

# MAS 965 Relational Machines: Project Proposal

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April 6, 2005

## 1 Overview

The purpose of this project is to encourage human patients to perform physical therapy exercises with the assistance of an expressive robot that builds a relationship with the patient. The style of the relationship is one of a collaborative partnership. Through teamwork, the human and the robot labor together to achieve better physical performance for both of them. The goals are thus to motivate the exercise itself, to provide natural and compelling performance feedback, and to be generally entertaining and empowering for the human.

## 2 Early User Feedback

I interviewed three individuals concerning this project. One was a researcher in the field of technology-assisted physical therapy, one was a product designer of physical therapy assistive devices for children, and one was a young sufferer of a recent stroke and associated physical therapy.

The researcher provided high-level guidance for the design of this type of system. He pointed out that there is a need for simultaneous feedback of the human's performance. This inspired the use of the robot's limbs to redisplay the human's performance while the face displays an affective rendition of the performance. The researcher agreed that displaying the human's motion on the robot can be more direct and easy to follow than a graphical representation. He also mentioned that the interaction itself must be kept simple so that patients can understand it even in the presence of complicating conditions such as visual neglect. Hence the movements and goals have been limited to iconic, easy to understand states. Finally he noted that tasks should have a scale of challenge levels, to provide more granularity of visible improvement.

The product designer provided examples of her company's current products which perform this sort of function. The interaction that they have designed is quite simple. The user selects from a number of activities that they can assist a graphical avatar in performing, such as blowing bubbles. Then the performance of the avatar matches very basic action scales of the patients, such as how hard they press a button. She appreciated the concept of this project with the physical robot. She pointed out that motions should be kept simple, such as how far a joint could be extended, or how high an arm could be lifted - in this fashion mirroring the button scenario. Her product did not have a relational, memory aspect to it, and she was in favour of this concept. She emphasized that it was important to have an interaction that was empowering for the patient and that the patient would feel proud of using.

The stroke patient made a number of useful observations from the point of view of the end user. Although she had suffered partial facial paralysis, she was not given any face exercises. She

found that she did not do most of the exercises she had been given - for example, she did not palpate a squishy ball she had been given to exercise her hand with, because she did not feel it accomplished anything in addition to the exercise. Instead, she would perform minimal tasks while doing other things, for example squeezing the edge of the table while eating or talking, or manipulating the cards while playing poker. She liked the idea of a game interaction that kept track of performance, although she said she had not played video games since her stroke since she found her hand's reaction time could not keep up with what was necessary. She also pointed out that her improvement in motion quality and range of movement was not a linear progression, but came and went to some degree. She said that her touch sensitivity was also degraded, and that the therapists had not thought of any ideas for exercises to improve this, and that in general the state of her performance was hard for her to judge, even with gross motion capabilities such as shoulder movement. She said that trembling and fluidity of motion would be useful things to get better feedback of.

### 3 Initial Specification

The requirements of the system are as follows:

- a. Visual sensing ability of human arm movement. This should be capable of sensing elbow extension and shoulder position, such as how high an arm can be lifted.
- b. A body mapping from the human to the robot, so that the robot can re-express the human's movements.
- c. A facility to store a model of the desired exercises and the performance metrics that will be used to evaluate them.
- d. Data structures for recording human performance over the long and short term. These records should be able to identify and respond appropriately to cyclic components of the patient's performance, as well as net increase over time.
- e. Affect-based feedback channels from the robot to the human. The human should be able to look at the robot and receive a natural and intuitive impression of how satisfactory the team's performance is at that point in time.

### 4 Demonstration

The demonstration of the system will take the form of the following interaction:

The human will approach the robot, and the robot will indicate that it senses and acknowledges the patient's presence. The robot will attempt to engage the human in the interaction by being enthused at the human's presence, in the manner of a friendly pet. The robot will at this point load its internal history of the human's activity with it, so it will know what level of exercise has been reached and what the baseline capabilities are. The human will have an opportunity to request a specific exercise, or if he or she does not do so then the robot may suggest a particular exercise by demonstrating it. This demonstration will not be the best possible example, and may in fact be significantly degraded in order to serve as a request for assistance from the human. The human and the robot then perform the exercise together, with the robot mirroring the human's actions using its internal body mapping. At the same time, the robot becomes visibly happier and more alert the more of the task the human can perform (e.g. the further the human can extend his or her elbow, the more joy the robot will express). If the exercise is one that has been performed before,

the robot will start at a happiness level that reflects the performance the last time this exercise was performed. However, since the robot has a maximum expressiveness, there will also be a decay on its happiness expression. If the human's performance does not improve, it will slowly return to a neutral expression. As this suggests, the robot will store its exercise-specific affective state for the next time the human and the robot play together.

## 5 Evaluation

Evaluation of the system will primarily consist of user self-report questionnaires, to be administered following each interaction with the robot. In order to evaluate the robot's relational nature, each subject will interact with the robot several times. Some questions may be different on each questionnaire, and some may stay the same in order to measure the progression of the human's opinion over time.

In addition, the sessions will be video taped and the recordings analyzed for technical and subjective conclusions. Importantly, the patient's motivation to perform the exercises can be judged by how many of the exercises he or she performs, or how long is spent on any given exercise. The effectiveness of the motion tracking and body mapping can also be judged by visually evaluating the correspondence between the human's activities and the robot's movements.