

# A Representation for Interaction



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# Motivation



- ⌘ HRI studies human robot social interaction. But what do we mean by interaction? And how do we represent it?
- ⌘ How can we represent social interaction without a definition of social interaction?



Is this social interaction  
with a robot?

How can we represent social  
interaction without a definition  
of social interaction?

# Defining Social Interaction

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- ⌘ Social psychologists define social interaction as **influence** —verbal, physical, or emotional by one individual on another. (Sears et al., 1991).
- ⌘ This is a broad definition.
- ⌘ Encompasses reputation, gossip, distant and indirect interaction.
- ⌘ Social interaction can be one way.

# Example



- ⌘ Have influenced us although we've never met them.
- ⌘ We all have detailed models of them.
- ⌘ Have we interacted with them?

# Representing Interaction



- ⌘ What information should a representation of social interaction represent?
  - ⌘ The other individual.
  - ⌘ The social actions available to the robot.
  - ⌘ The social actions available to the human.
  - ⌘ Robot's influence on the human.
  - ⌘ The human's influence on the robot.

# Purpose



- ⌘ This work explores the outcome matrix as a representation for human robot social interaction.



# Outcome Matrices



⌘ Includes information about the individuals.

⌘ The actions available.

⌘ The outcome value of each action pair.

⌘ Can be used to represent both interactions and social situations.

## Outcome Matrix

**Fireman**

**Robot**

	Rescue a Victim	Put out a Fire
Rescue a Victim	8 7	5 6
Put out a Fire	7 6	6 5

# Why the outcome matrix?



- ⌘ Why not:
  - ⌘ Neural Networks, support vectors, ...
  - ⌘ Ad hoc representations.
  - ⌘ Etc...
  
- ⌘ Because the outcome matrix has a long history (1930s) as a representation of social interaction.
  - ⌘ Game theory (Osborne & Rubenstein, 2004)
  - ⌘ Psychology (Kelley & Thibaut, 1978)
  - ⌘ Neuroscience (Sanfey, 2007)
  - ⌘ Economics (Gibbons, 1992)

# Interactive Notation



- ⌘ We can use this representation to develop formal tools related to social interaction.
- ⌘ Drawing from game theory:

let  $A^1 \in \{a_1^1, \dots, a_n^1\}$  denote individual one's action set

let  $A^2 \in \{a_1^2, \dots, a_n^2\}$  denote individual two's action

the term  $O$  is used to denote an outcome matrix,

a particular outcome resulting from the selection of two actions can then be represented as

$$O^1(a_1^1, a_1^2) = o_{11}^1$$

# Two Critical Questions

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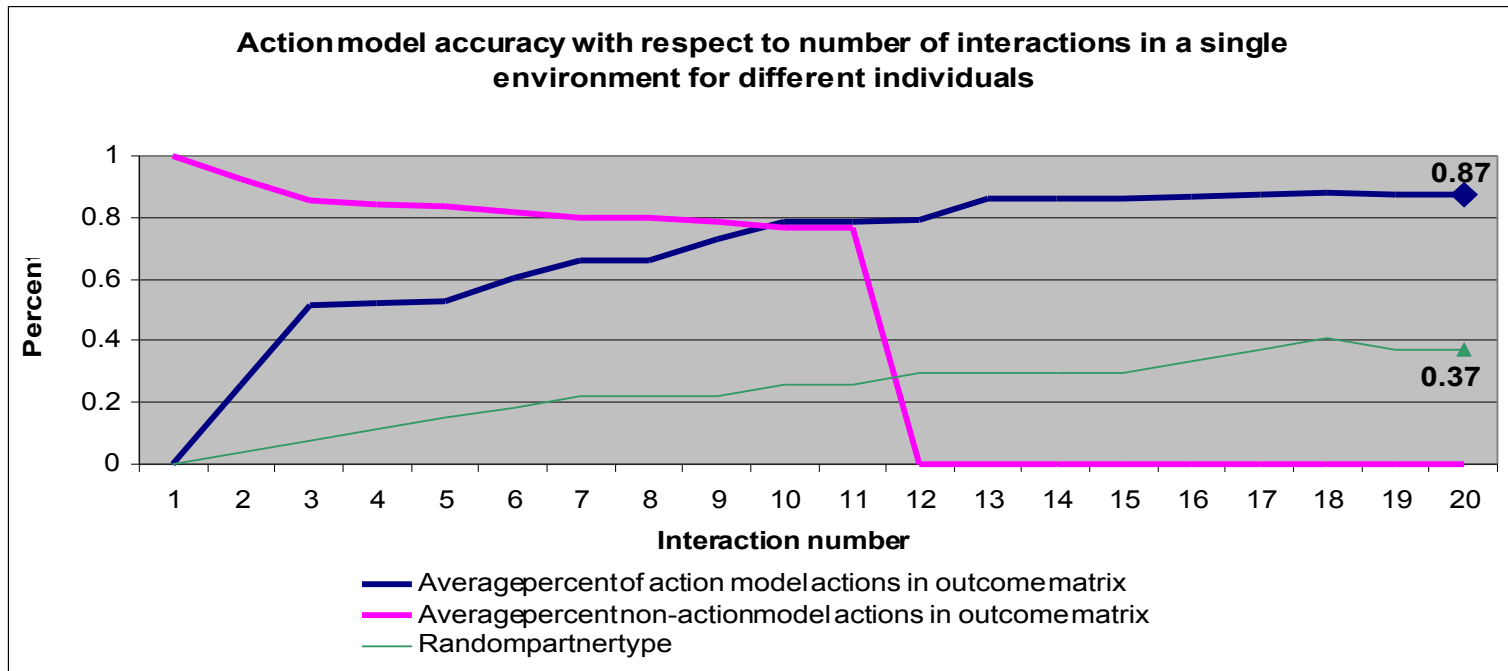


- ⌘ Can a robot or agent create these matrix representations?
- ⌘ How sensitive is the representation to noise, error, and misinformation?

# Can we create outcome matrices?



- ⌘ Yes, unpublished simulation results for an algorithm in which a robot learns its partner's actions and utilities.
- ⌘ Results:



# How sensitive are outcome matrices to error?

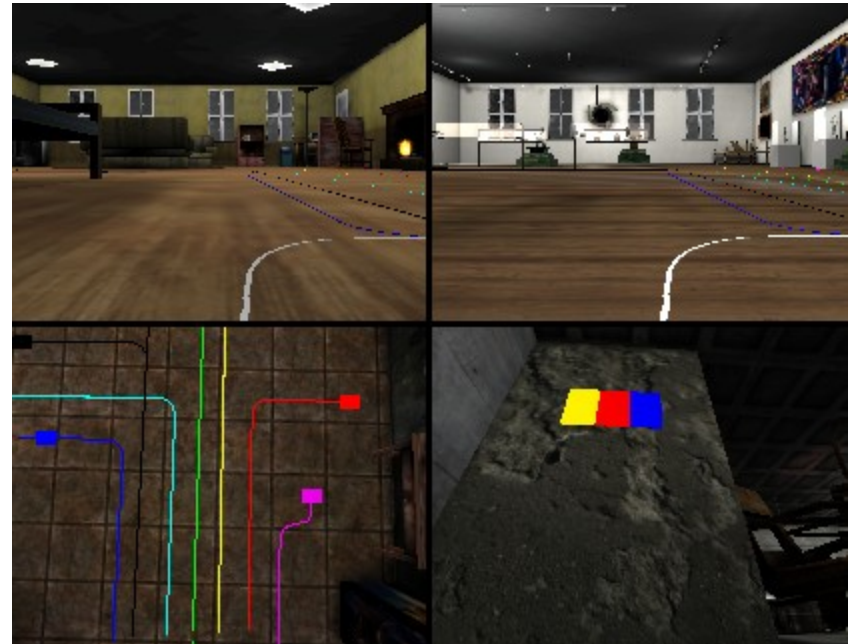


- ⌘ Workshop paper focuses on this topic.
- ⌘ Explored 4 types of errors:
  - ⌘ Errors in utility function magnitude—all values greater or less than real value.
  - ⌘ Errors in single utility values—one (or more) of the numbers is wrong.
  - ⌘ Action insertion errors—too many actions.
  - ⌘ Action deletion errors—too few actions.

# Experimental Setup



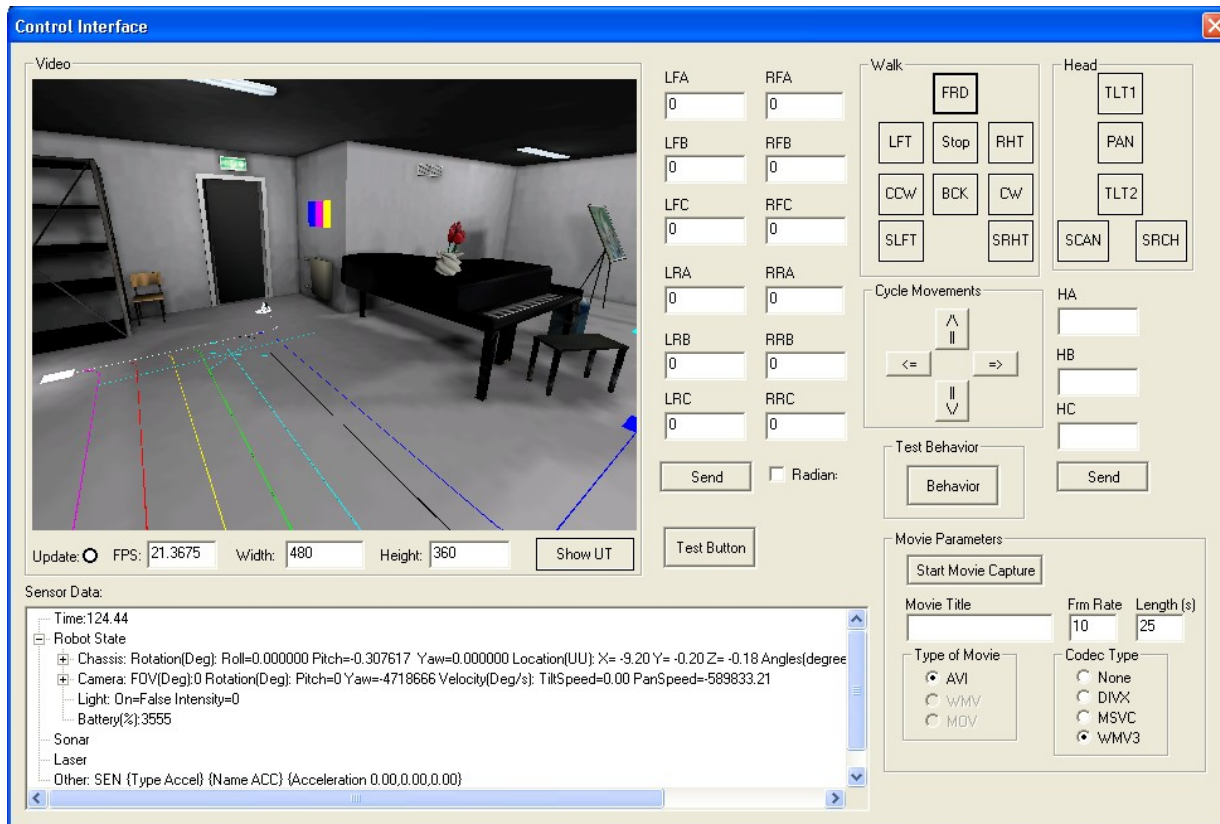
- ⌘ Tested interaction between a sim. robot and person.
- ⌘ The person's action selection was controlled. The robot's was determined by the outcome matrix.
- ⌘ Five different environments: hospital, household, museum, prison, search and rescue.



# Experimental Setup



- Human used a GUI
- Software based on USARSim (Carpin, et al., 2005)



# Experiments

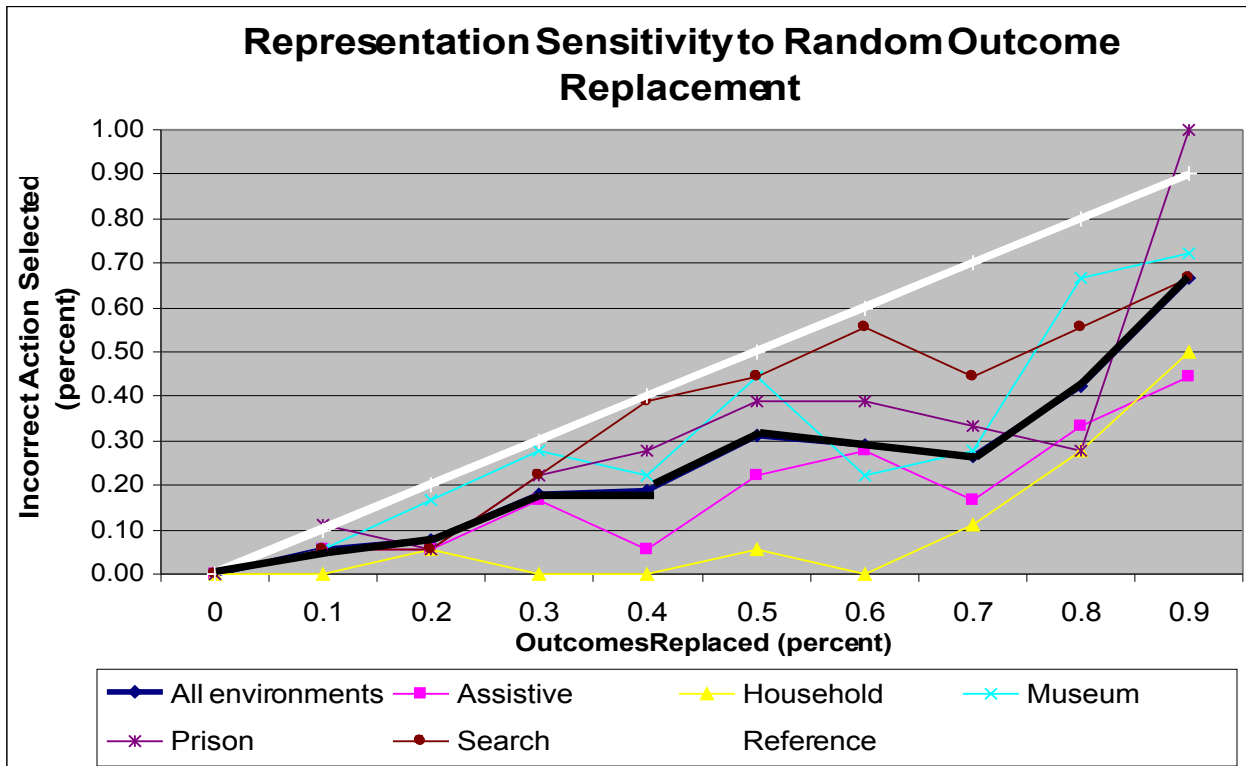


- ⌘ Robot interacted with the human in a environment. Both selected actions.
- ⌘ The real outcome matrix was randomly changed depending on the type of error (experimental condition).
- ⌘ Robot's action selection was recorded.
- ⌘ Independent variable: Number of errors.
- ⌘ Dependent variable: Percent incorrect actions selected.

# Results: Outcome Replacement



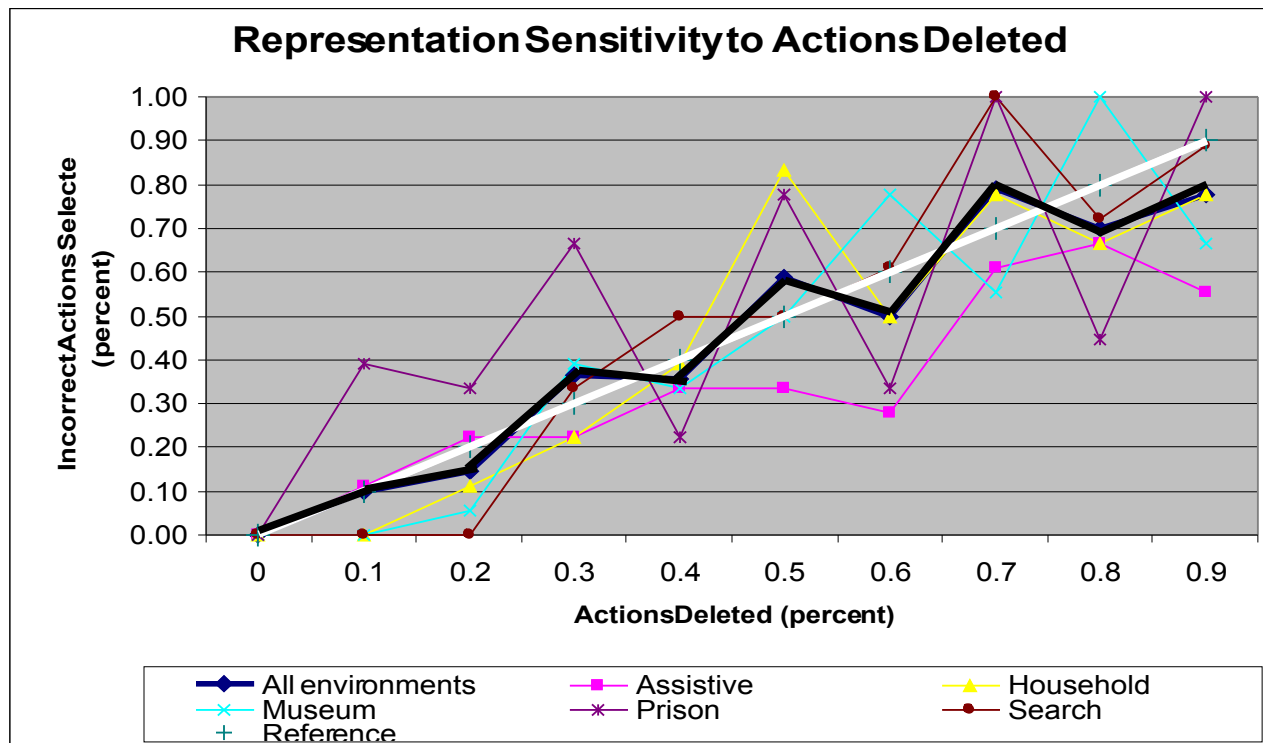
- ⌘ Compare bold white to bold black.
- ⌘ Conclusion: action selection error increases less than linearly.



# Results: Action Deletion



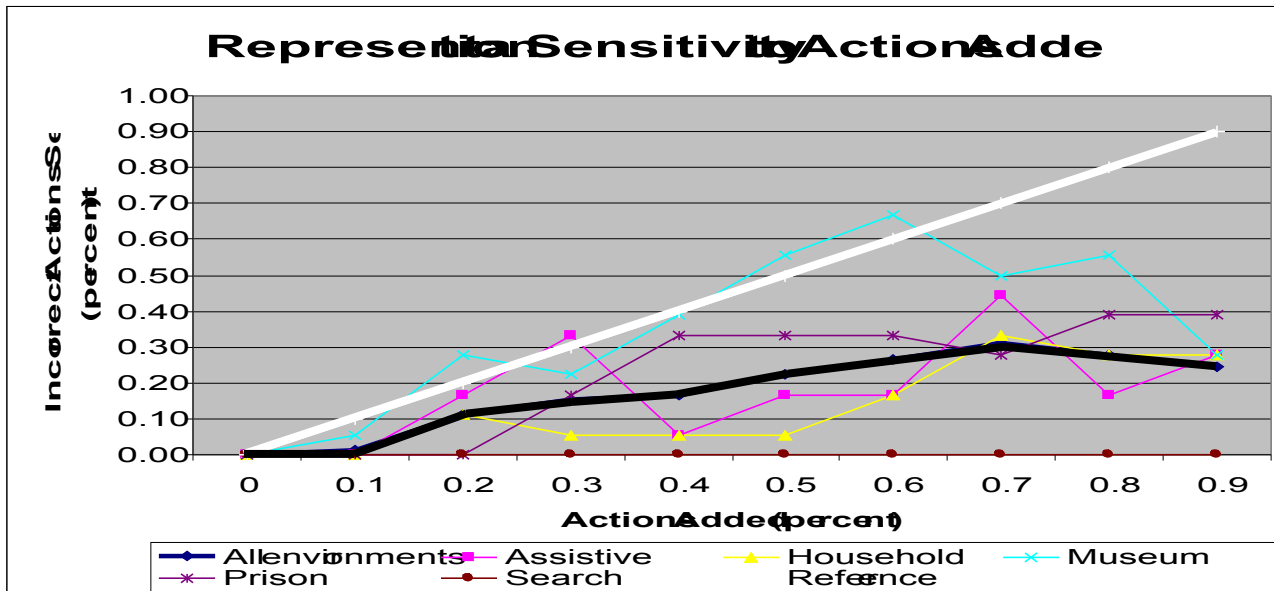
- ⌘ Black line increases at approx. same rate as white.
- ⌘ Linear increase in error with each action deleted.
- ⌘ Worse than random value replacement.



# Results: Action Insertion



- ⌘ Black line is sub linear again.
- ⌘ Overall conclusion: action deletion results in the most increase in error, then random outcome replacement, then action insertion. This result will effect develop of matrix creation algorithm.



# Conclusions



- ⌘ Outcome matrices are a viable representation for human-robot social interaction.
  - ⌘ Advantages: 1) long history in a variety of fields, 2) represents relevant information, 3) robust to errors, 4) standard testing paradigms.
  - ⌘ Disadvantages: 1) No established method for creating matrices, 2) scalability?

# Where to go from here?



- ⌘ Need algorithms for making matrices from perceptual information.
- ⌘ Need to explore the scalability of the representation.
- ⌘ Need to test on robots.

# References



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# Thank you

