**Notes on Handshaking Project**

Summary

**What we want to do.**

The hypothesis we want to test is the role of handshake dynamics (e.g. time response, grip force) in the human perception, for instance, how can which are the dynamical parameters that characterize a handshake that is perceived as “friendly”, or “shy”, or “confident”, etc?

**Contributors**

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**UNIPI:**

**How**

We want to instrument a robotic hand (the Pisa/IIT hand) and implement a control algorithm that allows to dynamically regulate the gripping force on the basis of the force applied by the human, for example: respond to a confident grip, a shy one and so on.

**State of the art**

* + Paper by Disney presented at IROS 2017
    - Looking at static contact area, spatial patterns. Measuring human-human handshakes, using as a benchmark for robot hands.
    - <https://www.disneyresearch.com/publication/handshakiness-benchmarking-for-human-robot-hand-interactions/>
  + Paper by Gosselin, presented at IROS, introducing a haptic device for handshaking simulation
    - Complete handshaking system. Builds on their previous work.
    - Controller: robot follows human (this is where we will be different)
    - Paper attached to email (not yet online)
  + Espen made a slide deck at the start of SOMA summarizing relevant work in handshaking.
    - <http://soma-project.eu/wiki/mediawiki-1.24.2/index.php/File:LitReview_handshake.pdf>
  + Tsalamlal et al: Affective handshake with a humanoid robot: How do participants perceive and combine its facial and haptic expressions?
    - Looking at how grip strength and robot facial expressions influence the perceived quality of handshakes.
    - <http://dx.doi.org/10.1109/ACII.2015.7344592>
  + Papageorgiou et al: A Kinematic Controller for Human-Robot Handshaking using Internal Motion Adaptation.
    - Looking at arm control, designing a controller with an attractive limit cycle, to get consensus motion
    - <http://ieeexplore.ieee.org/document/7139986/#full-text-section>
  + Zhai et al: Design of a Virtual Player for Joint Improvisation with Humans in the Mirror Game
    - Not directly related to handshaking, but looking at leader/follower characteristics in human-human cooperative tasks.
    - <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154361>
  + Melnyk, A. et al: Analysis of synchrony of a handshake between humans.
    - Instrument human hands with force sensors and accelerometers, look at profiles during handshake
    - (similar setup to us, but they don’t apply it to control/robot)
    - http://doi.org/10.1109/AIM.2014.6878337

**Force measure**

We need to measure either the gripping force applied by the human, passively felt by the robot, and the “active” gripping force applied by the robot to the human.

For the first component, we need to sensorize the hand palm.

UNIPI proposed a setup in their email at SOMA group. From Giorgio’s email

*Gaspare put four force sensor (FSR400,* [*http://www.interlinkelectronics.com/FSR400.php*](http://www.interlinkelectronics.com/FSR400.php)*) on four hot-spots on the hand back. These sensors are small (6mm internal diameter) and flexible. They lie between two thin silicone layers that function as protection, and then are glued on the back cover of the hand. Electrically they are pressure sensitive resistors, and are all connected in parallel and then in series to a variable resistor so as to form a voltage partition circuit. The voltage values are read by an ADC on the hand board.*

*In the attached video example, the hand controller is programmed to activate the hand closure proportionally to the forces read, and this is a simple and effective way of implementing a user-controlled hand-shake.*

*<https://www.dropbox.com/s/8ecfnhpswzonl04/forcesense.mp4?dl=0>*

Another possibility consists in using the tekscan glove, that is available both at Disney and IIT. The position of the sensors should be adapted in this case to measure the pressure on the palm rather than on the fingers.

For the second component, we need to estimate the gripping force from the actuator.

UNIPI provided a methodology for grasp force estimation based on hand actuator current.

**Force calibration**

Both the robot and human force measures and estimation should be calibrated.

This could be the first task for the student, that could collaborate with UNIPI.

**Control algorithm**

Handshake control algorithm aims at regulating the force actively applied, FA, as a function of some variables, namely

FA = f(x1,x2,x3)

Where variables x1,x2,x3 represent

x1: intrinsic features

x2: expectations from the handshaking interaction

x3: handshaking dynamics according to the actual interaction response.

Possible behaviours that could be exploited:

* Robot acts as leader: handshaking force is regulated by the robot according to intrinsic features and expectations, disregarding the actual interaction response, i.e. FA = f(x1,x2)
* Robot follows the human: handshaking force is regulated by the robot as a function of the measured interaction response, i.e. FA = f(x3)

These cases are the extreme boundaries, we can exploit also intermediate configurations and analyse the role of each parameter.

The simpler implementation for the second case is a proportional controller: if x3 represents the interaction force applied by the human,

FA = kp x3 (1)

Where kp is a constant proportional gain.

One aspect that should be considered is the ***dynamics***: i.e. if robot response is instantaneous, quick or slow. The function FA = f(x1,x2,x3) should not be algebraic but model also the dynamical behaviour (as an example, we could start from the hypothesis of a second order linear model). As a first step, we could consider a PD controller instead of a simple proportional one in the simple controller drafted in eq.(1).

**Human interaction - experiments**

In the experiments, it will be interesting to investigate whether and how the ***consensus*** is reached.

When is the consensus reached? When the human and robot forces are the same or are close?

To Do: bibliography research on this theme.

We should also analyse the time necessary to reach the consensus.

Human behaviour, emotional response. We should quantify and describe human feelings in the handshaking interaction with the robot. How can we obtain a leader or follower behaviour from the human?

***Possible publications and deadlines***

* Eurohaptics (the deadline is at the end of January)
* IROS

***Old notes from the previous calls...***

* Defining the hardware setup. We need to think to these points and think to a solution to discuss in the next meeting (Monday, October 16)
  + The hand: Pisa IIT hand or a specific simple device? Pisa IIT hand seems the simpler and more convenient choice in SOMA perspective.

* + Sensors on the hand: we should measure the force that the human apply to the robot hand and vice-versa. For the first, we need to instrument the palm: define the set and type of sensors.
  + For the second, do we need to put force sensors on the Pisa hand fingers? Can we use motor current to estimate the gripping force? Is the estimation algorithm available? Do we need to involve Pisa team in this phase?
  + We have to define procedures for system calibration.
* Algorithm:
  + We should consider and combine different aspects: human intrinsic features (variable A), human expectation from the handshaking interaction (variable B), human tuning of handshaking dynamics according to the actual interaction response (variable C). The overall handshaking task is a dynamic system involving these three variables, that we should define.
  + Its identification is not simple. In the work we can make simple reasonable assumptions on the model and test them with the setup.
  + This in one important contribution of the work, that can be managed mainly by IIT.
* Testing:
  + Human/human tests are difficult to be realised, since testing conditions cannot be properly controlled and are not reproducible.
  + So we proceed directly with robot/human interaction tests, that can be controlled in a simpler and more reliable way. We need tools for estimating the psychological and behavioural outcomes of the test.
  + This in another important contribution of the work, that can be managed mainly by Disney.
* Timing: we should define the timing of this work, in particular with respect to SOMA milestones.