# Designing Controllers For Human-Robot Interaction

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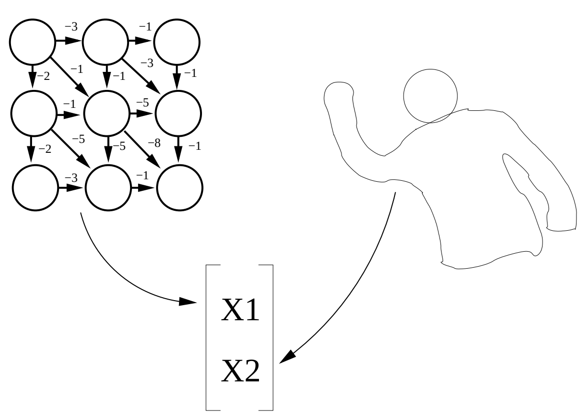
ABSTRACT

Robots need to interact with people for a variety of reasons. In order to perform in a way that is both efficient and acceptable to humans, we design controllers that incorporate human stress, and that are designed to facilitate engagement and interactivity. In two separate projects, we approach these problems in a data driven manner, by attempting to build generative models of human behavior.

## Controller Design using Biometric Feedback

### Problem

As robots become more capable, they will more often find themselves sharing physical workspace with humans. How can we design robot controllers that perform a task efficiently, but do not cause stress to humans in close proximity? (Examples: Robot assistants for the elderly, Robotics shopping carts for the blind)




We attempt to define controllers using the robot task specification as well as information about human preference [1] .In this work, we address the issue of defining controllers for two (possibly conflicting) tasks.

### Biometric Feedback

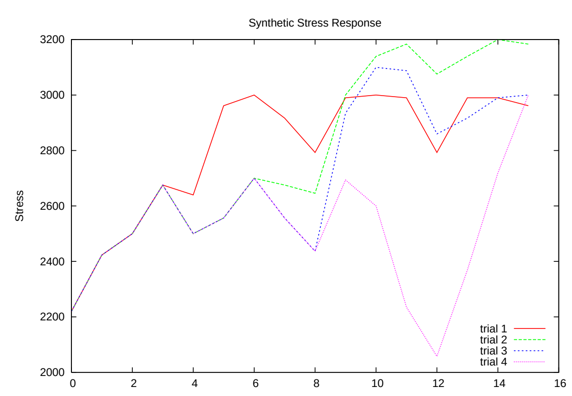
We evaluate the comfort level of the human using a Galvanic Skin Response (GSR) sensor. GSR measures the skin conductivity, which increases with stress and discomfort. We record the GSR measurement of the human at 4 hertz for four different robot motion strategies, each of which reaches the goal while avoiding the human.

## Stitching Controllers

**Algorithm 1** Policy Switch( set <controller> C)

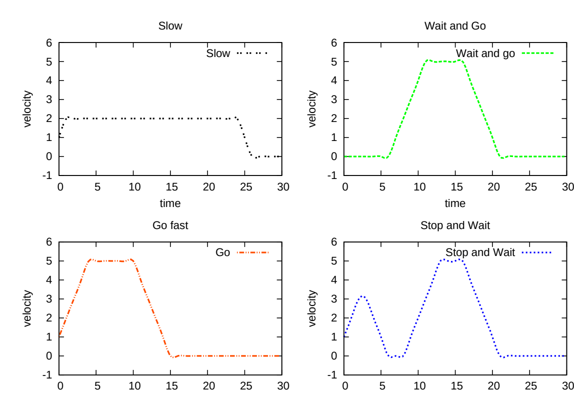
```
i = 0
π = C[i]
response = execute( π )
while response > HIGH do
    select switching point s from response
    ++i
    π = stitch π and C[i] at s
    response = execute( π )
end while
```

We posit that a human-friendly robot trajectory can be obtained by combining pieces from the trajectories that correspond to geometric objectives. At the heart of our approach lies the observation that for a fixed human trajectory and an initial position of the robot, what we are seeking is a robot trajectory, rather than a policy over the entire state space. To obtain such a trajectory, we first generate a number of candidate trajectories. These trajectories are obtained by computing optimal policies to various purely geometric objectives. The basis trajectories are then combined using biofeedback.



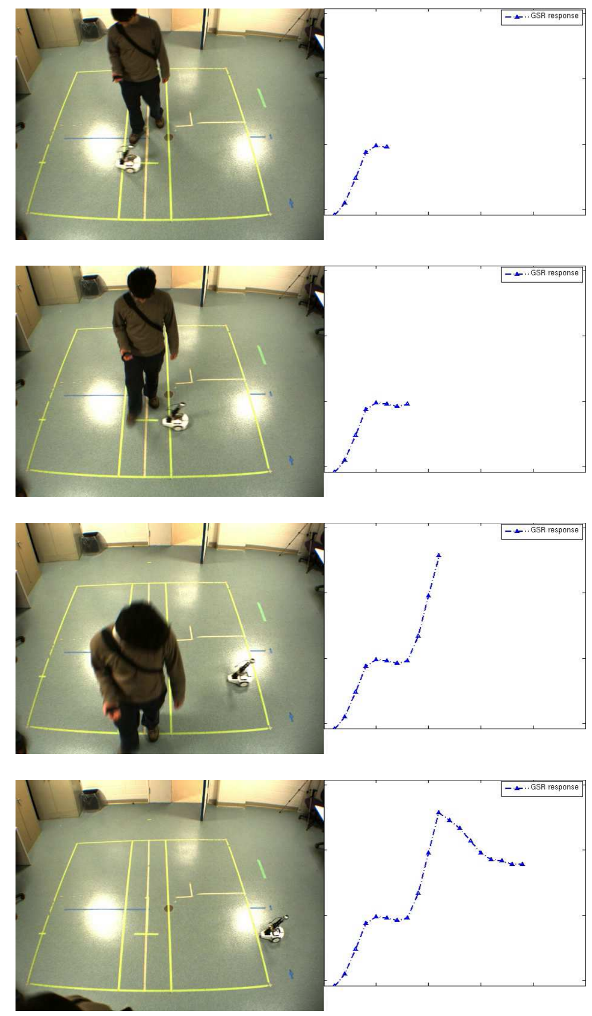

Results for four trials using synthetic stress model. The differently colored lines represent the separate runs of the controller stitching algorithm

## Path Crossing Velocity Controllers



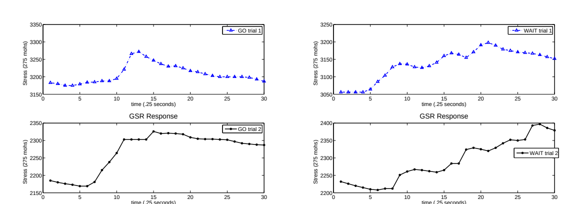

This figure shows the velocity profile of four controllers used in a human-robot path corssing experiment.

## Path Crossing Experiment



In this experiment we monitor the galvanic skin response of a human subject while walking a short path. In the mean time, a robot is tasked with traveling along a straight line to a goal location. The paths of robot and human are perpendicular and cross at the halfway point of the robots path and at 2/3 the length of the human's path.

## Repeatable Stress Response

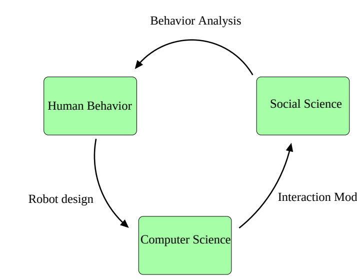


The plots show the GSR reading for two of the four controllers, executed twice on the same individual, roughly 90 minutes apart. This is provided to illustrate that the change in response can in fact be attributed to the robot's actions and that the affect from the robot behavior is repeatable, which is essential to our switching strategy.

## Rhythmic Interaction

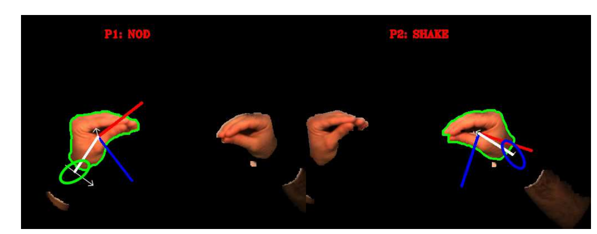
In a separate project we are studying rhythm in a prototype, two person interaction scenario: interacting through shadows [2] .

In this work we are using the prototype task to study gestural language, rhythmic synchrony, and interactive emergence.




Our goal is to construct and validate theories of interaction, and to automate labor-intensive behavioral coding process. We can use the robot as controlled tool to study anthropomorphism and interpretive flexibility.

## Behavior recognition




We attempt to leverage situational understanding for decision making. The approach is to compute the most likely situation given a series of observed behaviors. In our experimental setup, we collect data from two participants wearing wrist markers. This figure shows the processed frames of the perception system. This system processes video and outputs the stream of behaviors.

## References

[1] E. Meisner and V. Isler and J. Trinkle, J. Autonomous Robots **Vol. 24**, N. 2, (2008)

[2] Joint Work with Selma Šabanović and Linnda R. Caporael, RPI Science and Technology Studies (STS)