
Challenge and Opportunities in Human Robot Collaboration

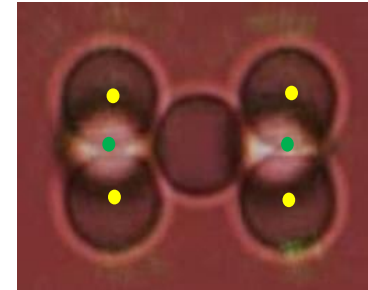
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Background

- Autonomous Unmanned Vehicles
- Hybrid Assembly Cells
- Automated Micromanipulation

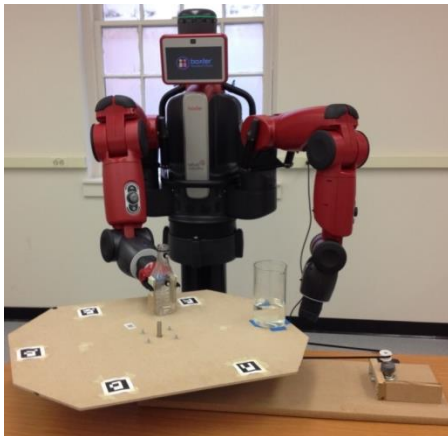
Optical Micromanipulation



Robo Raven



Robot Manipulation



Unmanned Surface Vehicles



Robo Crab



Videos

- <https://www.youtube.com/watch?v=mjOWpwbnmTw>
- https://www.youtube.com/watch?v=t1_mPe8Y0V4
- <https://www.youtube.com/watch?v=L-J3NW3sXY8\>
- <https://www.youtube.com/watch?v=1COcGHLgv0A>

Traditional Role of Robots

- Replace humans on dull, dangerous, and dirty tasks
 - Robots have been used to improve manufacturing on high volume production lines
 - Reduce labor cost
 - Increase production rate
 - Increase quality



(Image Source: ATACO Steel Products)

Humans and Robots

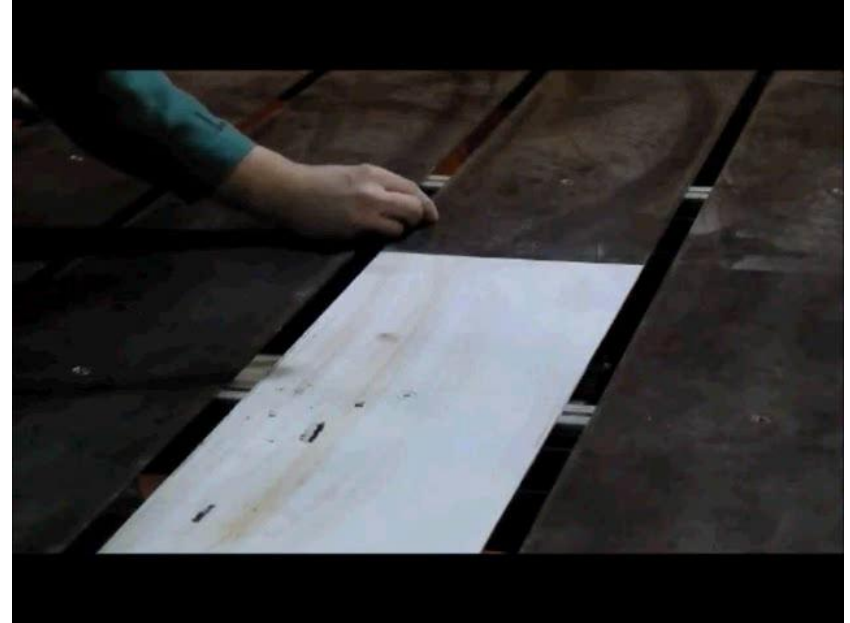
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- Humans and robots have complementary skills
 - Human and robot team can deliver better performance than human or robot alone
 - Robots can be used to enhance human team performance
 - Reduce risk
 - Relax physical constraints
 - Gather information from inaccessible regions

Human Robot Collaboration vs Autonomous Robots

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- Autonomy can be viewed as delegation of decision making
 - A highly autonomous robot will be deployed to serve some human(s)
 - Human will need to interact with the robot
 - Autonomy does not eliminate need for humans to interact with robots
 - Advances in human robot collaboration area will be relevant to widespread adoption of autonomy
 - Necessary to realize trusted autonomy

Collaborative Welding

- Human operator places parts in the cell
- Robot performs welding
- Augmented reality is used to deliver placement instructions to the human operator



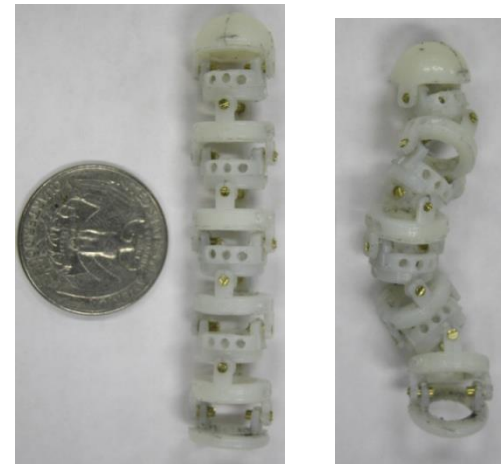
(Video Courtesy David Bourne)

Minimally Invasive Surgery

- Human robot collaboration enables minimally invasive surgery
- Robots are tele-operated by human surgeons



da Vinci



MINIR

Logistics

- Robots can carry loads for humans on rugged terrain
- Robot needs to be able to follow and interact with humans
 - Humans and robots may have asymmetric capabilities



LS3 from Boston Dynamics

Follow Behavior for Unmanned Ground Vehicle

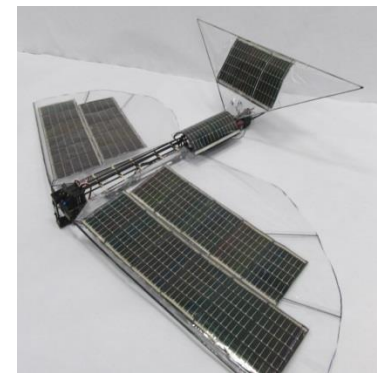
Created by: James Koo, Yalun Wu,
Jimmy Tanner, and Atul Thakur
Advisors: Satyandra K. Gupta and Petr Svec

Disaster Relief

- Provide support to human workers
 - Damage assessment in inaccessible regions
 - Search and rescue
- Robots are tasked by humans and expected to operate under direct supervisory control mode



R2G2

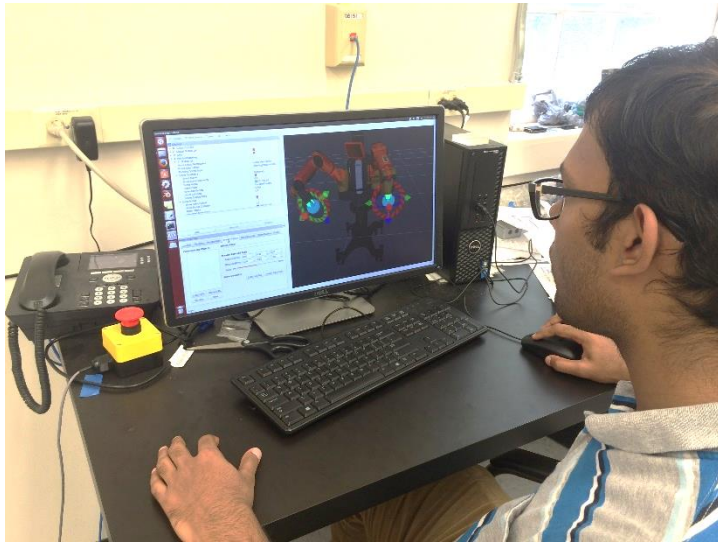


Robo Raven III

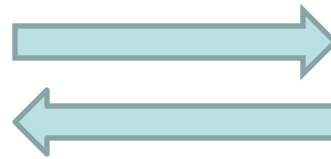
Other Potential Applications

- Food Safety
- Climate Monitoring
- Rehabilitation Therapy
- Deep Sea Exploration
- Elderly Care
- Prosthetics
- Nanomanufacturing
- Disposal of Improvised Explosive Devices
- Surveillance
- Search, Rescue, Recovery
- Education
- Intelligent Transportation
- Entertainment

Information Exchange in Human Robot Collaboration



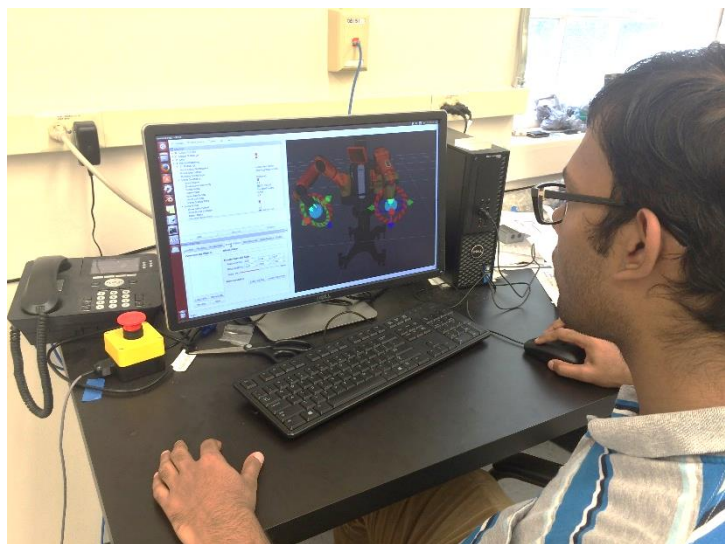
Human



Robot

What information robot needs from human

- Task goals
- Behaviors
- Control actions
- Intentions



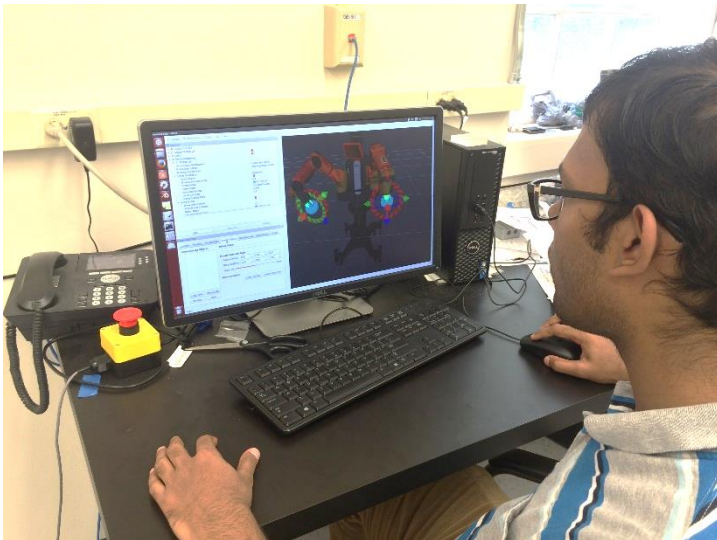
Human



Robot

What information human needs from robot

- Situational awareness
- Internal states
- Decision rationale
- Warnings
- Update on task progress
- Instructions



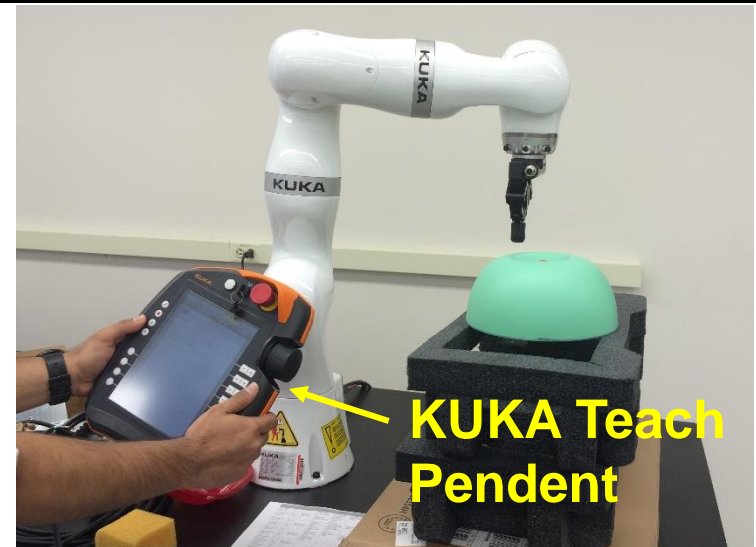
Human



Robot

Interfaces for transferring information from humans to robots

- Keyboard and mouse
- Teach pendants
- Speech recognition
- Gesture/behavior recognition



<http://tablet-news.com/wp-content/uploads/2014/10/uPoint4.jpg>



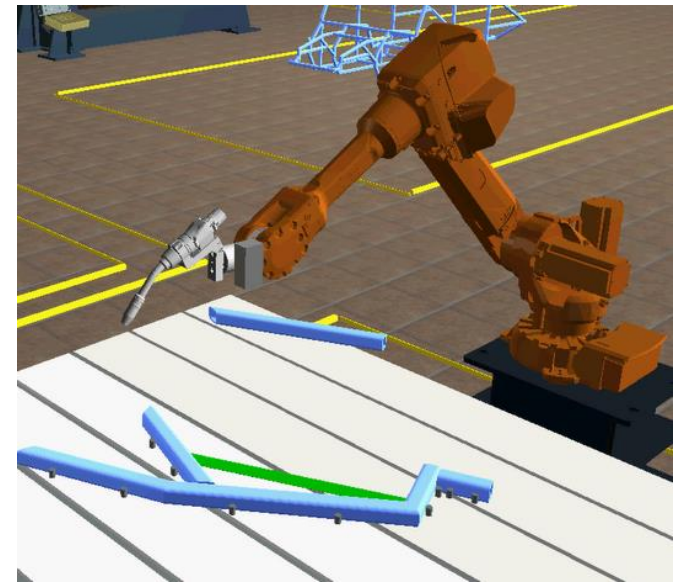
<http://robotik.dfki-bremen.de/typo3temp/pics/cef628588c.jpg>

Interfaces for transferring information from robots to humans

- Sound
- Synthetic speech
- Displays
- Gestures
- Augmented/Virtual Reality



http://vstepsimulation.com/wp-content/uploads/2015/03/VSTEP_using_Oculus_HMD.jpg



Current Challenge

- The rate at which humans and robots can exchange information is limited
 - Takes long time
 - Can be tedious
 - Requires training
- Often it requires an advanced degree in robotics to use robots!

Innovation in Interfaces

- Cars needed steering wheels
- Computers needed keyboard and mouse
- Smart phones needed touch screens
- TVs needed remote
- Video games needed Wii Mote and Kinect



http://www.newscientist.com/blogs/onepercent/2012/01/09/rexfeatures_1460534o.jpg



<http://sclick.net/cool%20gadgets/funny-top-newest-high-tech-electronic-gadget/13/top-cool-latest-new-best-gadgets-wii-active-playing.jpg>

Desirable Attributes of Human Robot Interaction Interfaces

- Precision
 - Minimize ambiguity
- Ergonomics
 - Comfortable to use
 - Easy to use
- Information transfer rates
 - Adequate rate to meet the need

Current Status

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- Interfaces have been adopted from other applications
 - Model of humans interacting with each other might not be the best model for human robot interaction
 - Current generation of robots “thinks” differently from humans
 - Advances in statistical machine learning will lead robots to process information in a fundamentally different way from humans
 - We have not seen radical innovations in human robot interaction interfaces

What will be enabled by new advances in interfaces?

- Eliminate need for programming
 - Learning from demonstrations
 - Imitation learning
- Operator safety and comfort
- Appropriate interactions with other humans in the environment
 - Self-driving cars, boats
- Improved diagnostics and prognostics in case of failures
- Improved policy/regulations
 - Auditing of decision making is very important

Trust Considerations in Autonomous Robots

- Unambiguous Communication
- Competency
- Reliability
- Safety
- Authenticity
- Protection of Privacy
- Cybersecurity

Trust Considerations in Human Robot Collaboration



MARYLAND
ROBOTICS CENTER
THE INSTITUTE FOR SYSTEMS RESEARCH

- Unambiguous Communication
- Safety
- Competency
- Reliability

Factors that Accelerate Trust Building

- Repeatability and Consistency
- Predictability
- Ability to Communicate Decision Making Rationale

Conclusions

- Autonomous robots will need to interact with humans
- Viewing autonomous robots as means to enhance human performance is creating new opportunities for deploying robots
- Effective human robot collaboration will require new advances in interfaces
- Trust considerations are very important for widespread adoption of robots
- System should be designed to ensure that it includes processes for building trust

Please send questions to
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