Enabling a Robot to Understand a Human

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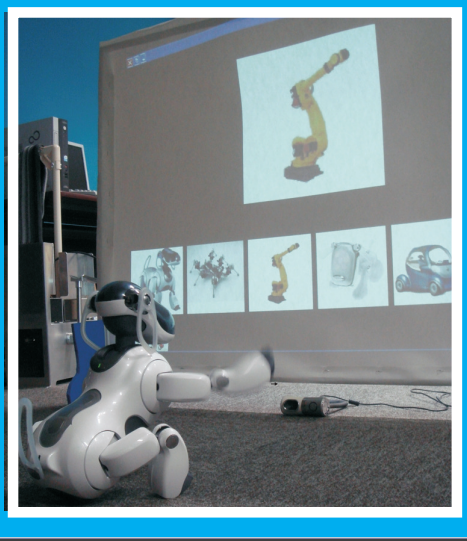


Goal: Adapting a robot to a user's preferred way of giving commands and feedback

Method:

Biologically inspired learning method

Special computerized training tasks for adaptation:

Training tasks allow the robot to provoke commands and feedback from the user:

1) Robot and user know state of training task
2) Robot and user understand which actions are good/bad
3) Robot provokes and learns commands / feedback by making good or bad moves and prompting for instruction

Learning Method

Combining **Hidden Markov Models** and **Classical Conditioning** in a two-staged algorithm

1) Stimulus Encoding Stage: Training HMMs for speech and prosody and using duration model for touch

Speech: Create utterance models from phoneme models to cluster similar utterances.

Feedback/Object/Places: Represent as one HMM per symbol

Command-Patterns: Determine parts of utterance that do not belong to expected object/place names. Train HMM(s) and model grammar with slots for objects/places

Prosody: Based on features from pitch/energy contours and frequency spectrum

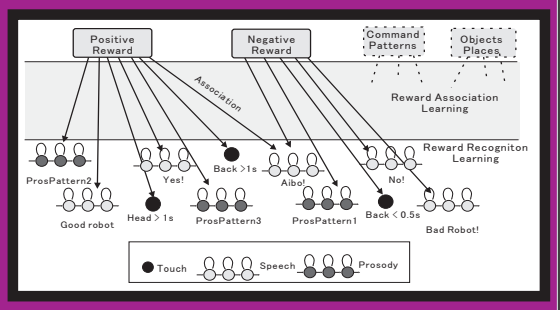
Touch: Head and back touch sensors: < 0.5 sec | between 0.5 and 1 sec | > 1 sec

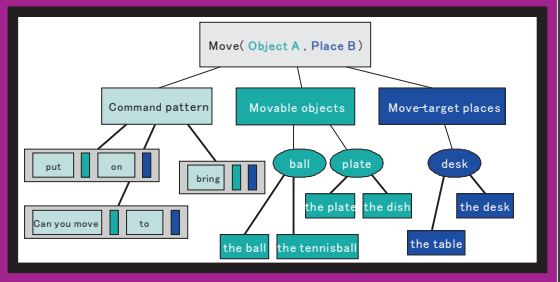
2) Associative Learning Stage: Associating HMMs with symbolic meanings

Using the Rescorla-Wagner model of classical conditioning:

Unconditioned Stimuli: Existing symbolic representations of commands, objects/places and positive/negative feedback

Conditioned Stimuli: Encoded stimuli from user represented by HMMs





Training Tasks

Four different training tasks to provoke positive/negative feedback:

1) Finding a sample Image
2) Playing the game "Pairs"
3) Playing "Connect Four" against the computer

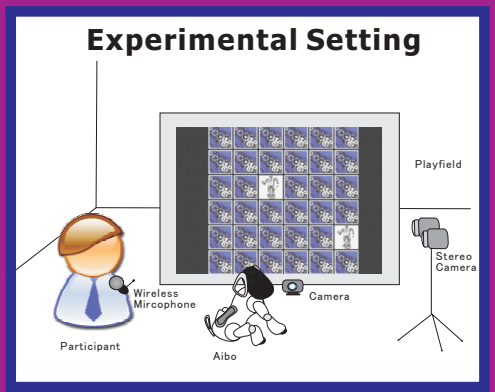
- 4)Learning "dog commands"

Experiments

First application: Learning positive/negative user feedback

10 participants (ages 23-47)

5.5 hours of audio/video data



Results

95.97% recognition accuracy for distinguishing between positive/negative feedback based on **speech, prosody and touch**

Considerable **improvement through multimodal integration**. Single modality recognition accuracies:

- Speech: 83.53%
- Prosody: 84.27%
- Touch: 88.17%