Building an Interactive Robot

Changing the way robots interpret and react to our actions

Franklin W. Olin College of Engineering

Adela H. Wee and Andrew A. Bennett

Olin College of Engineering

Olin Intelligent Vehicles Lab

Introduction

By the year 2030, robotics will be a multi-billion dollar industry. Instead of communicating with robots through a keyboard or mouse, you would interact more naturally through voice and gesture. The number of practical robotic applications increases significantly if we provide a more intuitive means of communication between a human and a robot. With the convergence of better sensors and computing technologies like the Microsoft *Kinect* and the Intel *Atom* processor, we are now closer to being able to create a cost-effective platform that can evoke feelings of trust and team intelligently with humans.

Challenges in Robotics: Perception, Intelligence, and Natural Interaction

Most organizations focus on some subset of the supporting technology components rather than integration.

Perception

Most robots do not have the great awareness of the world that we do. Many use a rotating single-beam laser to acquire an accurate but planar view of their surroundings. An interactive robot immersed in our 3D world requires more robust spatial perception. Until recently, the task of detecting a human required either writing complex software or using expensive hardware. With now commonly available technologies like smartphones and the Microsoft *Kinect*, these boundaries have been significantly reduced.

As smartphone technology drives demand for smaller, faster processors, it is now possible to have smaller, more intelligent robots at a more affordable price.

Intelligence

Robotic behaviors span a wide spectrum of command-and-control paradigms from teleoperation to human-independent autonomy. Extended missions where a robot works in close proximity to a human require a robot to be intelligent– preferably with the cognitive awareness to react and respond to a situation by automatically carrying out the appropriate supporting behavior.

Teleoperation is impractical for most scenarios because of reduced situational awareness and excessive control burden for the operator.

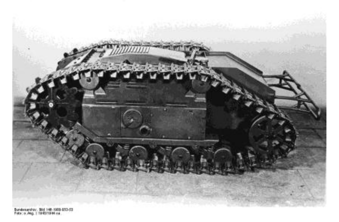
Natural Interaction

The success of a more team-oriented relationship between human and robot is heavily dependent on the development of an intuitive interface. With a more natural means of interaction, immersed robots are much better equipped to effectively address real-world problems.

Natural interaction with human-like robots can elicit fear and mistrust because the connection sensed through non-verbal cues is not well articulated.

Background on Selection of Robot Autonomy

1940



During WWII, German forces deployed teleoperated land mines, known as the *Goliath*.

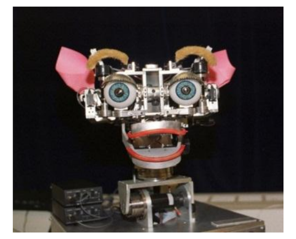
1982

ROBART I was an early mobile security robot built by H.R. Everett for his thesis project that was fully autonomous and had onboard sensors to detect intruders, fire, smoke, and flooding.

1986

ROBART II was the 2nd generation security robot that had more elaborate intelligence, planning, and navigational capabilities. Ran continuously from 1988-2002.

2000



Kismet was an early socially interactive robot built at MIT by C. Breazeal that could give emotional feedback through facial expressions and sounds but was stationary.

2004

ROBART III was used as a proof-of-concept vehicle for a voice-recognition interface under the *Warfighter's Associate* project at SSC Pacific and helped to further the concept of human-robot teaming.

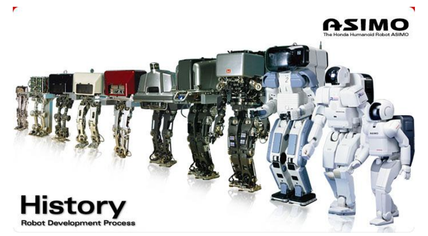
Man- portable robots saw significantly expanded deployment in Iraq and Afghanistan as QinetiQ's *Talon* and iRobot's *Packbot* for EOD teams. These robots were teleoperated using bulky suitcase-sized control units, which resulted in considerable operator fatigue and significantly reduced situational awareness in a battlefield environment.

2008

Disney-Pixar's *WALL-E* shows that one day, a fully expressive robot can communicate primarily through non-verbal cues and be smart enough to survive in a barren Earth, among other things.

2010

Olin College developed an autonomous rugged vehicle using a John Deere *Gator XUV* under an STTR with Scientific Systems and Spatio Systems LLC that can be controlled through voice and gesture input.



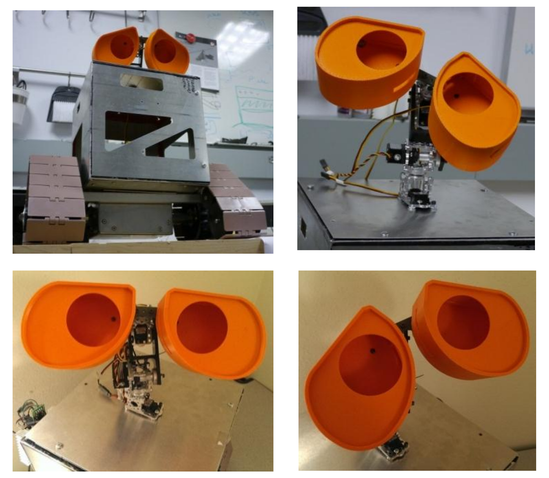
Honda has been developing its humanoid robot since 1986. The latest generation, post 2005, was recently deployed as a tour guide at the Miraikan Science Museum in Tokyo. That specific robot, however, only responded to questions via touchscreen and could not differentiate between a raised cellphone or hand.

Present

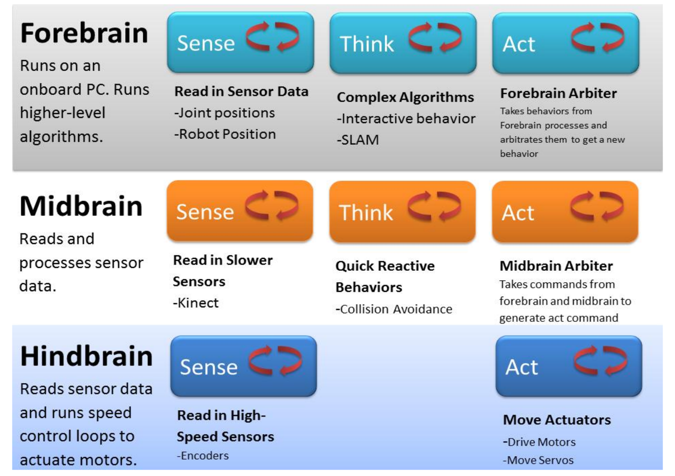
Interactive ground vehicle based on Disney-Pixar's *WALL-E* is developed at Olin College by A. Wee under the supervision of A. Bennett to help further a more natural and intuitive control paradigm between humans and robots.

The *WALL-E* Contribution

In order to make a sufficiently expressive robot that would be readily accepted without creating negative reactions due to too-humanlike forms, we decided to base our platform on the character *WALL-E* from the Disney-Pixar movie of the same name. This robot was specifically chosen because it communicates almost exclusively in a nonverbal fashion throughout the movie and is highly expressive, non-threatening, and compact. In the interest of increased acceptance and usage of robots that work directly with humans, we have to build more intelligent systems that not only understand what we're subconsciously signaling, but also comprehend our vocal commands and physical movements. These mobile robots must also be able to express emotions and perceive social cues in addition to understanding non-verbal commands for more natural interaction. *WALL-E* is going to help show that the concept of human-robot teamwork through non-verbal communication is a feasible and effective solution to controlling autonomous robots.



Examples of the different emotions that *WALL-E* can show through the 5 degrees of freedom in his head alone.



Brain architecture based on the Sense-Think-Act paradigm modeled after the Olin Robot Brain

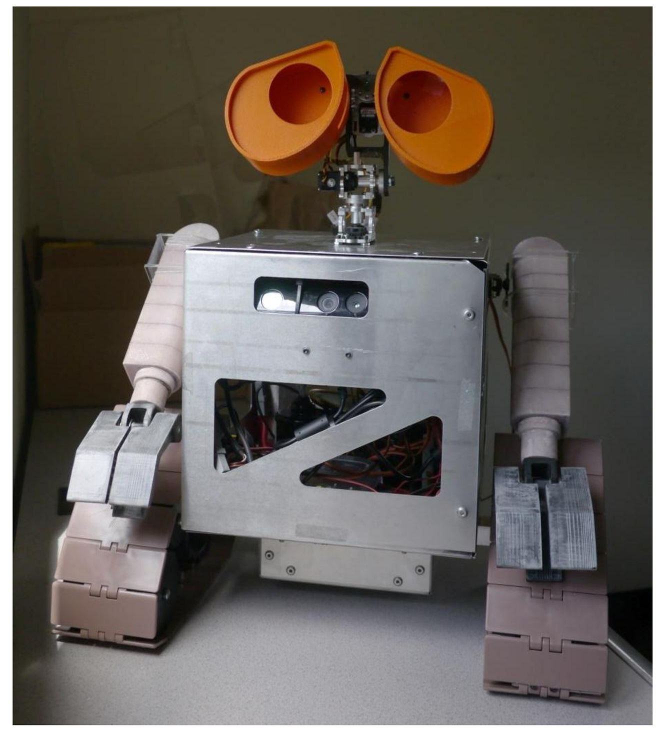
Technical Specs

Hardware Components

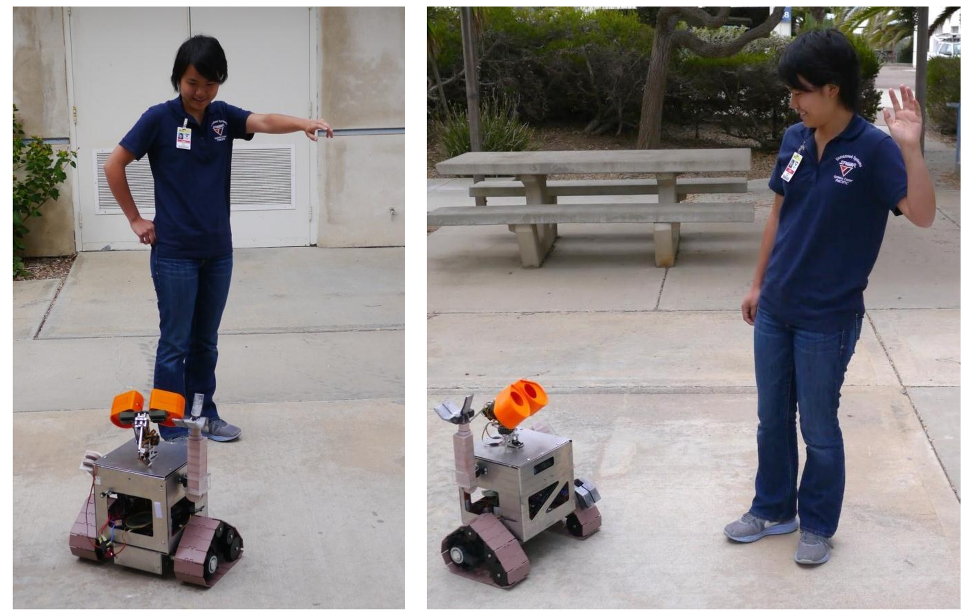
- Microsoft *Kinect*
- Pololu *Maestro 12 Servo Controller*
- Dimension Engineering *Sabertooth 25A Dual Motor Controller*
- Dimension Engineering *Kangeroo x2*
- AM Equipment *218-series 12V 212-in-lb left-hand* and *right-hand gear motors*

Software Details

- Currently runs sense-think-act paradigm
- Developed on Windows platform using National Instruments' *LabVIEW*



WALL-E as of late July 2013



Vision of what real-life interaction through body language would be.

Conclusion

As robots begin to play a larger role in our lives, it will be necessary to better understand the implications and needs of an interactive mobile robot that communicates naturally. A future involving robots working with humans in teams is inevitable; the applications are everywhere and will continue to increase, especially in our fast-paced digital world where technology and social media are already intertwined in our lives. As computers and other hardware get smaller and more easily affordable, the challenges of building a mobile robot center around systems integration and social interactions.

Future Work

Plan to enhance *WALL-E's* capabilities by

- Integrating natural-language interaction using onboard *Kinect* microphones
- Adding on additional sensors for better real-world feedback and obstacle avoidance
- Making the system *ROS* compatible

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