Developing Social Robots

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Social Interaction Network

- **Gedeon Deak.** Developmental Psychology.
- **Gwen Littlewort.** Machine Learning.
- **Scott Makeig.** Brain Dynamics, EEG.
- **Javier Movellan.** Machine Perception, Robotics.
- **Judy Reilly.** Language and Emotion Development.
- **Marian Stewart Bartlett.** Computer Vision.
- **Terry Jernigan.** Brain Development.
Many children entering kindergarten in the United States are not ready for school G. J. Duncan et al., Dev. Psychol. 43, 1428 (2007).
Study I: QRIO (2005)

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- Children developed sociable long term interactions that lasted for months.
- QRI0 had many limitations:
  - Not designed for education.
  - Not fully autonomous.
  - Very expensive.
Designing RUBI (2004-2008)
Challenges

- **Practical:** Safe. Durable. Useful. Economical
- **Cultural:** Teachers, parents, children, scientists, media have to like the idea.
- **Technological:** Develop useful perceptual and control primitives to enable social interaction. Smile detection.
- **Scientific:** How to put perception and action together in real time in uncertain, social environments. Meeting the challenge of the moment.
Design Philosophy

• **Embedded and Iterative Design**: Have scientists and engineers become part of the educational community in which the robot will operate. Have children, teachers, and parents shape our work early in the development process.
RUBI-4

- 1 df head with camera and microphones
- Touch sensors
- Proximity Sensors
- Touchscreen
- 2 df arms with torque and proximity sensing.
- Accelerometers
Emotion System

- Survive the children.
- Communicate critical states.
- Temporal coherence in the ongoing behavior.
  - Emotional dynamics implemented as stochastic dynamical system: A good formalism to combine external sensor information and internal temporal dynamics.
    - Lonely
    - Scared
    - Ticklish
    - Sleepy
  - Currently set up by hand and refined by experience.
Organization of Behavior

• Organized around the concept of games:
  - Formal games: “Where is the triangle?”
  - Informal games: Give and take. Songs. Tickles.

• Continuously making decisions within games and between games.
  - When to start and stop a game
  - When to provide feedback
  - When to ask questions
Teaching Engine: Apprenticeship Learning
Timing Learned from Human Teachers

![Graph showing the probability of giving a hint over time since the child last gave a correct answer.](image)
Timing Learned from Human Teachers

![Graph showing the probability of giving feedback over time since a correct answer was given.](image-url)
Evaluation Study (July 2008)

• 9 Toddlers Average age 20.4 Months. Std 3 months. Room 2 ECEC.

• 20 English words chosen from Bates-Macarthur inventory to be challenging for this age. Words matched in pairs, and each member of the pair randomly assigned to experimental (RUBI) or Control Group.

• Familiarization: 5 Days.

• Pretest: 2 Days.

• Intervention: 10 Days. RUBI programmed to teach the 10 words from experimental group. Fully autonomous.

• Posttest: 2 Days.
RUBI had a significant effect on vocabulary development. Error reduced by more than 10 percent points in 10 days. This is a lower bound in the actual performance gains.
The Magic Behind the Numbers

Angelica Rodriguez
(Inreach + Outreach)
Comforting RUBI
Learning To Say Thank You
Self Praise