Controller Design for Human-Robot Interaction

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Looming Health Care Crisis

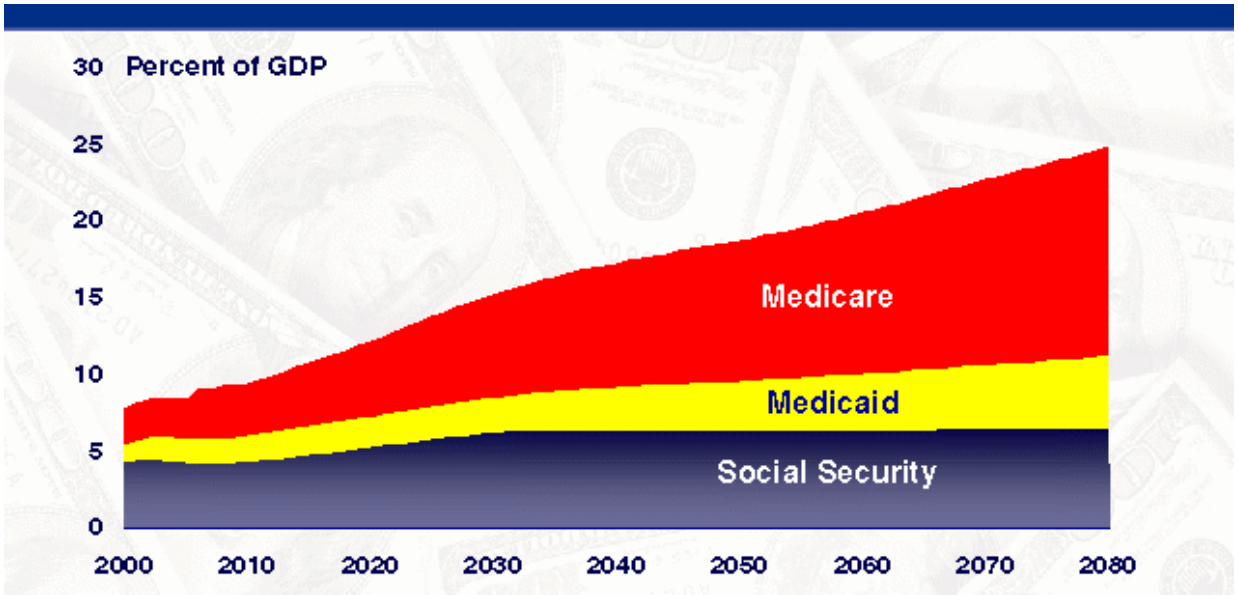
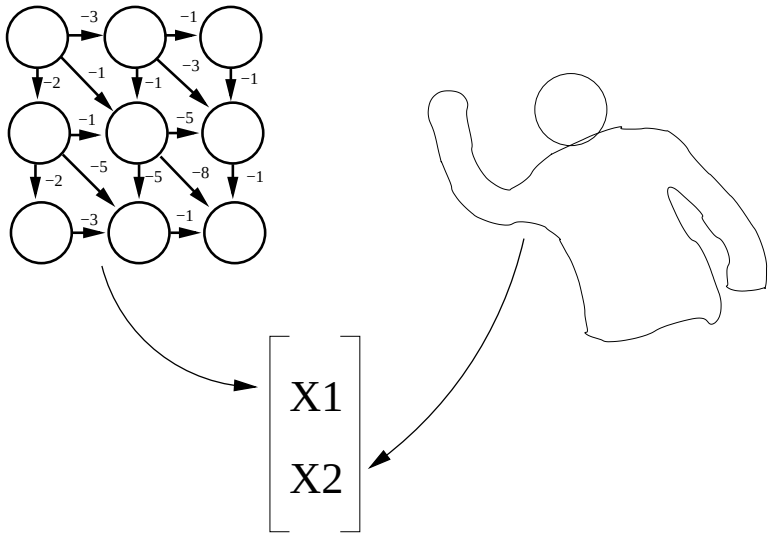


Figure: Sources, Social Security Administration, Centers for Medicare and Medicade Services, Congressional Budget Office, gao.gov

The growing elderly population is putting a strain on the resources of the healthcare system. Personal service robots may be able to help.

Controller Design using Biometric Feedback

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.

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.

Path Crossing Experiment

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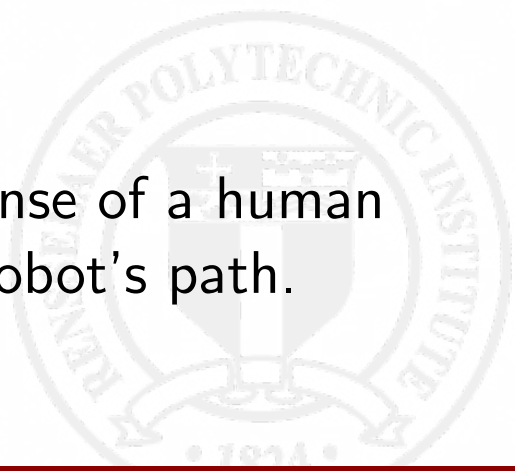
In this experiment we monitor the galvanic skin response of a human subject while walking a short path, that intersects a robot's path.



Path Crossing Experiment

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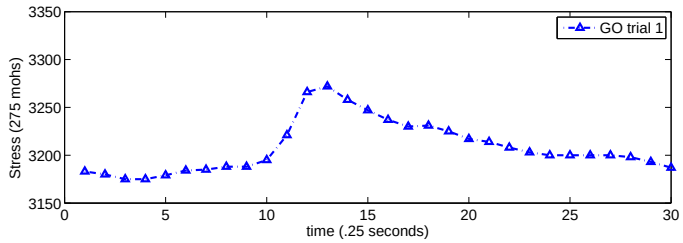
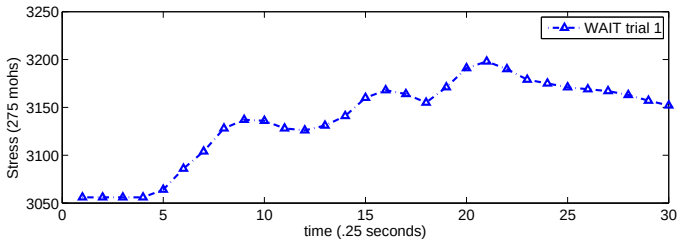
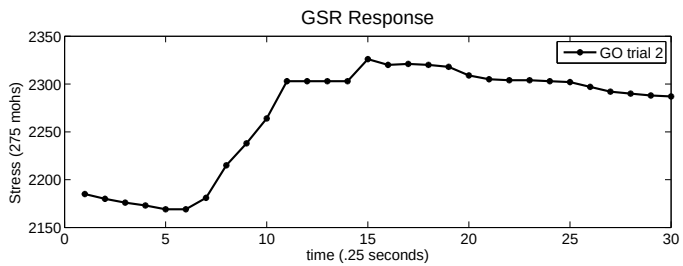
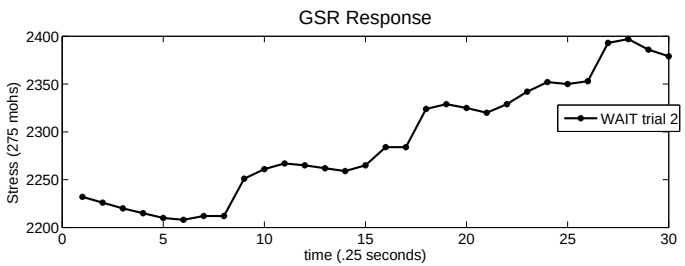
In this experiment we monitor the galvanic skin response of a human subject while walking a short path, that intersects a robot's path.

Repeatability







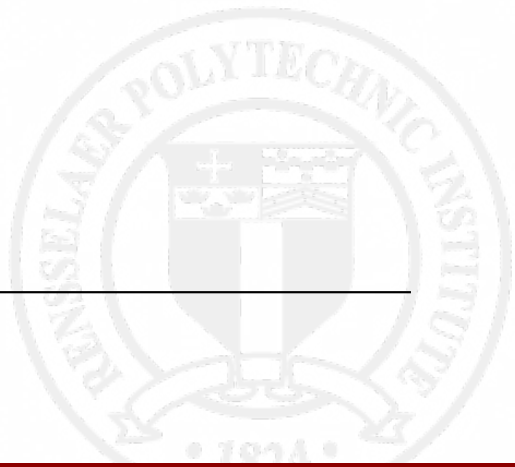


The plots show the GSR reading for two of the four controllers, executed twice on the same individual, roughly 90 minutes apart.

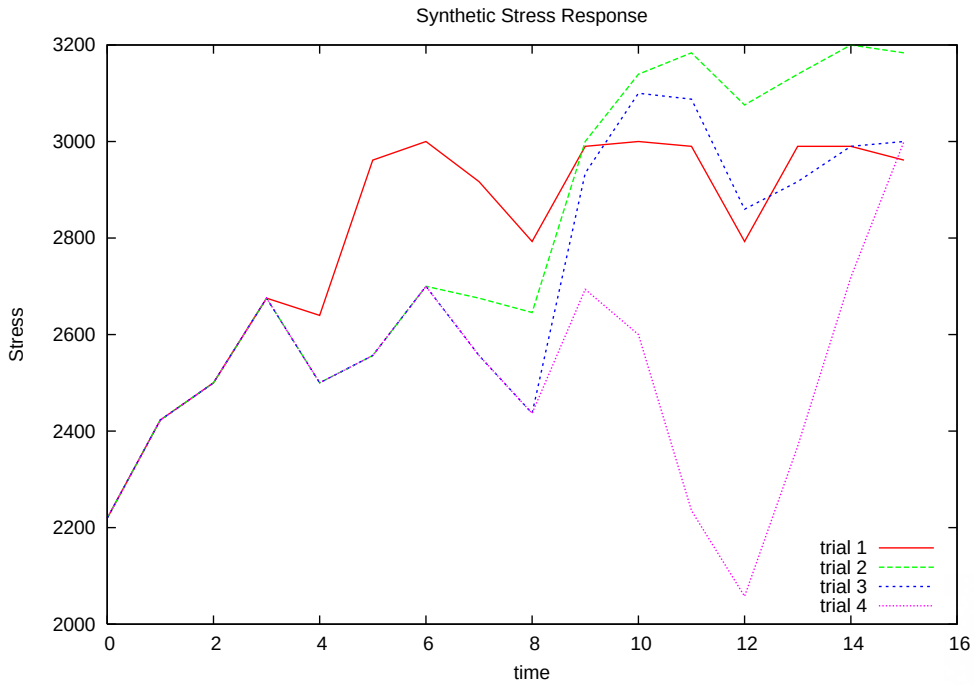
Stitching Controllers

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



Example

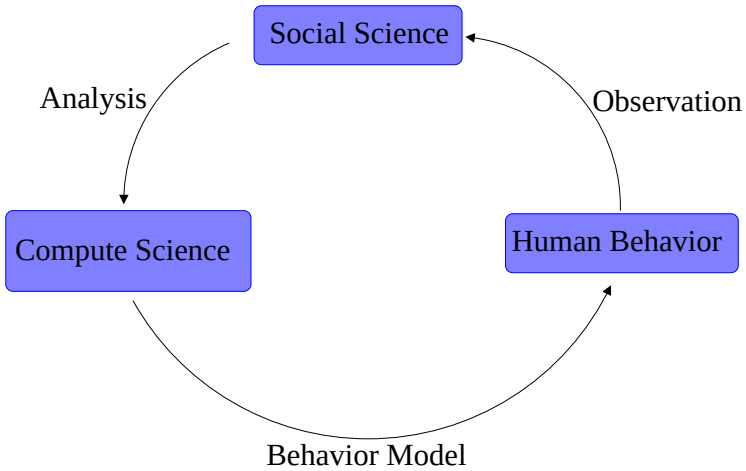


Results for four trials using synthetic stress model. The differently colored lines represent the separate runs of the controller stitching algorithm.

Rhythmic Interaction

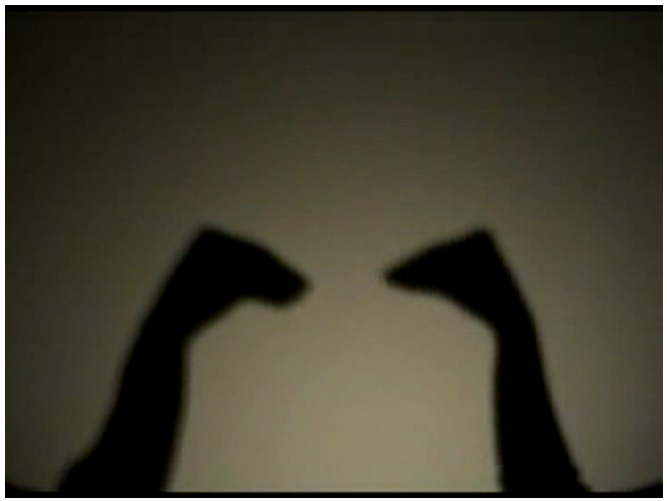
Joint Work with Selma Šabanović and Linnda R. Caporael, RPI Science and Technology Studies (STS)

In order to participate in embodied interaction with humans, social robots must be able to recognize relevant social patterns, including interaction rhythms, imitation, and particular sequences of behaviors, and to relate them to particular socially meaningful interaction schemas.



Shadow Puppetry

In this project we are studying rhythm in a prototype, two person interaction scenario: interacting through shadows.

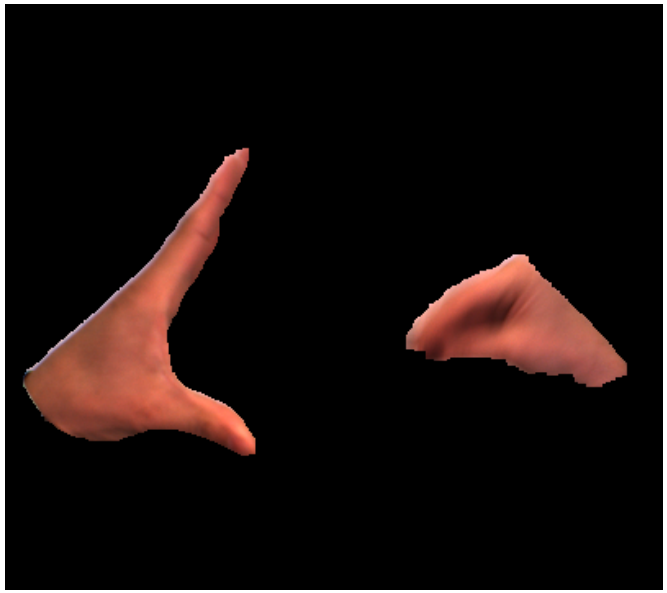


Interaction Survey

Step 1: Record Interactions

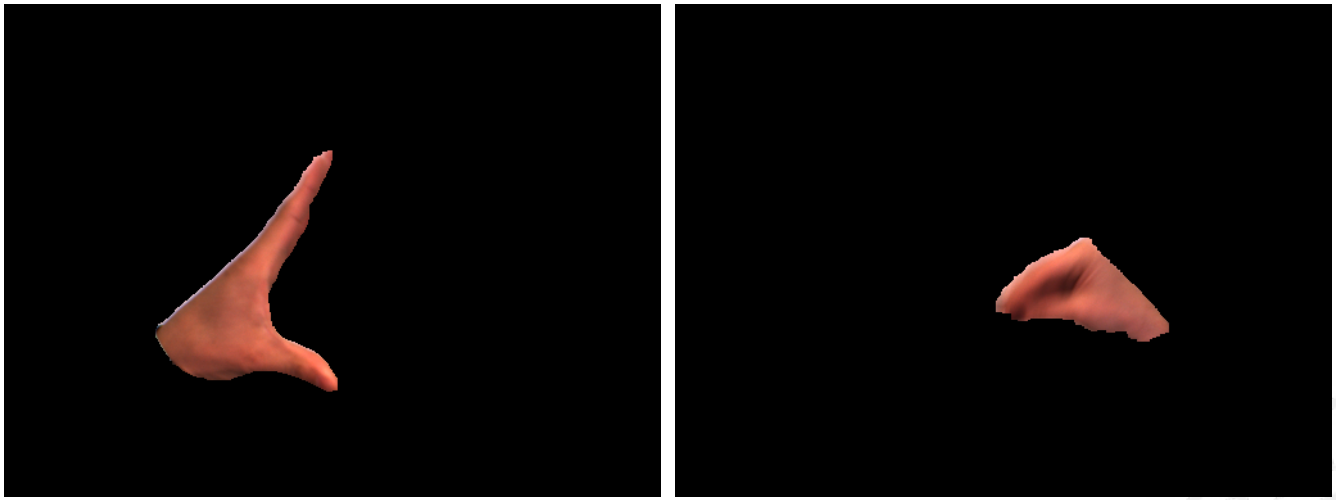
Interaction Survey

Step 2: Process the videos



Interaction Survey

Step 3: Isolate and separate the left and right players

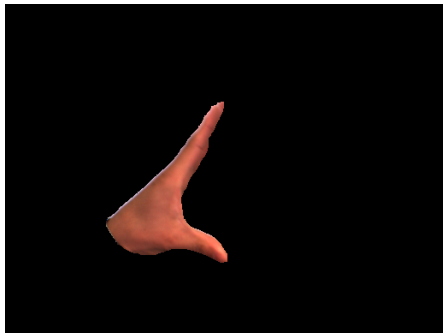


(a) Left

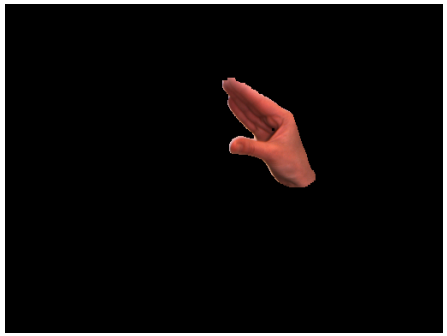
(b) Right

Interaction Survey

Step 4: Recombine left and right sides for non-interactive videos

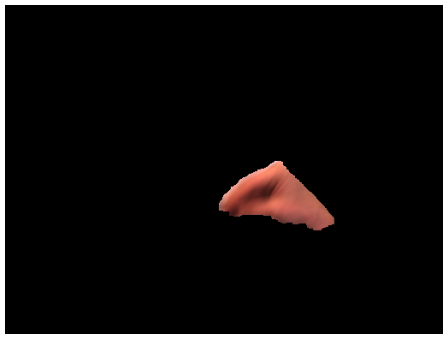


(c) Left A



(d) Right B

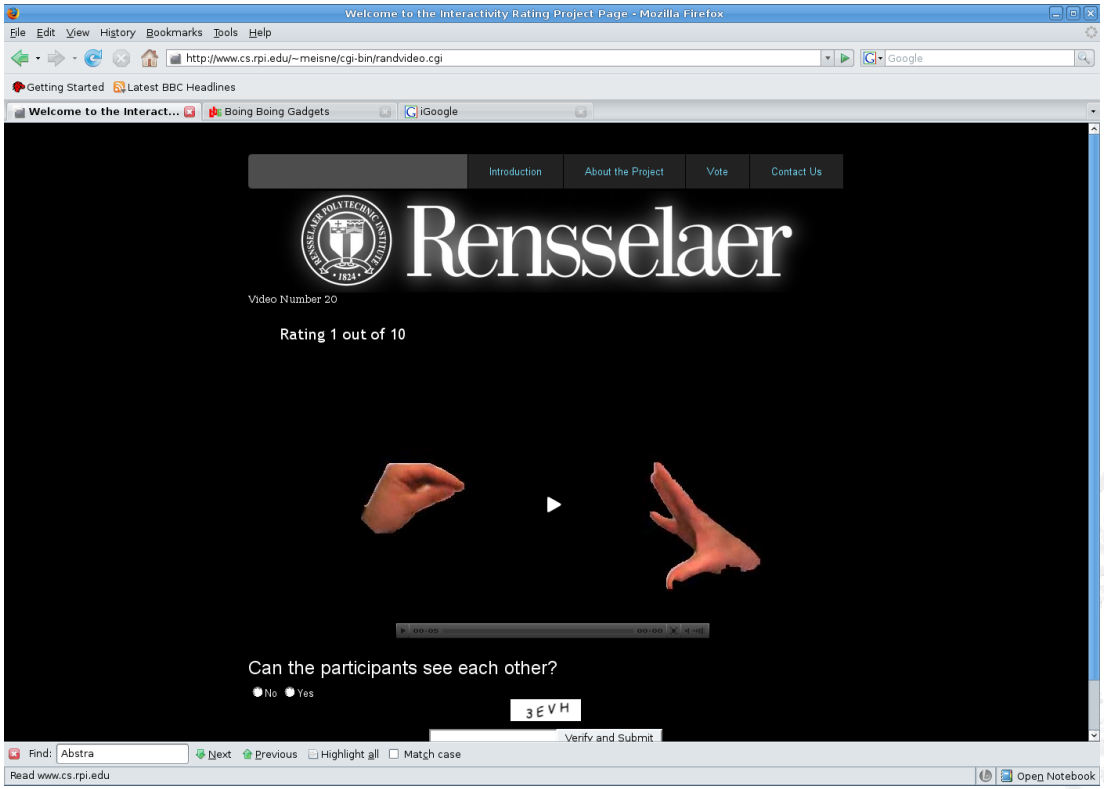
(e) Left B



(f) Right A

Web Survey

As a measure of interactivity, count the number of affirmative responses for each video.
www.cs.rpi.edu/~meisne/interaction/introduction.html



Extracting Behaviors

In our experimental setup, we collect data from two participants interacting through shadows.

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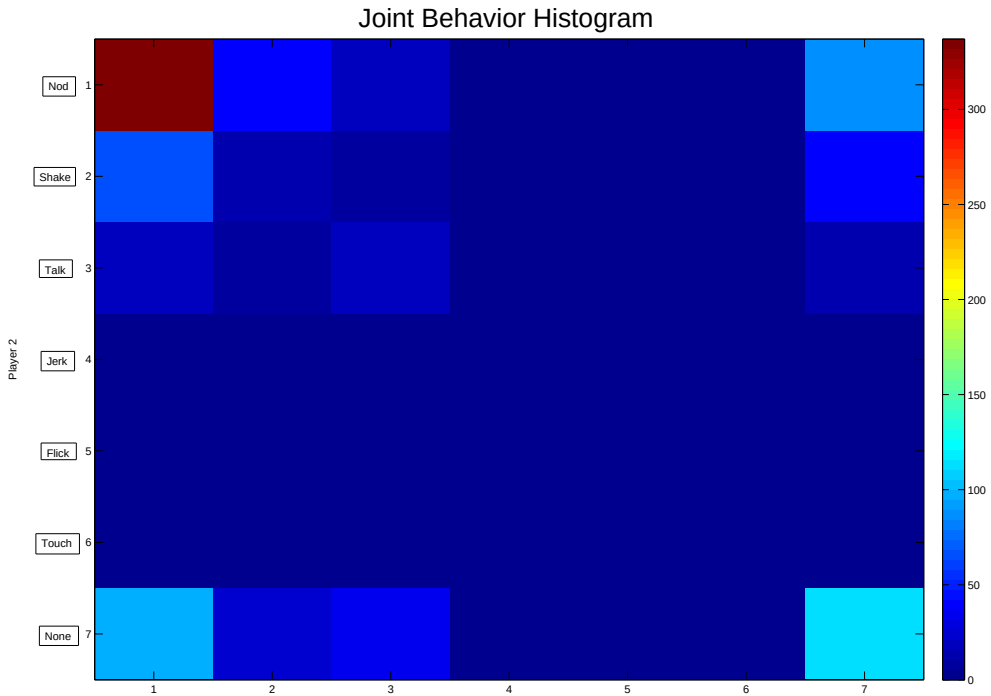
This figure shows the processed frames of the perception system. This system processes video and outputs the stream of behaviors.

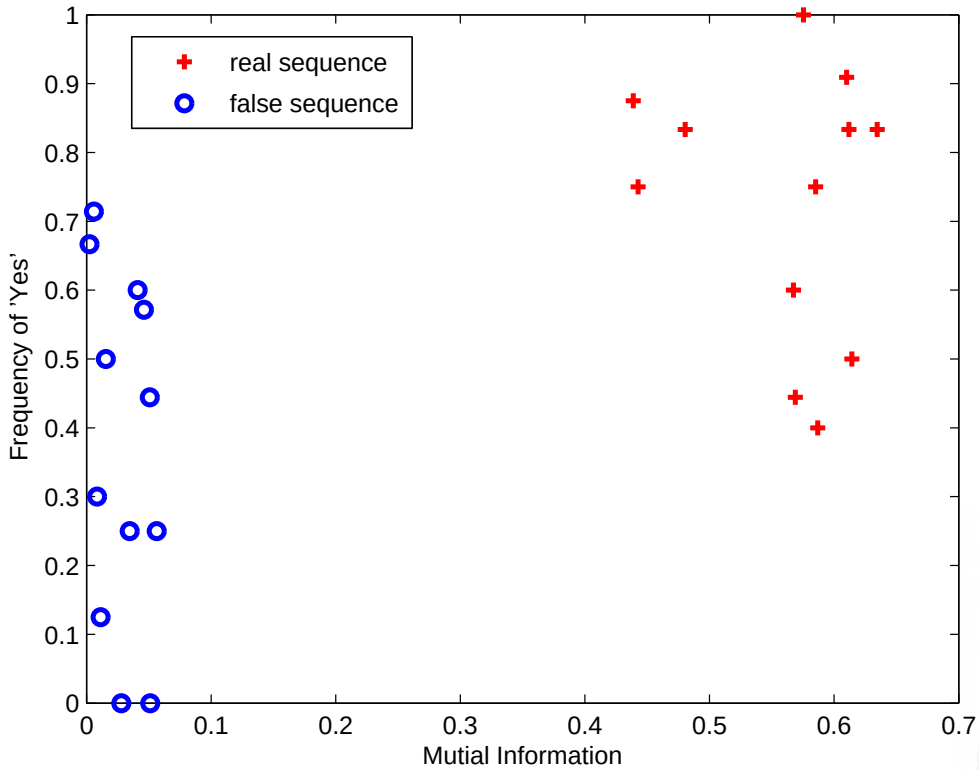
Mutual Information

For each video, real and false, we compute the mutual information of the joint behavior histogram.

$$\sum_x \sum_y P(x,y) log(\frac{P(x,y)}{P(x)P(y)})$$



Comparing the two measures



Future Work

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An interactivity Turing test.