Human-robot handshake experiments

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1 Environment

The environment for this experiment includes: pisa/iit softhand, four FSR 400 sensors plugged to an arduino uno managed by Robotic Operating System. The FSR sensors are varying the voltage of the attached pins proportionally with the applied force. The physical position of the sensors and their id on the softhand is shown in the following figure:

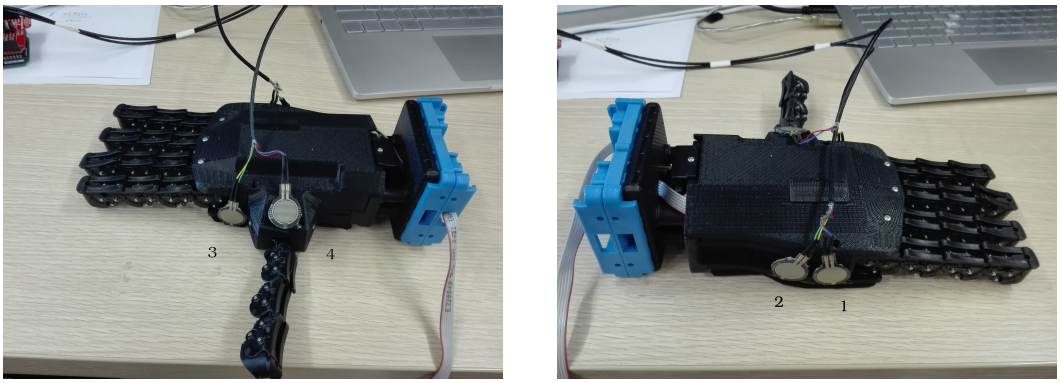


Figure 1: softhand with FSR sensors

The system ROS is taking care about the connection between the devices involved, the following figure 2 shows the node graph. The node '/steps...' is the created from the script executing the experiment, is responsible for sending the reference position to the node of the softhand /qb_interface_node and for saving the data coming from the FSR sensors /sensors_FSR and from the softhand itself /qb_class/hand_measurement. Ros nodes are displayed with en ellipse and ros topics are displayed with rectangles.

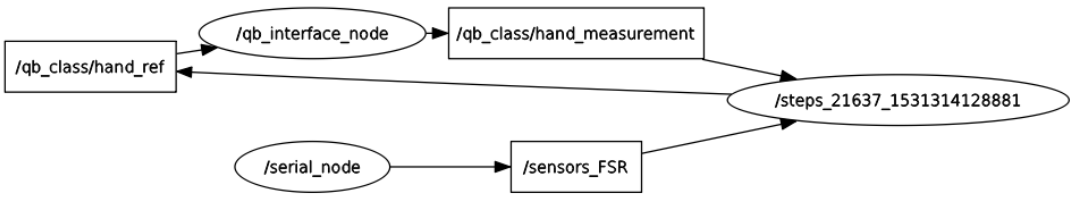


Figure 2: Ros node graph

2 Objective

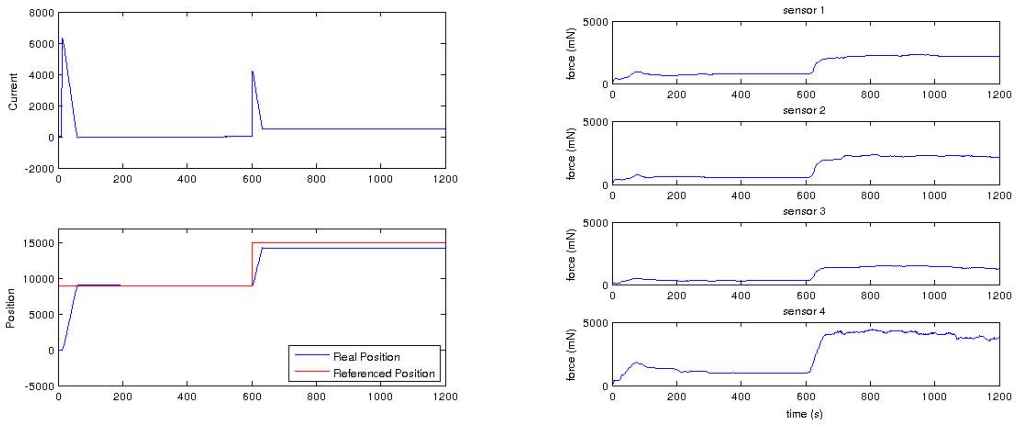
The current experiment wants to find a correlation between the closure position of the softhand and the human reaction measured with the force sensitive resistors. The main hypothesis is that increasing the reference position to the softhand means increasing the force that the human feels. The human will react to that force with a coherent force measured by the sensors.

3 Experiments

This work is describing two main experiments, a one step signal and a pseudorandom step signal. Each step lasts 3 seconds, the frequency rate is set to 100Hz. A file standard has been created in order to compare different experiments. The file is a '.csv' file with columns [FSR1, FSR2, FSR3, FSR4, Current, Real Position, Reference Position] availables at link . All the plots below are obtained considering files with the previous structure. Each experiment start with reference position set to 0 and finish with the reference position set to 0. The experiments are in openloop so in order to avoid injuries an emergency function has been created, if the human starts feeling pain the key 'x' on the keyboard must be pressed. The softhand will take as position 0 (open) and the whole program will be stopped. The described python executable can be found in link.

3.1 One step

In order to test the hypothesis we are sending to the softhand a simple step signal, asking before the experiment to the human to try to react in the most natural way. We are expecting to appreciate a correlation between the step signal and the values of the sensors. In this experiment the reference position sent is [9000, 9000, 15000, 15000], each position is held for 3 seconds so the estimated time of the experiment is 12 seconds.



(a) Current and Positions

(b) Sensor values

Figure 3: One Step Experiment (ms), stiffness = 0.7

From the previous plots we can notice a correlation between the closure value and the force values. It's interesting to notice the current before the transition in 600 and after the transition. The steady value is slightly higher in second part due to the residual current absorbed by the dc brushed motor.

3.2 Pseudorandom step

The pseudorandom step experiment is made with 22 different positions from [6000 to 17000] with a step of 500. Each position appears only once and lasts 3 seconds. So the whole experiment lasts 66 seconds. The experiment is pseudorandom since the vector used for storing the 22 values is shuffled randomly using a fixed seed.

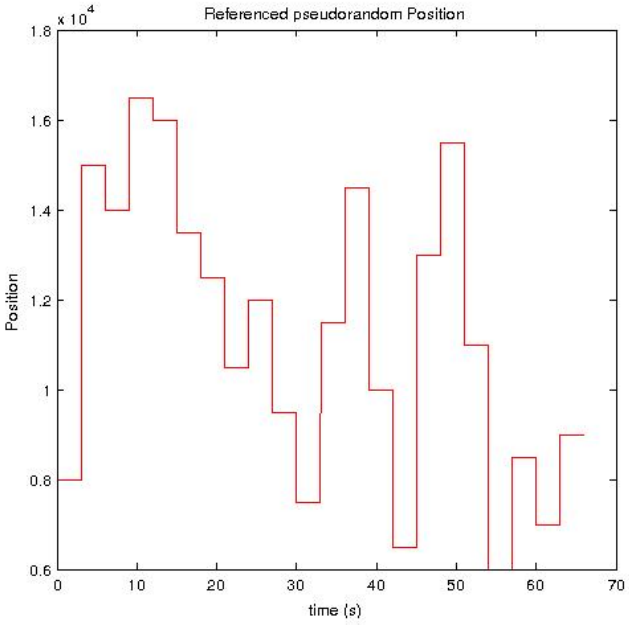
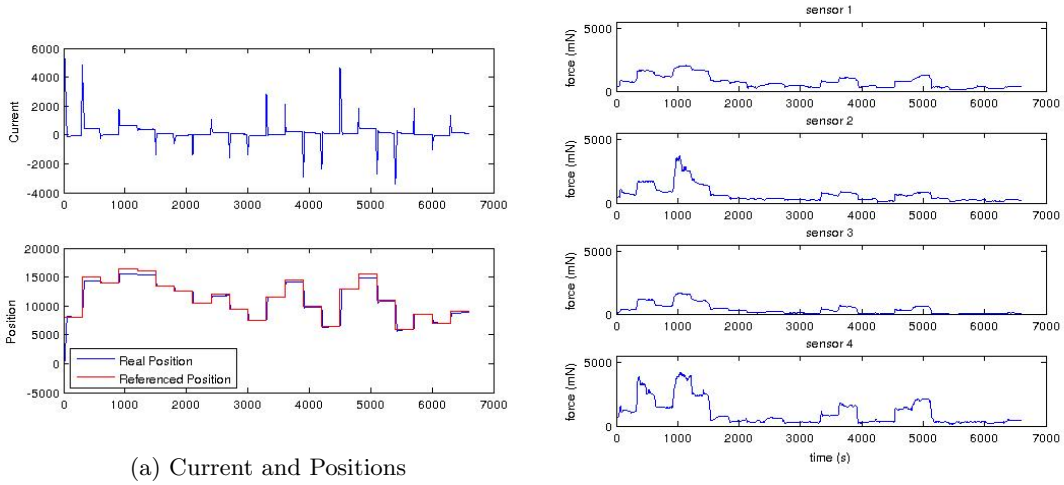


Figure 4: Pseudorandom Step Experiment (ms)

This method is useful because it avoids the human to predict the next closing position and enables to repeat the experiment multiple times, having always the same steps order. The following figure 5 shows the FSR sensor values, the reference position and the real position.



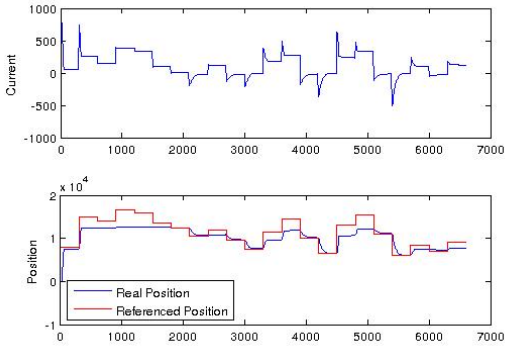
(a) Current and Positions

(b) Sensor values

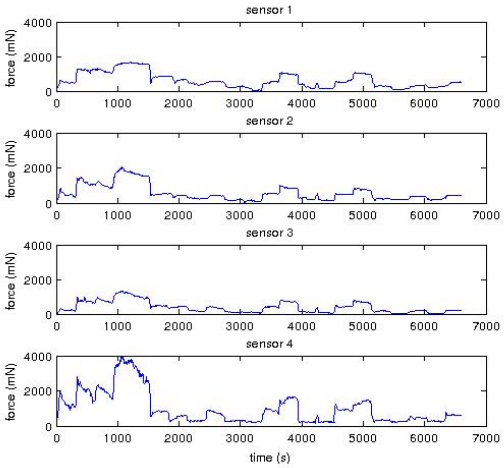
Figure 5: Pseudorandom Step Experiment (ms), stiffness = 0.7

4 Results and Conclusions

The softhand uses a PID in order to control the position, the proportional parameter '/stiffness' is set to 0,7. The range of this parameter is [0,1 ; 0,9] where 0,9 corresponds to the minimum error between desidered position and real position. The previous experiments can be evaluated with more than one subject, and with different '/stiffness' values. The following figure shows the pseudorandom step experiment with a the stiffness set to 0.1. From the assumption just mentioned we are expecting the real position to follow, with a greater error then before, the Referenced one.



(a) Current and Positions



(b) Sensor values

Figure 6: Pseudorandom Step Experiment (ms), stiffness = 0.1

The next step will be to validate what can be clearly seen in these plots. There is a correlation between the softhand closing position and the human grasping force, now is left to map the softhand position with the force in order to control the softhand with the desidered force and not anymore with the position. How do you think we can map these two quantities(force/position)? A really straight forward approach is to assume a spring like behaviour, so there's only a constant to find; but what if this scaling factor is not constant in the position range? [1]

[1] All the files related to this work are stored in *github.com/vignif/tesi*