Theoreticians

Research issues

Development and Learning

- **Learning as a developmental process.**

***Learn to take an action to learn more**
(online vs. offline).

***Machines that self-program like infants**
do not specify all tasks a priori

***Combine**
Developmental Psychology
Cognitive Science
Neuroscience
Robotics
Machine Learning
Theatre and Improvisation

Introduction

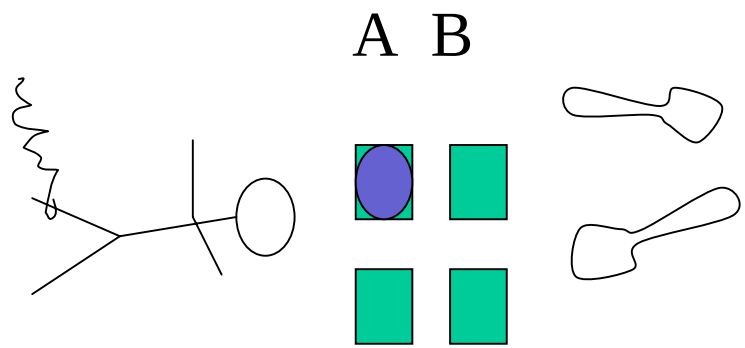
Goals: behavior prediction, language learning

Speech & developmental pathologies in children
-> there is no generalization

***Innateness vs. Experience**
***Modularity**
***Perception, Sensing, Grounding, Embodiment**
***Terminology: architectures, psychology, algorithms, biology, philosophy, cognitive science, robotics**

Developmental Psychology

***Piaget: Children not mini-adults, learning via experience**
***Cephalcaudal trend (baby with rope on leg)**
***A-not-B error (box & spoons)**
***Look, plan, reach, remember**
***Perception, action, mental activity**
coupled dynamic systems

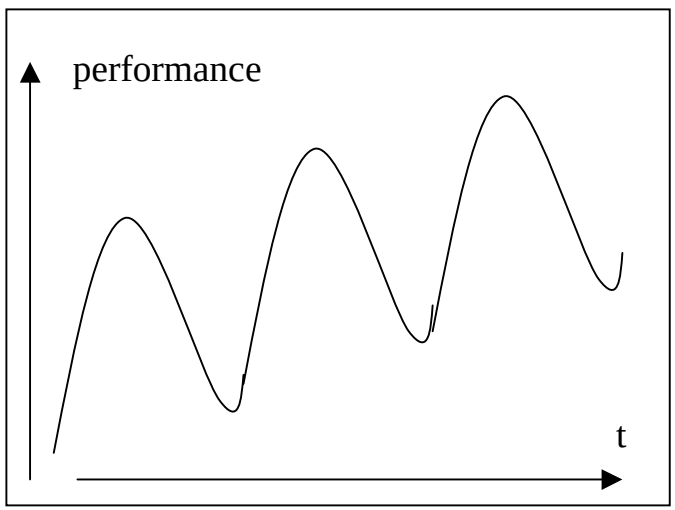


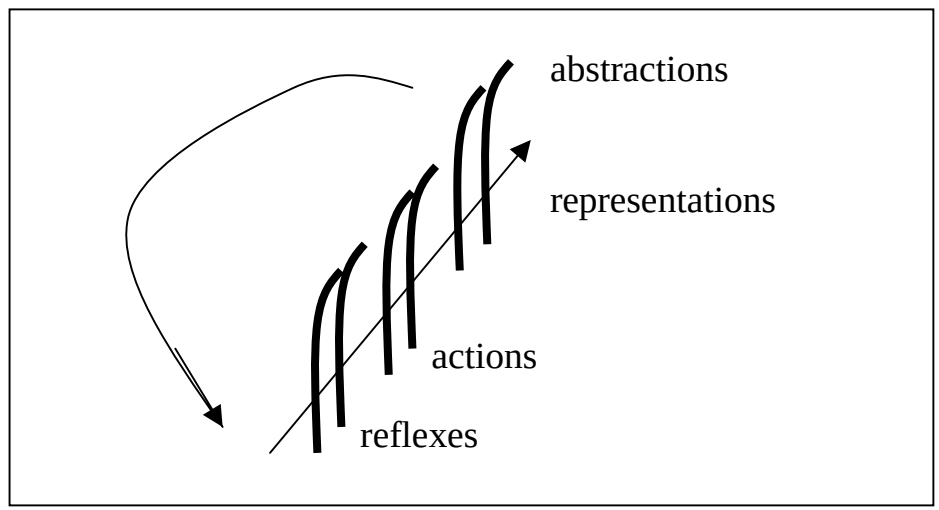
Developmental Psychology

***Scalloping: reflexes->actions->representations->abstractions**

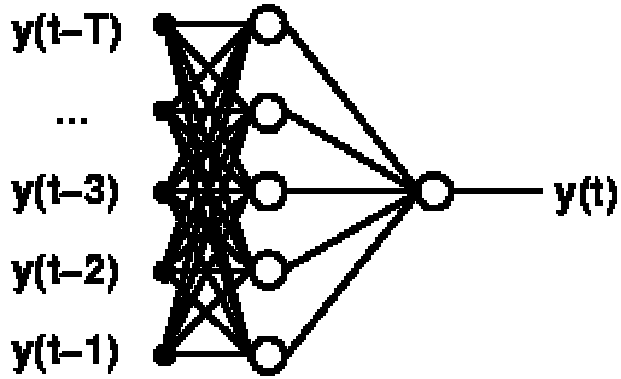
***Lego mindstorms understanding task**

***Why adults don't learn new languages as quickly as children.**





Networks & Learning



Kim Plunkett

* Temporal proximity: natural metric, nearby events, simultaneous, near-term future.

*Visual model and auditory model based on NNs and rNNs.

Tomaso Poggio:

*SVMs & Regularization Theory

*Generic object detection (appearance based) faces, cars, people

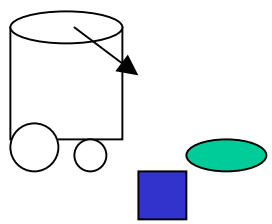
*3D Object visualization via appearance based paper clips

Gerald Edelman (Olaf Spurns):

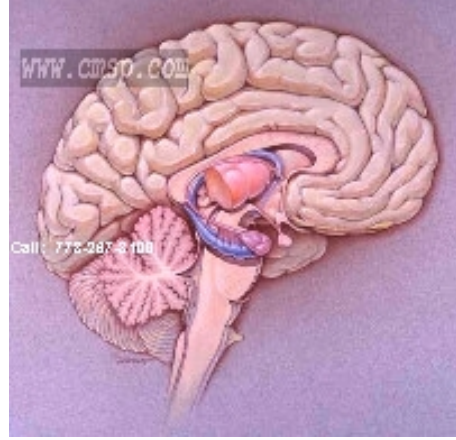
*Darwinian neuronal group / model selection

*Reentrant signaling (like recursive or feedback)

*Robot platform: sensory invariance by multi-dynamics neuronal layers (slow / fast) with competitive neural model learning



Neuroscience



Mriganka Sur:

*Retina -> LGN & SC -> Area 17 with horizontal tubes

*Cochlea & IC ->MGN->A1 with horizontal stripes

A1 orientation selectivity, maps, hypercolumns

(related to braille reading in blind)

James McClelland:

*Hippocampus Destruction-> Inability to form new memories

-> Loss of recent material

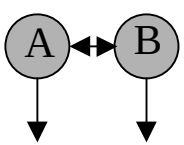
-> Knowledge & Smarts Preserved

Theory: gradual structure discovery, hippocampus -> neocortex

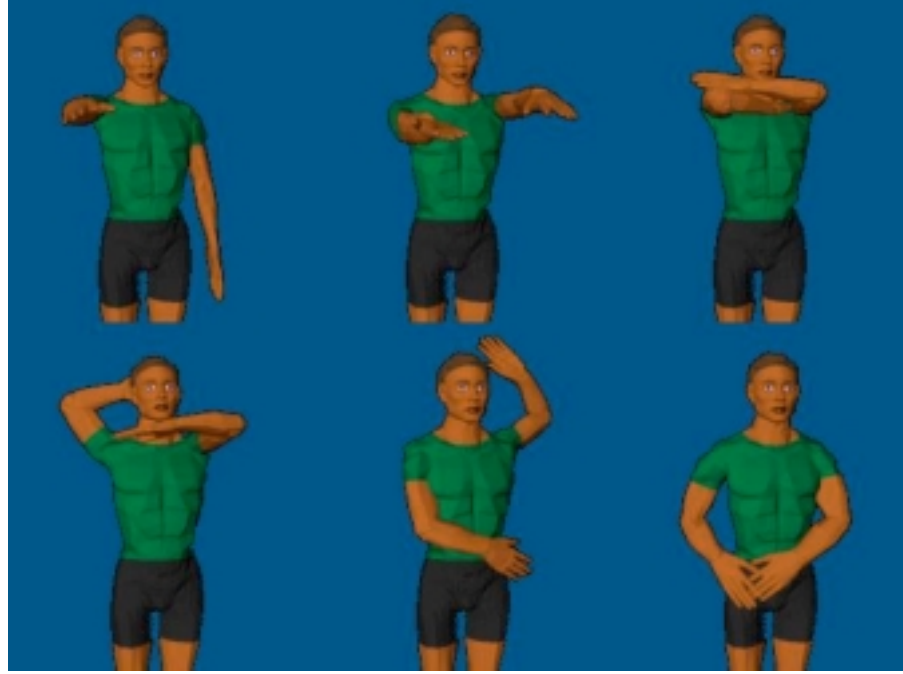
*Hebbian learning: if A fires with B, strengthen connection A-B

->leads to self-reinforcing of reactions to input (bad)

->Japanese trouble learning ‘l’ and ‘r’



Robotics



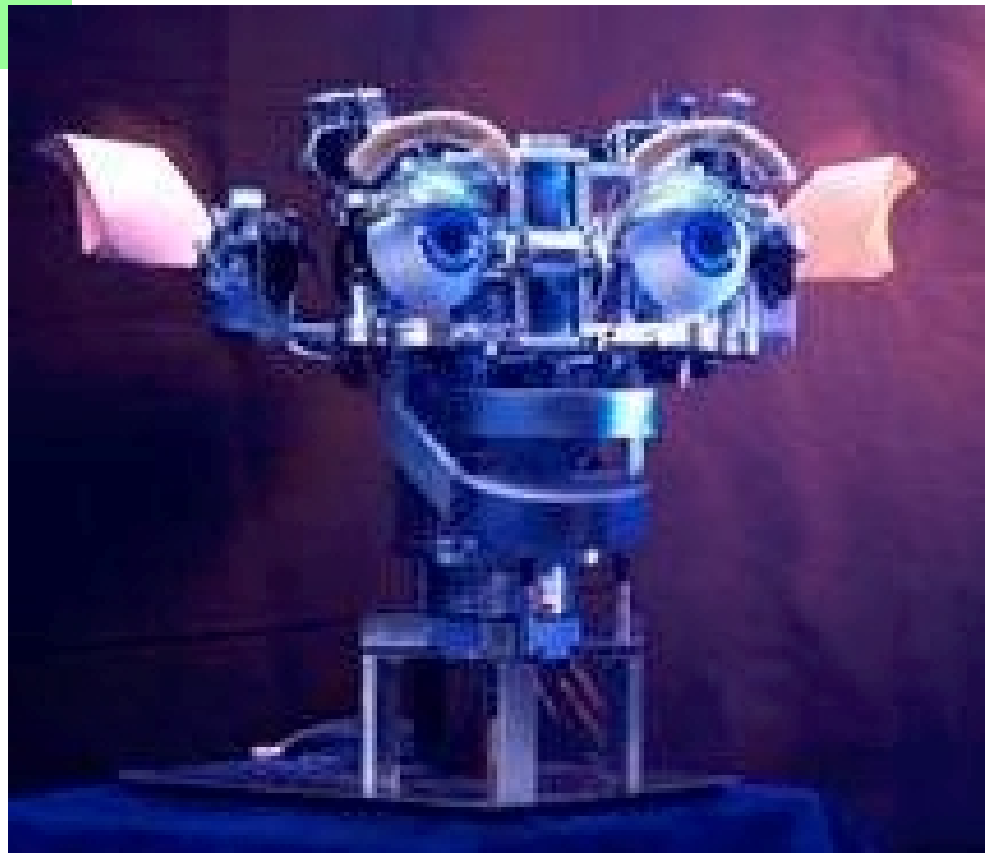
Rod Grupens:

*Distal stiffening (<DOFs, baby walking, adult skiing)
*Annealing for development
*Control+Reinforcement, map effectors via goals
*Multi-task multi-context, dynamical systems
*Switch light with my elbow when holding groceries

Maja Mataric:

*Herding, hunting, foraging via switching behavior subgroups
*Perceptual and action space mapping for Imitation
*Eigenbasis of motions

Robotics



Brian Scasselatti (Rod Brooks):

*Social Interaction

* Tracking own hands

*Cog / Kismet: face tracking, color, motion modules

*Weights from each module decay via habituation

Open Problems

*Innateness versus Experience
*Modularity
*Perception, Sensing, Grounding, Embodiment
*Terminology: architectures, psychology, algorithms, biology, philosophy, cognitive science, robotics

Environments to study these problems. Theatre?

New Conference & Community
Data Sets
Funding
Joint Programs & Transfers

Theater as a Metaphore for Robotics Research

- The **ATTENTION AND AFFECT PROJECT**
  - at the the University of Birmingham.
  - This project is headed up by Aaron Sloman and is interested in evaluating the design space of agent architectures.
  - In particular, they are examining the design of agent architectures for resource-bounded agents with multiple sources of motivation and the role emotions plays in such agents.
- The **VIRTUAL THEATER PROJECT** at Stanford.
  - This project is headed up by Barbara Hayes-Roth and Edward Feigenbaum.
  - They are looking at tools to allow children to create impovisational plays on the computer.
- The **AUTONOMOUS AGENT GROUP** at the MIT Media Laboratory.
  - This group is headed up by Pattie Maes.
  - They build all sorts of agents for a variety of purposes.
- Fujitsu's **TEO WORLD** (The Other Earth)
  - it includes PhinPhin, an animated animal character, that is related to work we are doing in believable agents.
- The **OZ Project** at CMU.

Barbara Hayes-Roth and Stanford University: Virtual Theater

1998 - present

Virtual Theater

– **Part of** their past and current research.

– The Virtual Theater project has implemented several systems for exploring:

- how software agents interact,
- how users can guide them to craft stories or simply to experience improvisational, interactive narrative.

– Animated Puppets

- Animated puppets is a graphical world inhabited by creatures called ***woggles*** who move about and talk and play with one another.
- In this world, the user can control one woggle, **while the other woggle is directed by the computer.**
- The woggles use intelligent improvisational ability to choose interesting behaviors.

Virtual Theater

- There is more detailed information available about the woggles and animated puppets on their WWW Page.
- Ruth Huard is using the woggles system for her own research in childrens' storycrafting; there is a set of slides outlining her research.
- For more information on the animated puppets, see also the paper Directed Improvisation by Computer Characters.

Virtual Theater

– CyberCafé

- The CyberCafé project uses a **text-based, multi-agent environment** in which users can interact via avatars with autonomous characters.
- In the basic scenario, two users take the forms of customers in the CyberCafé, while the computer directs the actions of their waiter.
- Daniel Rousseau used the CyberCafé to study **models of personality** in computer-controlled characters.
- In his studies, several different **waiter personalities** were used in the scenario, to compare how their personality models generate substantively similar actions, but actions infused with *distinct mannerisms and behaviors*.
  - There is a set of slides overviewing the Cybercafé and Daniel Rousseau's research in it. The summary papers on this project are A Social-Psychological Model for Synthetic Actors, and Interacting with Personality-Rich Characters, and Improvisational Synthetic Actors with Flexible Personalities.

Virtual Theater

- **The Forest Sauvage**
  - **believable characters** with broad, abstract domain knowledges,
  - characters placed in virtual environments that provide specific domain details in the form of embedded annotations,
  - the goal is to study how, in this way, believable agents may visit a variety of domains and act naturally and entertainingly within them.
- **The current testbeds:**
  - text-based Multi User Domains (MUDs) and educational Web pages.
  - in which there exists a guide character called ***Merlyn***,
    - named after the befuddled old magician in T. H. White's *The Once and Future King*.
    - Merlyn exists and acts independently of the user.

Virtual Theater

- ***Merlyn*** can:
  - scan his environments for actions and information about them,
  - communicate with the user,
  - suggest activities,
  - play with the user,
  - and develop a model of the user

- this is done across multiple sessions by observing the user's actions and preferences.

More Virtual Theater Information

- An introductory overview of this work is Guided Exploration in Virtual Worlds.
- Current research is reflected in Agents in Annotated Worlds.
- There is also a set of slides overviewing the project . On their WWW Page

Virtual Theater

–Tigrito

- Tigrito is intended to contrast the effectiveness of different modes of interaction with a synthetic character.
- The character in question is an animated stuffed tiger.
- Users may interact with the tiger through another tiger avatar or *as disembodied entities*;
- They may also observe the computer-controlled actions of two tigers, Tigrito and Hobbes.
- This work is now being extended by Heidy Maldonado as a potential mechanism for second-language learning of English or Spanish.
- A summary of the initial phase of this work is contained in Tigrito: A Multi-Mode Interactive Improvisational Agent.

Virtual Theater

- **Master/Servant Scenarios**
  - In the master/servant scenarios, they study how two autonomous agents interact with one another without human intervention.
  - The master and the servant each have knowledge about the environment and their status within it.
  - These scenarios test their behavior under computer-controlled stimuli and emotional variations.
  - There are screen shots for viewing on their WWW page.
  - They are part of a video that shows the master, Otto, reversing roles with his servant, Gregor.
    - Collaboration with Ken Perlin at NYU's Media Research Lab to use of their animation system in creating these stories.

Virtual Theater

- The Virtual Theater project aims to provide a multimedia environment.
- In this environment the users can play all of the creative roles associated with *producing and performing* plays and stories.
- In a mode of an improvisational theater company.
- These roles include:
  - producer,
  - playwright,
  - casting director,
  - set designer,
  - music director,
  - real-time director,
  - and actor.

- **Intelligent agents** fill roles not assumed by the user. In particular, in a typical production, animated actors perform the play in a multi-media set,
  - all under the supervision of an automated ***stage or story manager***.

Virtual Theater

- Actors not only follow scripts and take interactive direction from the users. They bring "life-like" qualities to their performances;
  - for example, variability and idiosyncracies in their behavior and **affective expressiveness.**
- They also **improvise,** thus collaborating on the creative process.
  - Each time the actors perform a given script or follow a given direction, they may improvise differently.
  - Thus, users enjoy the combined pleasures of seeing their own works performed and **being surprised** by the improvisational performances of their actors.

Virtual Theater

- Current research focuses on **building individual characters** that can:
  - take direction from the user or the environment,
  - and act according to these directions
  - **in ways** that are consistent with their unique emotions, moods, and personalities.
- The Virtual Theater project is part of the Adaptive Intelligent Systems (AIS) project at Stanford University
- Its primary goal is to be a testbed for important research issues in artificial intelligence
- In addition, the Virtual Theater offers attractive opportunities for *interdisplinary collaboration* and for addressing important social, educational, and commercial objectives.

Virtual Theater Publications:

- **Hayes-Roth, B., and Doyle, P. Animate Characters. To appear in *Journal of Autonomous Agents and Multi-Agent Systems*, 1998.**
- **Johnson, L., and Hayes-Roth, B. Perspective on the First International Conference on Autonomous Agents. To appear in *Knowledge Engineering Review*, 1998.**
- **Hayes-Roth, B., Ball, G., Lisetti, C. Picard, R. W., Stern, A. Panel on Affect and Emotion in the User Interface. In *Proceedings of the Conference on Intelligent User Interfaces*, January, 1998.**
- **Isbister, K., and Hayes-Roth, B., Social Implications of Using Synthetic Characters: An Examination of a Role-Specific Intelligent Agent. Stanford Knowledge Systems Laboratory Report KSL-98-01, 1998.**
- **Rousseau, D., and Hayes-Roth, B., Improvisational Synthetic Actors with Flexible Personalities. Stanford Knowledge Systems Laboratory Report KSL-97-10, 1997.**
- **Doyle, P., and Hayes-Roth, B., Agents in Annotated Worlds. Stanford Knowledge Systems Laboratory Report KSL-97-09, 1997. A revised version appears in the *Proceedings of the Second International Conference on Autonomous Agents*, Minneapolis, MN, May 1998.**

Virtual Theater Publications:

- **Maldonado, H., Picard, A., Doyle, P., and Hayes-Roth, B., Tigrito: A Multi-Mode Interactive Improvisational Agent. In *Proceedings of the 1998 International Conference on Intelligent User Interfaces*, San Francisco, CA, January 1998. Also available as Stanford Knowledge Systems Laboratory Report KSL-97-08, 1997.**
- **Rousseau, D. and Hayes-Roth, B. A Social-Psychological Model for Synthetic Actors Stanford Knowledge Systems Laboratory Report KSL-97-07, 1997. A revised version appears in the *Proceedings of the Second International Conference on Autonomous Agents*, Minneapolis, MN, May 1998.**
- **Rousseau, D. and Hayes-Roth, B. Interacting with Personality-Rich Characters Stanford Knowledge Systems Laboratory Report KSL-97-06, 1997.**
- **Doyle, P. and Hayes-Roth, B. Guided Exploration of Virtual Worlds. Stanford Knowledge Systems Laboratory Report KSL-97-04, 1997.**
- **Huard, R. D. and Hayes-Roth, B. Children's play with improvisational puppets Stanford Knowledge Systems Laboratory Report KSL-96-27, 1996.**
- **Huard, R. D. and Hayes-Roth, B. Children's collaborative playcrafting Stanford Knowledge Systems Laboratory Report KSL-96-17, 1996.**
- **Rousseau D., Hayes-Roth B. La personnalité dans les acteurs synthétiques. To be published in *Analyse de Systèmes*. Also Stanford Knowledge Systems Laboratory Report KSL-96-28, 1996.**

Virtual Theater Publications:

- **Rousseau D., Moulin B. Mixed initiative in interactions between software agents. *Proceedings of the 1997 Spring Symposium on Computer Models for Mixed Initiative Interaction*, AAAI Press, Menlo Park, CA, March 1997.**
- **Rousseau, D. and Hayes-Roth, B. Personality in synthetic agents. Stanford Knowledge Systems Laboratory Report KSL-96-21, 1996.**
- **Doyle, P. and Hayes-Roth, B. An intelligent guide for virtual environments. In *Working Notes of the IJCAI-97 Workshop on Animated Interface Agents: Making Them Intelligent*, Nagoya, Japan, August 1997. Also available as Stanford Knowledge Systems Laboratory Report KSL-96-20, 1996.**
- **Hayes-Roth, B., van Gent, R. and Huber, D. Acting in character. In R. Trappl and P. Petta (Eds.), *Creating Personalities for Synthetic Actors*. Also available as Stanford Knowledge Systems Laboratory Report KSL-96-13, 1996.**
- **Doyle, P., and Hayes-Roth, B. Computer-aided exploration of virtual environments. In *Working Notes of the AAAI-96 Workshop on AI/ALife*, AAAI Press, Menlo Park, CA, 1996.**
- **Rousseau, D. Personality in computer characters. In *Working Notes of the AAAI-96 Workshop on AI/ALife*, AAAI Press, Menlo Park, CA, 1996.**

Virtual Theater Publications:

- Hayes-Roth, B. and van Gent, R. Improvisational puppets, actors, and avatars.. In *Proceedings of the Computer Game Developers' Conference*, Santa Clara, CA, 1996. Also available as Stanford Knowledge Systems Laboratory Report KSL-96-09, 1996.
- Hayes-Roth, B. and van Gent, R. Story-making with improvisational puppets and actors. Stanford Knowledge Systems Laboratory Report KSL-96-05, 1996.
- Hayes-Roth, B., Brownston, L., Sincoff, E., and van Gent, R. Directed improvisation by computer characters. Stanford Knowledge Systems Laboratory Report KSL-95-04, 1995.
- Hayes-Roth, B., Sincoff, E., Brownston, L., Huard, R., and Lent, B. Directed Improvisation. Stanford Knowledge Systems Laboratory Report KSL-94-61, 1994.
- Hayes-Roth, B., Brownston, L., and van Gent, R. Multiagent collaboration in directed improvisation. Stanford Knowledge Systems Laboratory Report KSL-94-69, 1994.

Press Coverage and Talks

- **Press Coverage**
  - **Orange County Register (Dawn C. Chmielewski): Interview on High-Tech Toys, March 1998.**
  - **Discover Magazine: Report on Awards for Technological Innovation, July 1997.**
  - **Wall Street Journal (G. Pascal Zachary): Storytelling and Technology, 1997.**
- **Talks**
  - **B. Hayes-Roth, "Interacting with Characters," Imagina European Conference on Images and Technology, Monte Carlo, Monaco, March 1998.**
  - **B. Hayes-Roth, "Interacting with Characters," Kodak Imagination Research Center, Palo Alto, CA, March 1998.**
  - **B. Hayes-Roth, "Interactive Guides," Bay Area Computer Education and Training Association, San Rafael, March 1998.**
  - **B. Hayes-Roth, "Interactive Guides," Autodesk, San Rafael, February 1998.**
  - **B. Hayes-Roth, "Interacting with Characters," Phillips Media Research Center, Palo Alto, CA, January and February, 1998.**

Talks

- B. Hayes-Roth, "Interacting with Characters," NASA Ames Seminar Series, Palo Alto, CA, January 1998.
- P. Doyle, "Annotating Virtual Worlds," Virtual Worlds and Simulation Conference, San Diego, CA, January 1998.
- B. Hayes-Roth, "Affect and Emotion in the User Interface," Invited to Chair Panel, Conference on Intelligent User Interfaces, San Francisco, January 1998.
- H. Maldonado and A. Picard, "Tigrito: A Multi-Mode Interactive Improvisational Agent," Conference on Intelligent User Interfaces, San Francisco, CA, January 1998.
- P. Doyle, B. Hayes-Roth, R. Huard, K. Isbister, H. Maldonado, A. Picard, "The Virtual Theater Project," Stanford CSLI Affiliates Tutorials.
- B. Hayes-Roth, "Interacting with Characters," MIT Media Lab, October 1997.
- B. Hayes-Roth, "Animate Characters," Invited Panelist, The Next Big Thing, IJCAI, Nagoya, Japan, August 1997.
- P. Doyle, "An Intelligent Guide for Virtual Environments," IJCAI Workshop on Animated Interface Agents, Nagoya, Japan, August 1997.
- B. Hayes-Roth, "Mastery of Character," IJCAI Workshop on Animated Interface Agents, Nagoya, Japan, August 1997.
- B. Hayes-Roth, "Characters," Virtual Humans Conference, Los Angeles, CA, August 1997.

- **B. Hayes-Roth, "Improvisational Actors and Avatars," ART & CSLI Workshop on Empathy for Interactive Environments, Stanford, June 1997.**
- **B. Hayes-Roth, "Mask and Cyber Mask," Computer Game Developers' Conference, Santa Clara, CA, April 1997.**
- **B. Hayes-Roth, "Improvisational Characters," NSF-CNPq Workshop Int. Agents, Porto Alegre, Brazil, March 1997.**
- **B. Hayes-Roth, "State of the Art of Autonomous Agents," Panel Leader, First International Conference on Autonomous Agents, Los Angeles, CA, February 1997.**
- **B. Hayes-Roth, "Storymaking with Improvisational Puppets," First International Conference on Autonomous Agents, Los Angeles, CA, February 1997.**
- **B. Hayes-Roth, "Improvisational Characters," Intel, Hillsboro, OR, January 1997.**
- **B. Hayes-Roth, "Acting in Character," AAAI '96 Invited Talk, Portland, OR, August 1996**

- **B. Hayes-Roth, "Directing Improvisational Actors," AAAI Workshop on Adaptive Intelligent Agents, Portland, OR, August, 1996**
- **B. Hayes-Roth, "Agents as Improvisational Puppets, Actors, and Avatars," Institute for Systems Science, Singapore, August, 1996**
- **B. Hayes-Roth, "Agents as Actors," Symposium on Internet Agents, Symposium on Media and Network Applications, Stanford University, May, 1996**
- **B. Hayes-Roth, "Improvisational Puppets, Actors, and Avatars," Computer Game Developers' Conference, Santa Clara, CA, March, 1996**
- **B. Hayes-Roth, "Intelligent Agents as Improvisational Actors," Japan AI Symposium, Nagoya, Japan, November, 1995**
- **B. Hayes-Roth, "Intelligent Agents in Education: Learning Assistants and Learning Toys," Symposium on Intelligent Interfaces, Stanford University, November, 1995**
- **B. Hayes-Roth, "Agents on Stage: Advancing the Art of AI," International Joint Conference on AI (IJCAI), Montreal, August, 1995**
- **B. Hayes-Roth, "Animated Puppets," IJCAI Workshop on AI and Entertainment, August, 1995**

- B. Hayes-Roth, "Directed Improvisation: A Paradigm for Human-Computer Interaction," IBM, Boca Raton, July, 1995
- B. Hayes-Roth, "AI Environments for Learning through Creative Play," International Workshop on Smart Machines & Education, Seaside, FL, May, 1995
- B. Hayes-Roth, "A Virtual Theater for Children," Volunteers Celebration, Stanford, May, 1995
- B. Hayes-Roth, "Animated Puppets in a Virtual Theater, Developmental Psychology, Stanford, CA, May, 1995
- B. Hayes-Roth, "Agents on Stage: Advancing the Art of Artificial Intelligence," Invited Lecture, International Joint Conference on AI, Montreal, August, 1995
- B. Hayes-Roth (co-authors: K. Isbister, L. Friedlander), "A Model for Interactive Story Systems," Invited Lecture, IJCAI Workshop on AI and Entertainment, August, 1995
- B. Hayes-Roth (co-authors: L. Brownston, R. vanGent), "Multi-agent collaboration in directed improvisation," First International Conference on Multi-Agent Systems, San Francisco, June, 1995.
- B. Hayes-Roth, "Experience-based learning in a Virtual Theater Environment," International Workshop on Smart Machines & Education, Seaside, FL, May, 1995.

- B. Hayes-Roth, "A Virtual Theater for Children," Celebration of Alumni Volunteers, Stanford, May, 1995
- L. Brownston, R. van Gent, E. Sincoff, B. Hayes-Roth, (co-authors: R. Huard, B. Lent), "Animated Puppets Interactive Exhibit," Conference on Human Factors in Computing Systmes, CHI'95, Denver, CO, May, 1995.
- B. Hayes-Roth "Animated Puppets in a Virtual Theater," Developmental Psychology Group, Stanford University, May, 1995
- L. Friedlander, "Design Strategies for Hypermedia," Hypermedia Conference, University of Paris, 1995.
- L. Friedlander, "New technologies and writing strategies," Authors Guild Conference, Palo Alto, 1995.
- B. Hayes-Roth, "Directed improvisation: A new paradigm for computer games," Computer Game Developers' Conference, Santa Clara, CA, April, 1995
- B. Hayes-Roth, "Directed improvisation by computer characters," Colloquium Series, Georgia Institute of Technology, Atlanta, April, 1995
- B. Hayes-Roth, "Directed improvisation by computer characters," Colloquium Series, Institute for Learning Sciences, Northwestern University, Evanston, April, 1995.
- B. Hayes-Roth (co-authors K. Isbister, L. Friedlander), "Immersion Story Systems," AAAI Symposium on Interactive Story Systems, Stanford, CA, March, 1995

- Katherine Isbister (co-authors: Virtual Theater Project Members), "Overview of the Virtual Theater Project," AAAI Symposium on Interactive Story Systems, Stanford, CA, March, 1995.
- Robert van Gent (co-authors: B. Hayes-Roth, L. Brownston, E. Sincoff), "Animated Puppets," AAAI Symposium on Interactive Story Systems, Stanford, CA, March, 1995.
- B. Hayes-Roth, "Using abstract control plans to guide situated behavior," AAAI Symposium on Integrated Planning Applications, Stanford, CA, March, 1995.
- B. Hayes-Roth, "Directed Improvisation by Computer Characters," AI Lecture Series, Stanford University, March, 1995
- Barbara Hayes-Roth, "Directed improvisation by computer characters," Visual Programming Series, Stanford CSLI, March, 1995
- Barbara Hayes-Roth, "Directed improvisation by computer characters," Seminar on Human-Computer Interaction, Stanford, February, 1995

- Barbara Hayes-Roth, "Directed improvisation by computer characters," Invited Speaker Series, Apple Advanced Technology Group, Cupertino, January, 1995
- Barbara Hayes-Roth, "Directed improvisation," Invited Speaker Series, Microsoft Adv. Technology Center, Bellvue, September, 1994
- Barbara Hayes-Roth, "Design for a computer-animated improvisational theater," AAAI Workshop on AI, the Arts, and Interactive Entertainment, Seattle, WA, August, 1994
- Barbara Hayes-Roth, "Children's learning in a computer-animated improvisational theater," Psychology Department, UC Santa Cruz, May, 1994

- *pdoyle@cs.stanford.edu*

April 17, 1998

The Company

- **Barbara Hayes - Roth**
  (Principal Researcher) Dr. Hayes-Roth is the director of this company.
- **Patrick Doyle My interests include operating autonomous agents on MUDs, for educational, exploratory, and narrative purposes. I am currently developing an agent called Merlyn who will help guide children in virtual worlds.**
- **Ruth Duran Huard Ruth, an education Ph.D. student, is studying how young children use improvisational computer tools (such as the *Woggles* environment) for playcrafting and learning group cooperation skills.**
- **Katherine Isbister Katherine Isbister is a PhD student in the Communication Department. She's studying how to bring personality dimensions from Psychology into the development of compelling interactive characters. Katherine is interested in how artists in other media use artful ambiguity to create engaging and lasting characters, and in the role of gesture and body language in establishing character.**
- **Heidy Maldonado Heidy is a Master's student in Computer Science and Latin-American Studies, working on a multi-lingual, animated tiger called *Tigrito*. She is using Tigrito to contrast different modes of human-character interaction and explore the impact of affect on language learning.**

Carnegie Mellon University
School of Computer Science

Oz Project Home Page

1999 - present

The Oz Project

- The Oz Project at CMU is developing technology and art to help artists create high quality interactive drama
- Based in part on AI technologies.
- Multimedia Research Lab (**MRL**).
- This especially means building believable agents in dramatically interesting micro-worlds.

Oz Project Overview

- [This is an excerpt from: Kelso, M., Weyhrauch, P., and Bates, J. Dramatic Presence. In *PRESENCE: The Journal of Teleoperators and Virtual Environments*, Vol 2, No 1, MIT Press.]
- *Dusk in Cairo. You are walking down a dusty street, on your way to a museum. You wish to discover the origin of a symbol found in a book belonging to your father the archeologist. Your father had told you, before he died, that this book contained his life's work. Suddenly, you hear footsteps. A man grabs the shoulder of your leather jacket. He says he is Horace, a friend of your father's, and if you come with him, he can help you. You stop in Cafe Tut -- he is charming and surprisingly knowledgeable about your father. You absorb his every word, until you suddenly get an eerie feeling. Horace is asking strange questions about the book. Your father's book. You then notice a suspicious gun-like bulge in his suit jacket. You slowly get up, mentioning the restroom, and then bolt out of the cafe, barely evading Horace's hands as you jump into the nearest taxi. ``Quick, get me to the museum,'' you scream over the sound of the screeching tires. You relax as you see Horace getting smaller though the rear window of the cab. ``Yes, Sir,'' the gold-toothed cabbie replies with a smile, heading quickly in the wrong direction.*

From Oz Project Page:

- **This is a description of what a short segment of Interactive Drama should be like.**
- **You find yourself immersed in a fantasy world with exciting characters and the *possibility of many adventures.***
  - **You control your own direction by choosing each action you take,**
  - **But you are confident that your experience will be good, because a master interactive-storyteller subtly controls your destiny.**
- **``Interactive drama'' - the presentation by computers of rich, highly interactive worlds, inhabited by dynamic and complex characters, and shaped by aesthetically pleasing stories.**
- **People interacting with these worlds will be called ``interactors.''**
  - **A similar notion, which has influenced their work, has been presented by Laurel (Laurel 89, Laurel 91).**
- **``Highly interactive'' is an important phrase of their description.**

From Oz Project Page:

- **The word ``interactive'' distinguishes their work from conventional media.**
- **``Highly interactive'' indicates the interactor is choosing what to do, say, and think at all times,**
  - **in contrast to other interactive media such as hypertext, where the interactor is given only a small number of fixed choices.**
- **If their example had been a conventional story, the author alone would decide exactly what happens to the protagonist.**
- **In interactive drama, the interactor is the protagonist and determines the action.**

From Oz Project Page:

- Likewise, the term ``drama'' is important.
- Even though the interactor is choosing what to do, say, and think, there is a destiny, created by the author of the interactive drama.
- This destiny is not an exact sequence of actions and events, but is subtly shaped by the system, which embodies dramatic theory and principle, in order to create a cathartic experience.
- Oz is a computer system we are developing that allows authors to create and present interactive dramas (Bates 92).
- Figure 1 shows the Oz system architecture.

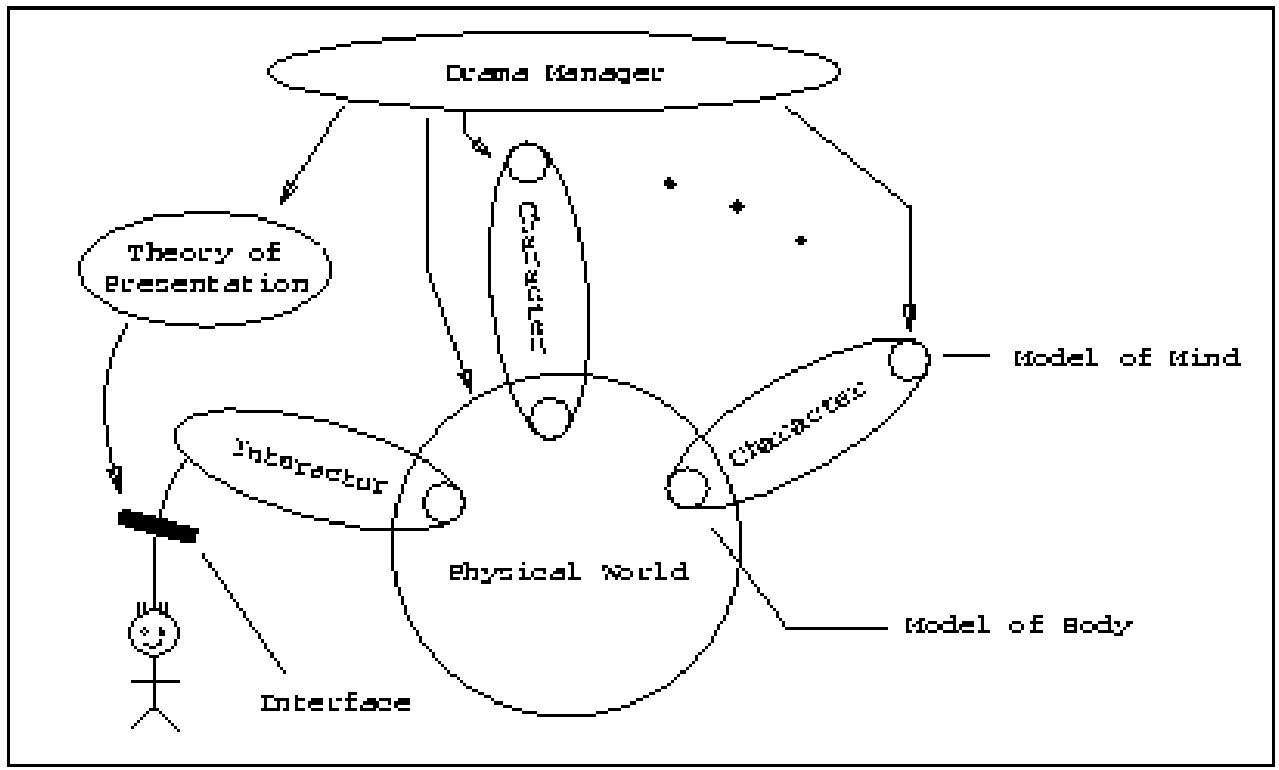


Figure 1. The Oz System Architecture

From Oz Project Page:

- The architecture includes:
  - a simulated physical world,
  - several characters,
  - an interactor,
  - a theory of presentation,
  - and a drama manager.
- A model of each character's body and of the interactor's body are in the physical world. Outside the physical world, a model of mind controls each character's actions.
- The interactor's actions are **controlled by the interactor.**

- Sensory information is passed from the physical world to the interactor through an interface
- This interface is controlled by a theory of presentation.
- As shown, the drama manager influences:
  - the characters' minds,
  - the physical world,
  - and the presentation theory.
- Oz has three primary research foci:
  - characters,
  - presentation,
  - and drama.
- As in traditional media, *each of these areas* is important for creating a rich dramatic experience.
- In the research on characters they study how to create computer controlled agents that appear:
  - reactive,
  - goal directed,
  - emotional, moderately intelligent,
  - and capable of using natural language (Bates et al. 91, Bates et al. 92, Reilly & Bates 92).

From Oz Project Page: two presentation modes

- Currently, the project has two different presentation models:
  - textual
  - and animated.
- The textual system uses text as the input and output medium.
  - The world and characters are described through text,
  - and the interactor's actions are entered to the computer through text.
- In the animated system, the world and characters are presented graphically.
  - Humans interact with the system physically, through sonar sensors and a mouse.
  - In the future of both systems, people may interact through sounds and speech.
- Their presentation research deals with how to generate English narrative text (Kantrowitz 90, Kantrowitz & Bates 92).
- Study how the state of a story can affect the best way to describe a scene (Smith & Bates 89).
- The work on **drama**:
  - how to represent and control an **interactive story** with the computer (Bates 90).

From Oz Project Page: References

- (For a complete list of Oz papers, see our publications page.)
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- Reilly, W. S., and Bates, J. (1992). Building Emotional Agents. Technical Report CMU-CS-92-143, School of Computer Science, Carnegie Mellon University, Pittsburgh, PA.
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Current Members

- **Joseph Bates.** The wizard of Oz, Joe is the head of the Oz project and tries his best to keep the rest of this motley group in line.
- Michael Mateas. Michael explores the use of AI as a vehicle for artistic expression. His current projects include subjective avatars for story worlds, a narrative machine that constructs historical documentaries, and a robotic office plant that responds to light, sound, and email activity.
- Phoebe Sengers. Phoebe is studying the nature of agency in contemporary society and the creation of artificial agents as a cultural practice. She works on using that knowledge to build better agents.

Group Alumni

- **Matt Glickman.** Matt is interested in creating agents through evolutionary methods.
- Mark Kantrowitz. Mark is developing a language generation system that will enable interactive characters to converse naturally and emotionally.
- **Bryan Loyall.** Bryan is working to create believable agents. Such agents could be used as characters for interactive drama, personalities for user interfaces or anywhere where agents with personality are desired. He is currently focusing on believable agents that act and use natural language in a real-time animated, visual world.
- Scott Neal Reilly. Scott is working on tools that will allow artists to create emotional and social characters for interactive drama.
- Peter Weyhrauch. Peter wants to become one with the concept of interactive story. Right now he is building a system that can subtly control the flow of interactive stories to create a dramatic experience for the interactor.
- Dr. Sarah Sloane. Sarah is interested in the intersections of narrative theory, feminist theory, cultural theory, and building virtual worlds.
- Most of the people on this list are working on Oz from the computer science department at Carnegie Mellon University. We work with others at CMU and elsewhere in CS, Drama, English, and a number of other disciplines.

Worlds and Images

- The Oz project is designing technology to make it possible for artists to create interactive, dramatic microworlds. To demonstrate the potential of this work, they built a few systems.
- Two versions of the Oz system:
  - A real-time animation version which is built on top of C and RAL (a C preprocessor with a built-in Rete matcher). Using this system they built a world called *The Edge of Intention* (or *The Woggles*).
  - A text system which looks similar to classic interactive fiction titles (like Adventure or Zork). This system is built on top of Lisp. Using this system they built *Lyotard*.
- Scott Neal Reilly, who works primarily on emotion and social behavior for Oz agents has also built 3 small demo worlds called *Robbery World*, *Office Politics*, and *The Playground*.

Edge of Intention

- The Edge of Intention is an interactive animated art piece.
- The world looks like something out of a Dr. Seuss book
- It is inhabited by ellipsoidal creatures called Woggles.
  - the "user" of the system controls one of the Woggles
  - the other three (Wolf, Shrimp, and Bear) are controlled by the computer.
- There is no set story in this world. It is primarily a demonstration of our attempts at creating believable characters for simulated worlds.
- The Woggles have individual personalities,
  - They display emotions.
  - They engage in social behaviors (like fighting and playing follow-the-leader).
  - They react to their dynamic environment (including the user-controlled Woggle).
  - They communicate by stylistic squashes and spins and they move by jumping.
  - They can also move their eyes to watch what's going on around them.

Edge of Intention

- This piece was first shown at the AAAI-92 Art Exhibit in San Jose, CA.
- Since then it has been shown at SIGGRAPH-93, the Hewlett Gallery in Pittsburgh, PA, and is on permanent display at the Computer Museum in Boston, MA.
- It was also awarded an honorable mention at the 1993 Prix Ars Electronica.

The Edge of Intention was a joint effort with the Computer Animation group at CMU and a number of other artists and researchers. The complete list is: Joseph Bates, Andrew Witkin, James Altucher, Alexander Hauptman, Mark Kantrowitz, Bryan Loyall, Koichi Murakami, Paul Olbrich, Zoran Popovic, Scott Reilly, Phoebe Sengers, William Welch, and Peter Weyhrauch.

Lyotard

- Lyotard is the name of a simulated house cat that lives in a simulated apartment.
  - The user "sees" this world by reading computer generated descriptions of the surroundings
  - The used "acts" in the world by typing actions to perform.
- Lyotard was the first attempt to build a believable character for a simulated world.
  - He displays complex behaviors in response to his changing environment.
  - He displays emotional behavior and has a relationship with the interactor that changes based on the way the interactor treats him.
- Like the Edge of Intention, this world has no designed story.
- The experience is that of interacting with a house cat.
- Future systems will be more story-oriented than either the Edge of Intention or Lyotard.

The Playground

- A test and demonstration of ability to build interesting characters that engage in reasonably complex social behaviors.
- These behaviors have to reflect:
  - the personality of the character,
  - the emotional state of the character,
  - and the relationship the character has with the other characters.
- This is a simulation of 3 kids (one is the user) on a playground.
- Although they can engage in a number of different behaviors, one of their favorites is trading baseball cards.

Responsive Animated Characters

- Prof. Ken Perlin groundbreaking noise techniques used in image rendering
- The MRL's Responsive Animated Character research uses these techniques for character movement.
- Characters created in this manner can smoothly blend and layer animations, compositing them in time
  - much as programs like Photoshop composite images in space.
- This type of smooth blending is often referred to as procedural animation.

Responsive Animated Characters

- These characters can also use noise-influenced models for decision making at many levels:
  - low-level animation triggering (e.g., eye blinking),
  - mid-level behaviors (e.g., approach/avoid),
  - high-level attitudes that develop over time.
- These characters aren't attempting to be intelligent in their behavior.
- They use *carefully-crafted statistical models* to engage their audience of users.

Responsive Animated Characters

- This combination of techniques for creating improvisational virtual characters was first demonstrated in 1987.
- A wire-frame made its own decisions about when to reach toward an animated bird,
  - and then smoothly animated the appropriate behaviors and transitions between them.

Responsive Animated Characters

- Several years later, Prof. Perlin decided to take these research results and push them forward, and in 1994 submitted a film to the SIGGRAPH Electronic Theatre.
- This film showed a continuously animated shaded 3D dancer, displayed on a single-processor machine, in a real-time performance created by a piano player and director improvising together along a storyline.
- This lead to a great deal of interest, and increasingly sophisticated versions of this work were demonstrated at SIGGRAPH 95, 96, 97, 98, and 99 under the name "Improvisational Animation."
- During this time, significant project contributions were made by Athomas Goldberg, Clilly Castiglia, Duane Whitehurst, Jon Meyer, Troy Downing, Eric Singer, and Sabrina Liao.
- In 1999 the Improv system, developed through these projects, was spun off by the NYU Center for Advanced Technology.
- The company, Improv Technologies , is headed by Athomas Goldberg.

Responsive Animated Characters

- At the MRL, work in Responsive Animated Characters continues, including characters for the web, handheld devices, live performance, and virtual worlds - as well as tools for content creators, at all skill levels, working in these contexts.
- This work also influences the MRL's engineering work. For example, recent research in autostereoscopic displays was motivated by a desire to make it possible for these characters to engage their audience more fully.
- In the past, the Improv system has been used in engineering contexts for robot control.

• Responsive Face

- Some of the MRL's most recent work has been on expressive characters with minimal geometry - suitable for the web or handheld devices.
- This face implements a small number of degrees of freedom, but can still express a significant subset of Paul Ekman's Facial Action Coding System.
- This face was shown, on an HP Jornada, running in Java, at SIGGRAPH 2000. Chris Poultney and Lisa Mackie worked with Prof. Perlin on this project.

Dancer and Body Guy

- The dancer was first shown at the SIGGRAPH 99 Web 3D Roundup.
  - Her simple, expressive full-body design was entirely implemented in Java 1.0.
  - How might children or naive users be able to design their own characters like this?
  - Body Guy demonstrates an intuitive, constraint-based approach to character authoring for children.
- **Leon at SIGGRAPH 99**
  - Improv Technologies (an MRL/CAT spin-off) was launched at the SIGGRAPH 99 Electronic Theatre, where their interactive character Leon was Master of Ceremonies.
  - This project was a collaboration between Improv Technologies, Mitch Butler of Flimsy Entertainment (who created Leon for SIGGRAPH 98's "The Smell of Horror"), and Clilly Castiglia of the MRL

Aria II

- The MRL has a history of collaboration with the Integrated Systems Laboratory at the University of Sao Paulo
- especially sound researcher and composer Ruggero Ruschioni, lab director Prof. Marcelo Zuffo, and parallel architecture expert Prof. Sergio Takeo Kofuji.
- For SIGGRAPH 96, the MRL worked together to create Aria - a demonstration in the Digital Bayou that allowed visitors to conduct the tone and tempo of a virtual opera singer.
- In 1998 and 1999 more advanced versions of Aria were created and shown in venues ranging from the Itau Cultural museum in Sao Paulo to SuperComp 99 in Portland, Oregon.
- Currently, the two labs are working together with Itau Cultural, artist Ricardo Ribenboim, and composer Wilson Sukorski on an opera featuring responsive animated characters.

Sid and the Penguins

- At the SIGGRAPH 98 Electronic Theatre, the MRL presented a ***live performance*** by a troupe of virtual actors
- ***It took place within a web browser.***
- This project was a collaboration involving dozens of undergraduate computer science and animation students, as well as faculty from both disciplines.
- It tells the story of the lovable Sid and his interaction with a group of dancing penguins

Willy

- Working with NYU Music Technology professor Robert Rowe, in 1998 the MRL created Willy - a saxophone player who improvises music and movement in response to a jazz piano player.
- At their first rehearsal, Clilly Castiglia remembers the piano player jumping back from his keyboard to say, "This is the first time in years someone's really listened to me."
- Willy was presented in a series of performances at Lincoln Center, as well as at conferences such as ISEA and ICMA.

Wendy

- At SIGGRAPH 97, Wendy helped the MRL introduce the then-new Java/VRML version of Improv.
- Her click-controls are still one of the best introductions to our motion layering and blending techniques.

SIGGRAPH 96 Bayou

- For the SIGGRAPH 96 Digital Bayou, the MRL created "Botanica Virtual."
- This room-size installation allowed a single user (wearing a stereoscopic carnival mask) to interact with mysterious bayou denizens while a larger audience watched on a projection screen.
- All graphics, behavior, and environmental sound were produced in real time on Silicon Graphics and Apple computers.

SIGGRAPH 95 Characters

- At SIGGRAPH 95 the MRL allowed audiences a number of ways of interacting with Responsive Animated Characters.
- Using voice recognition, they could play "Simon Says" with the comical Otto.
- Motion tracking made it possible for participants to turn themselves into virtual bats, flapping their arms to fly around a castle inhabited by interacting Improv characters.
- The more severe Gregor character from this scene joined Otto, and the Improv system of this period, to make possible Barbara Hayes-Roth's "Master/Servant Scenarios" at Stanford University.
- Gregor and Otto also starred in a number of important experiments at the MRL, using relatively simple techniques to achieve engaging emotional effects

SIGGRAPH 94 Dancer

- This 1994 demonstration, shown in the SIGGRAPH Electronic Theatre, marked the initiation of Responsive Animated Character research as a major focus of the Media Research Laboratory.
- Its visual and musical story is of a dancer, becoming more comfortable and free in her movements, until she breaks the bounds of conventional movement altogether.
- It was produced in real time, on a single processor machine.