



UNIVERSITÀ
DI SIENA
1240

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE E SCIENZE

MATEMATICHE

Computer and Automation Engineering

ROBOTICS AND AUTOMATION

Closed loop approach to Human-robot handshake

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A.A. 2017-2018

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Abstract

Closed loop approach to Human-Robot Handshake

The following Master's Thesis wants to exploit the Human-Robot interaction when it comes to the handshake event. The handshake event between human beings is a well known task, it is able to transmit participants feelings as a mixture of physical features like: strength of the handshake, velocity approach, duration of the handshake, oscillation frequency of the wrist, etc.. The target of this work is to set up an environment in order to test different closed loop controllers for the handshake event. The environment includes: The Pisa/IIT SoftHand, four FSR 400 sensor plugged to an Arduino Uno, all the communication are managed by Robotic Operating System (ROS). The FSR sensors are varying the voltage of the attached pins proportionally with the applied force, the work is splitted in two main experimental parts: the calibration and the tests. The calibration part is an open loop system in which the Pisa/IIT SoftHand is executing pseudorandom closures and the FSR are recording what the human is doing. The hypothesis is to model the human response to the handshake as a spring, once this part is completed different models are fitted to the data and are embedded, for the tests, into the closed loop controller which is varying the closure position of the Pisa/IIT SoftHand with respect to the online readings of the sensors.

Introduction

The following work wants to explore the phases of the handshake between a human and a robot, reaching a consensus in the human-machine interaction. The handshake event can be divided in two steps: the approaching and handshaking. The consensus is a parameter that allow the human to evaluate a handshake mixing aspects like: duration of the event, dynamics, force exchanged etc.. The handshake is the most common human-human interaction and is extensively used worldwide in events like: greetings, introduction routine between human beings and agreements. This work focuses only on the latter handshake step, with the purpose of evaluating different models for the closed loop controller.

Chapter 1

The state of the Art

Develop a robot capable of performing a smooth human-like handshake is still a highly interested topic in the scientific literature. A natural handshake between two humans is a very complex task to replicate, this work just focuses on the interaction force between the artificial hand and the human hand. The consensus is a complex task to encode inside a robot, the human will easily distinguish the event with respect to another human or to a robot. A human will take into consideration the skin feedbacks like: the temperature, the humidity and the softness. These are all characteristics that are still not embedded into the hardware available in the market. The aspect taken in consideration in this work is the grasping force exchanged in the handshake. Robots, nowadays, are highly involved in industries where mostly they have to execute repetitive tasks. These kind of robots, when it comes to grasping objects, commonly uses multi purposes grippers[2]. The grasping force exchanged in the human-Robot handshake event is a complex value to identify, therefore this work is estimating the grasping force from values which can be clearly identified.

[5] [3] [6] [4]

Chapter 2

The Idea

The idea is to create a closed loop controller for the human-robot handshake event, using hardware as simple as the soft hand produced for research purposes at Università degli studi di Pisa and augmenting it with four independent FSR sensors which uses an Arduino uno in order to communicate the data. The FSR sensors are located on the robotic hand so there are no wearing device on the human hand during the execution of the experiments. This choice lead the work to be focused in the theoretical part of the handshake event, and potentially reach robust results. The chosen robotic hand (Pisa/IIT SoftHand) has 19 degrees of freedom and its main characteristic a single dc motor that is pulling a tendon which is embedded in each phalanx. This physical approach results in an under actuated robotic hand which can be controlled only by the dc motor.

Chapter 3

Hardware setup

3.1 The Pisa/IIT SoftHand

The Pisa/IIT SoftHand is a simple, robust and effective hand designed for grasping and soft manipulation presented in [1], the hardware is provided with a controller developed by the same group which implements a PID [fig. 3.1] on the motor position. This enables the researchers to control the Pisa/IIT SoftHand with a reference position, without dealing with the current control of the motor. The proportional coefficient can be set up as preferred since its read from ROS as a *roscparam*, this parameter is thought to range between 0 and 1.0. Setting the parameter to 1.0 is minimizing the error value $e(t)$ between the setpoint $r(t)$ and the output $y(t)$. The reference position is a value which should be defined, this robotic hand is under actuated, therefore there is no 1:1 correspondence between the physical position movement of the fingers and the movement of the dc motor. Having a single motor to control makes the robotic hand really easy to control but introduce uncertainty on the position of each finger. A tendon is running through all the fingers and is pulled by the dc motor, therefore, the only available information is the overall movement of the Pisa/IIT SoftHand.

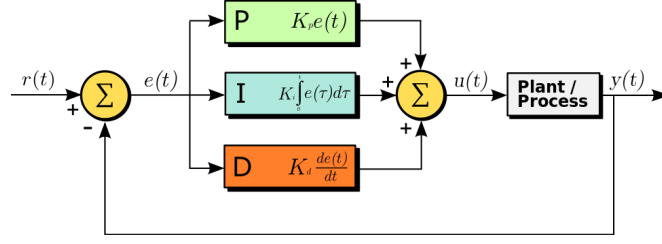


Figure 3.1: Block Diagram PID controller in a feedback loop

3.2 The Sensors

The core of the closed loop control is to have a feedback in the whole system which is proportional to the force applied during the handshake from the human. The sensors used in this work are Force Sensitive Resistors measuring the force applied from the human to the Pisa/IIT SoftHand, in order to decouple this force from the one applied from the Pisa/IIT SoftHand to the human hand, an extensive study[[3]] in handshake has been done and the physical interaction during the handshake has been setted up accordingly. These mentioned sensors are the more natural choice for handshake experiments since the response time to the system is negligible with respect to the dynamics of the handshake event.

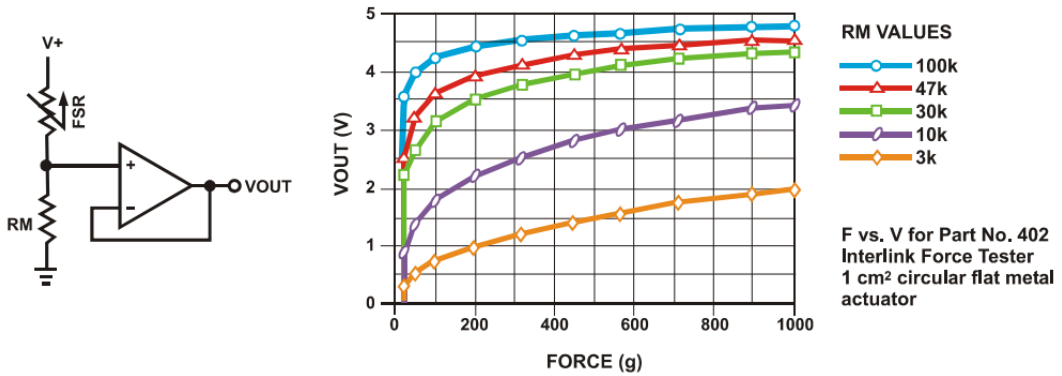


Figure 3.2: FSR Voltage Divider

The physical position of the FSR sensors is shown in the figure 3.2

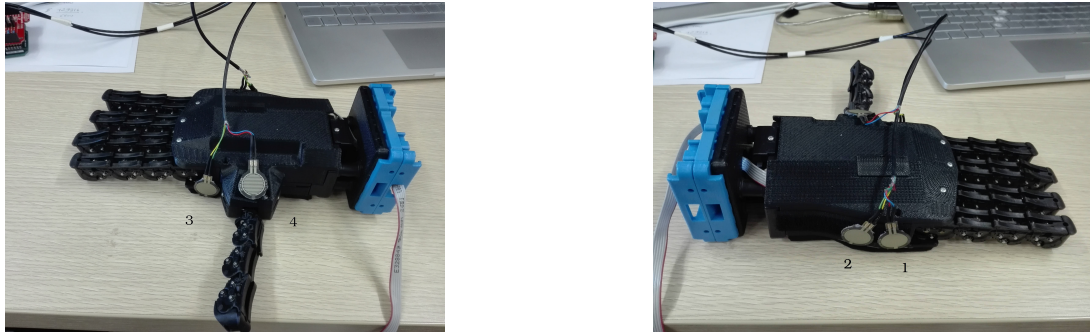


Figure 3.3: FSR sensors position

3.3

Chapter 4

Software setup

The experiments described needs a software capable of exchanging informations between robots, without the interaction of a human, therefore the Robot Operative System has been chosen in order to manage the informations between the devices involved in these experiments.

4.1 Ros

The Robot Operative System (ROS) is a set of frameworks and libraries useful for robot software development. The logic of this software is really intuitive, it lets the developers to represent a device as node inside a graph. Each device is therefore a node inside this graph, and all the communications are going through a main node, also called master node, which takes care about forwarding the informations between nodes.

Conclusion

This project applies learning [?] techniques to MNIST handwritten dataset. As we can see in the previous confusion matrix the accuracy of the final work is 97.6%. The overall idea is to train *autoenc1*, *autoenc2* and *softmax1* once per time and to crop the nets in order to have coherent dimension between network interconnections. At the end of [?]this process we stack all the partial neural network together and the deep neural network come to life.

The satisfaction behind this project can be experimented by running the file "MNIST_drawsim.m" which is a matlab function that allows the user to draw a digit and returns the correct digit value 97,6 times over 100.

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