. Ning, M. Tamosiunaite i F. Worgötter. „Joining Movement Sequences: Modified Dynamic Movement Primitives for Robotics Applications Exemplified on Handwriting". W: *IEEE Transactions on Robotics* 28.1 (2012), s. 145–157. DOI: 10.1109/TRO.2011.2163863 (cyt. na s. 1).

[Ruo+16] Ruohan Wang, Y. Wu, Wei Liang Chan i Keng Peng Tee. „Dynamic Movement Primitives Plus: For enhanced reproduction quality and efficient trajectory modification using truncated kernels and Local Biases". W: *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2016, s. 3765–3771. DOI: 10.1109/IROS.2016.7759554 (cyt. na s. 1).