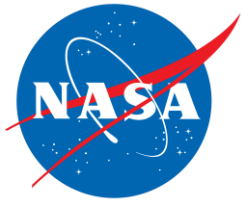
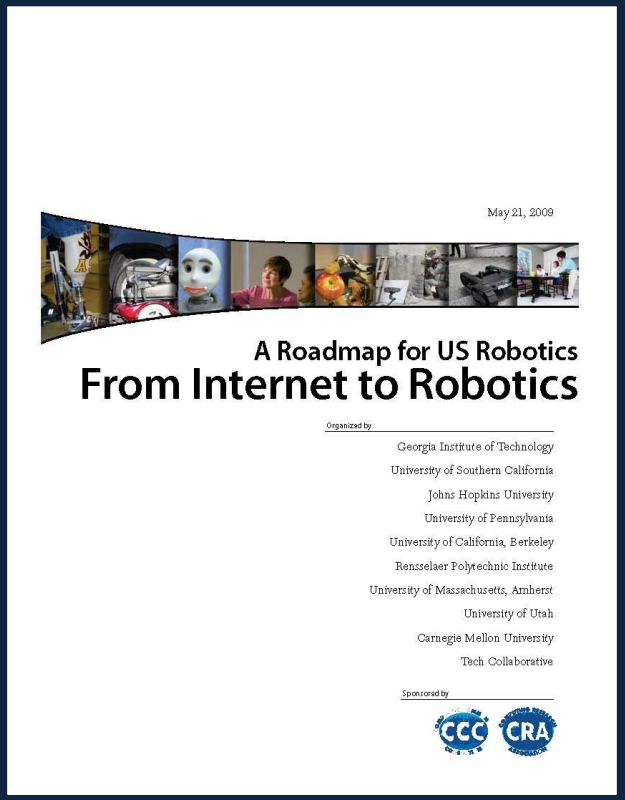
National Robotics Initiative Overview

Satyandra K. Gupta
Program Director
National Robotics Initiative and Robust Intelligence
Division of Information and Intelligent Systems
Directorate for Computer and Information Science & Engineering
National Science Foundation



United States Department of Agriculture
National Institute of Food and Agriculture


May 21, 2009

A Roadmap for US Robotics

From Internet to Robotics

Organized by

Georgia Institute of Technology
University of Southern California
Johns Hopkins University
University of Pennsylvania
University of California, Berkeley
Rensselaer Polytechnic Institute
University of Massachusetts, Amherst
University of Utah
Carnegie Mellon University
Tech Collaborative

Sponsored by

http://www.us-robotics.us/reports/CCC Report.pdf


REPORT TO THE PRESIDENT AND CONGRESS

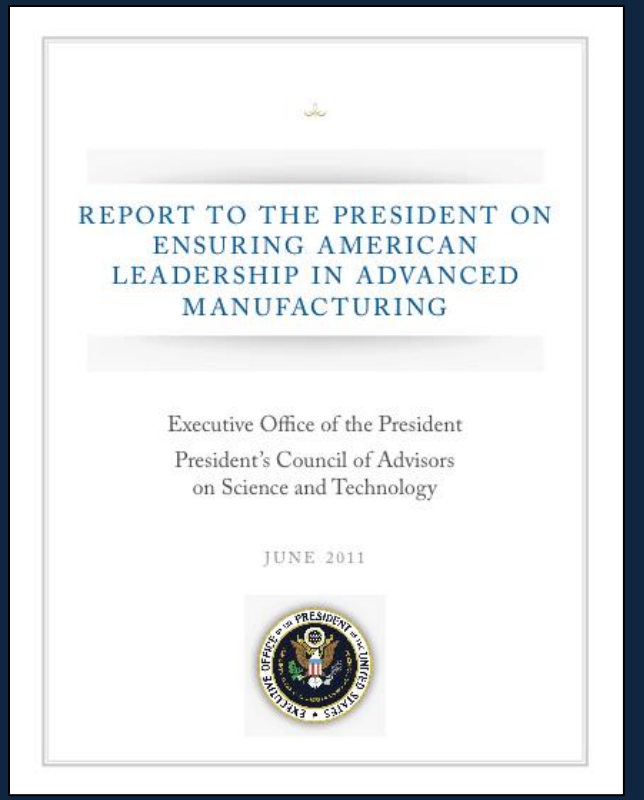
DESIGNING A DIGITAL FUTURE: FEDERALLY FUNDED RESEARCH AND DEVELOPMENT IN NETWORKING AND INFORMATION TECHNOLOGY

Executive Office of the President

President's Council of Advisors on Science and Technology

DECEMBER 2010

http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-nitrd-report-2010.pdf


REPORT TO THE PRESIDENT ON ENSURING AMERICAN LEADERSHIP IN ADVANCED MANUFACTURING

Executive Office of the President

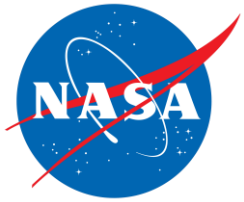
President's Council of Advisors on Science and Technology

JUNE 2011

http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_amp_steering_committee_report_final_july_27_2012.pdf

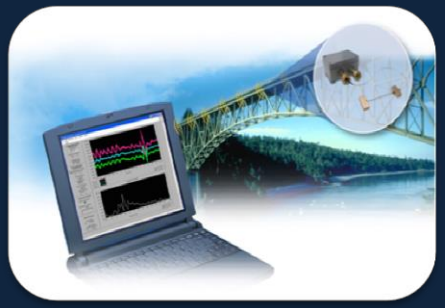
The National Robotics Initiative (NRI)

A **nationally coordinated** program across multiple government agencies to develop the **next generation of robotics**, to advance the **capability and usability** of such systems and artifacts, and to encourage existing and new communities to focus on **innovative application areas**.



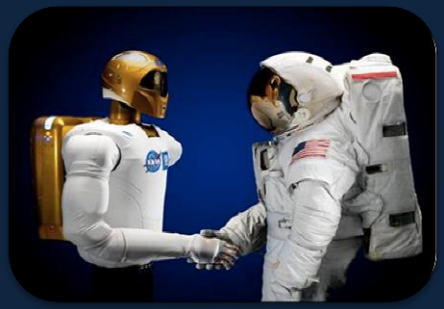
United States Department of Agriculture
National Institute of Food and Agriculture

NRI serves multiple key national priorities



Manufacturing & Smart Systems

Agriculture

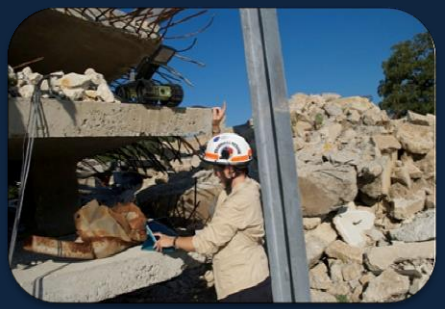


Space and Undersea Exploration

Health & Wellbeing

Transportation & Energy

Personal and Homeland Security

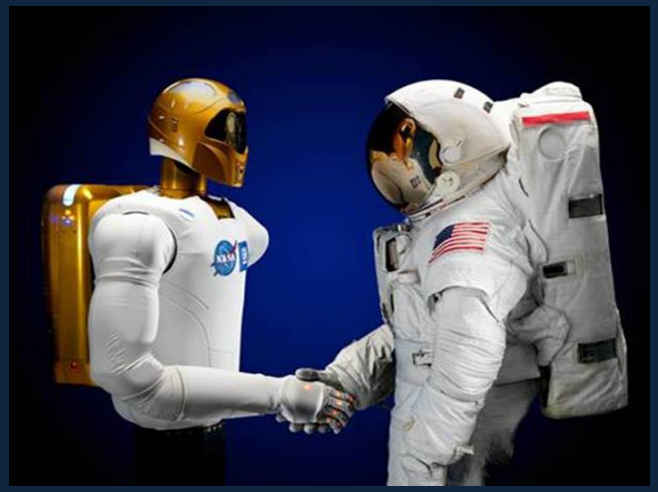


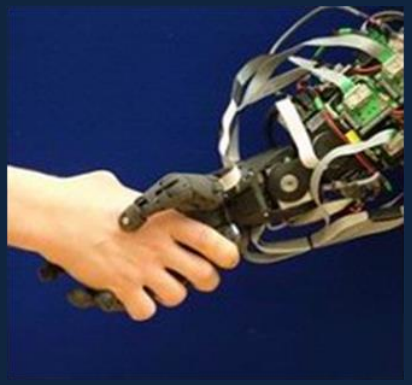
Emergency Response & Disaster Resiliency

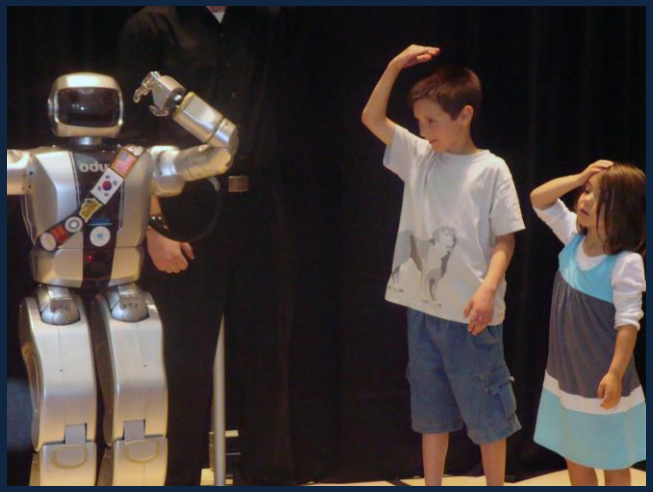
Education and Workforce Development

A new era of collaborative robots

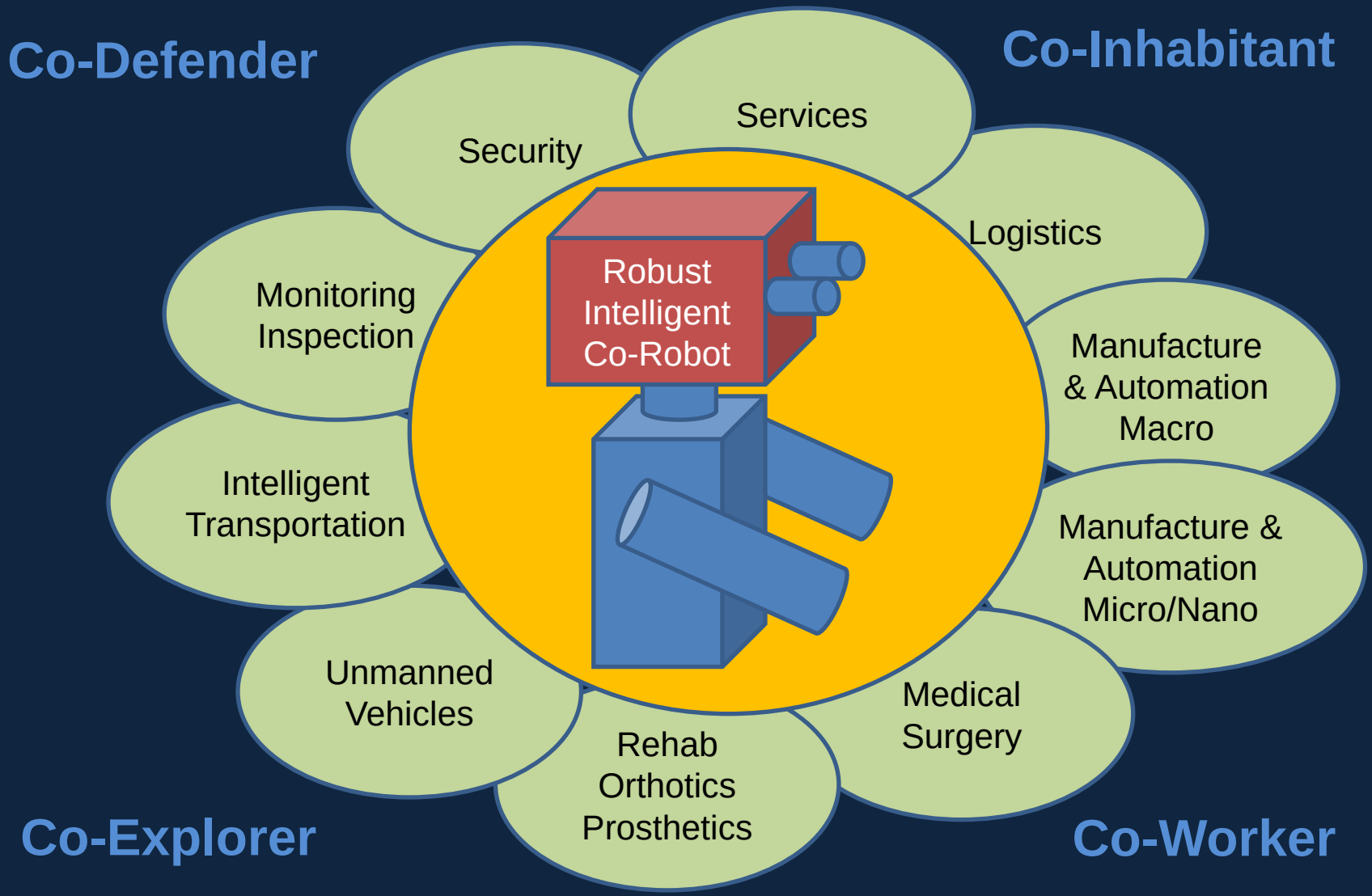
New machines that will work with humans as co-workers, co-protectors, co-drivers, co-explorers, and co-inhabitants, to enhance personal safety, health and productivity







Possibilities for co-robots



NRI Thrust Areas

Fundamental research in robotics science & engineering

Understanding the long term **social, behavioral, and economic implications** across all areas of human activity

Use of robotics to facilitate and **motivate STEM learning** across the K-16 continuum

NRI: The Technology Space

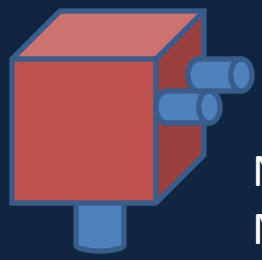
Cognition: Learning,
Knowledge representation,
Planning, Navigation

Smart structures and environments

Sensors & perception

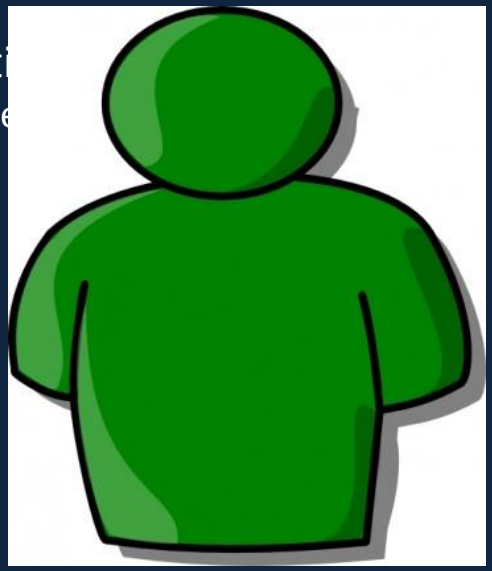
Intelligent Co-Robot

Cognitive prosthetics



Networked Multi-Agents

Human-robot interacti
physical & social, language
communication



HW/SW Architecture
Platforms – Mechanisms,
Control, Modeling

Manipulation:
Haptics, Tactile

Mobility: legged, wheeled, aquatic, aerial

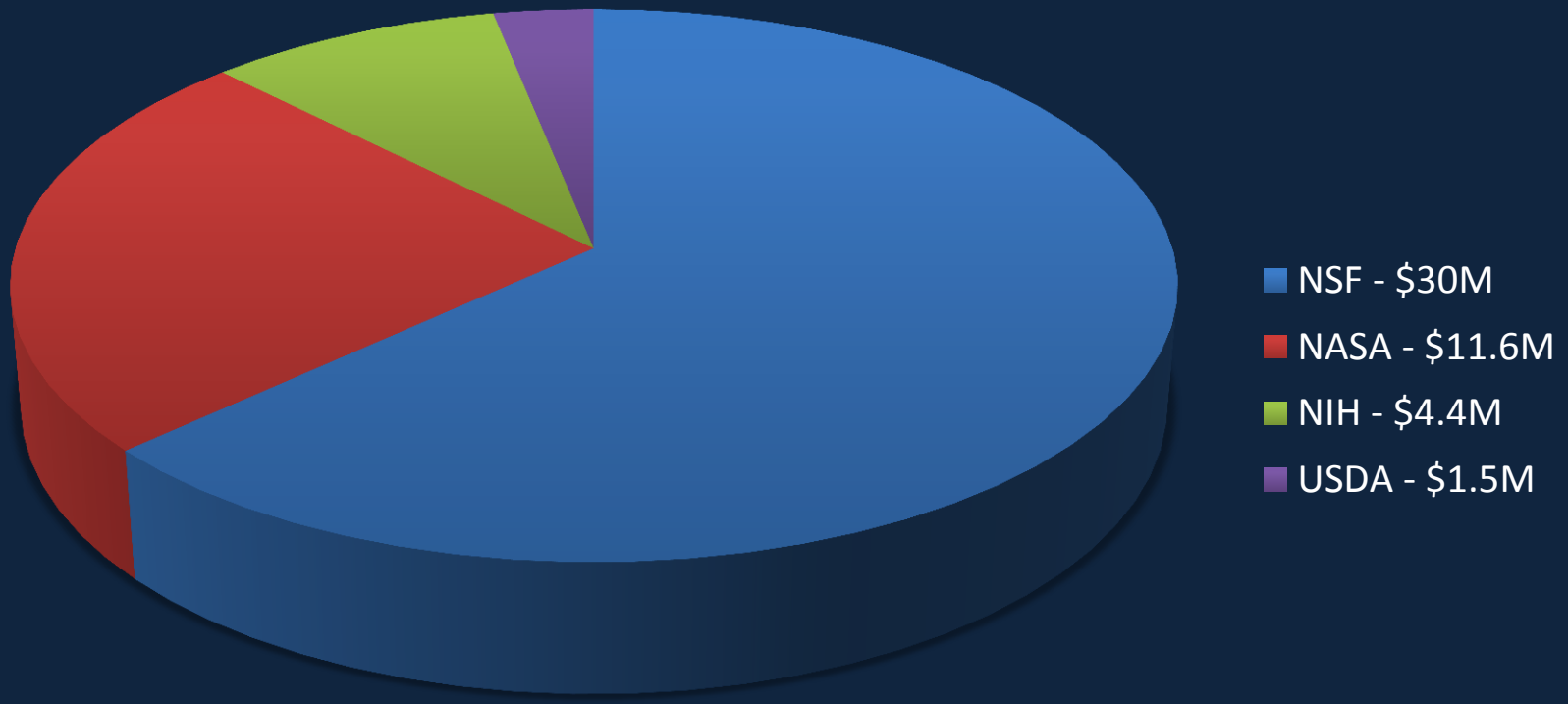
Exo-skeleton augmentation

Soft structures

Special Review Procedures

- NSF conducts all panels
- Panels are composed of panelists recommended from all agencies as appropriate to the subject matter
- Other agency PD’s & observers attend as appropriate to their subject matter interest
- Every proposal in NIH-interest panels receive both NSF and NIH ratings and rankings
- Agencies may select for funding any reviewed proposal that interests them

FY 2012 Solicitation



$47.5M allocated across participating agencies

- Over 700 proposals submitted
- Over $1B in funding requested

FY 2013 Solicitation

- Total requested of all proposals: $480M
- Number of proposals: 447
- Awards
  - NSF New Awards: $31M (41 awards)
  - USDA New Awards: $4.5M (5 awards)
  - NIH New Awards: $2.4M (3 awards)
- NASA has continued to support all projects from FY12

FY2014 Solicitation

- Proposals are due on January 21, 2014

Overview of NSF NRI Portfolio

FY 2012: NSF Awards

- 31 Projects
- 42 Awards
- $30 M

FY 2013: NSF Awards

- 30 projects
- 41 awards
- $31 M

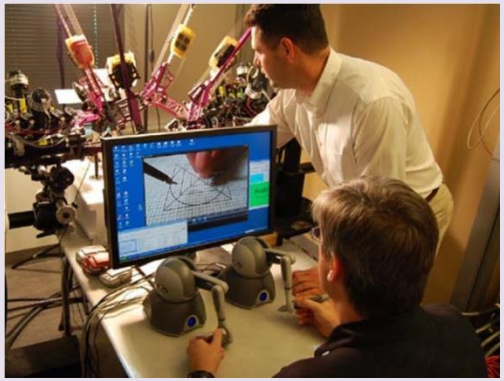
Representative Awards

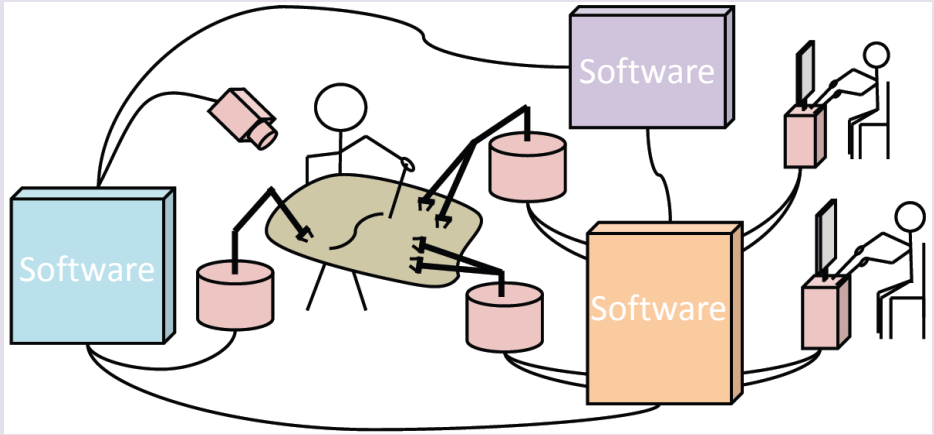
Fundamental Research into Co-Robotic Apprenticeship for Manufacturing and Surgery

Experts and Apprentices routinely collaborate - Why not robots?

Stanford, Berkeley, UC Santa Cruz, Johns Hopkins, U of Washington, Intuitive Surgical, Inc., Willow Garage, Inc., Spirit Aerosystems

This project advances the fundamental science of human-robot collaborative systems guided by specific applications from surgery and manufacturing. This work will enable robots and humans to learn from each other while working side-by-side and at a distance.



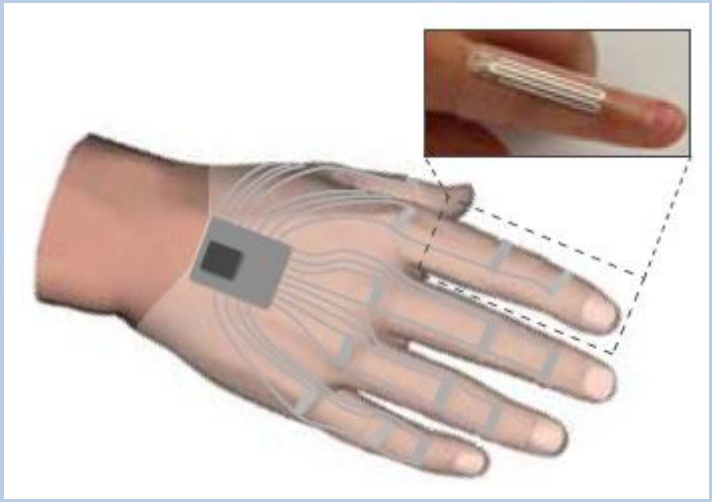


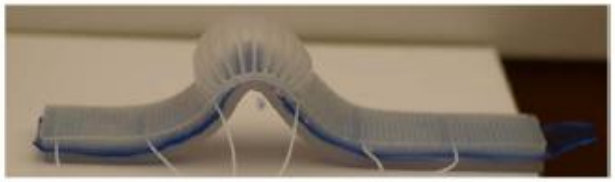
Fundamental Research into Safe, Soft Actuators for Co-Robots

Intrinsically safe human assistants

MIT, Harvard University, University of Colorado

Humans are soft and easily injured while robots have traditionally been hard, cold, and unyielding. To make co-robots intrinsically safe when working with humans, they must be soft and compliant like an elephant's trunk or a human's arm. New types of artificial muscles are required and new ways to control how they move must be explored. The result can be new types of soft, wearable "human-amplifiers," compliant hands, and safe robot arms.





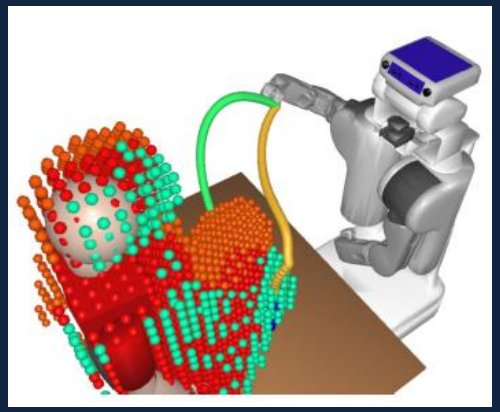
Human-Robot Collaboration for Manufacturing

Worcester Polytechnic Institute (WPI)
Massachusetts Institute of Technology (MIT)

This project advances the fundamental science of human-robot collaboration. This work will enable robots and humans to collaborate safely and efficiently in shared workspaces.

Humans collaborating in manufacturing

The methods developed in this project have the potential to significantly improve American competitiveness in manufacturing; especially for small-batch manufacturing and burst production.

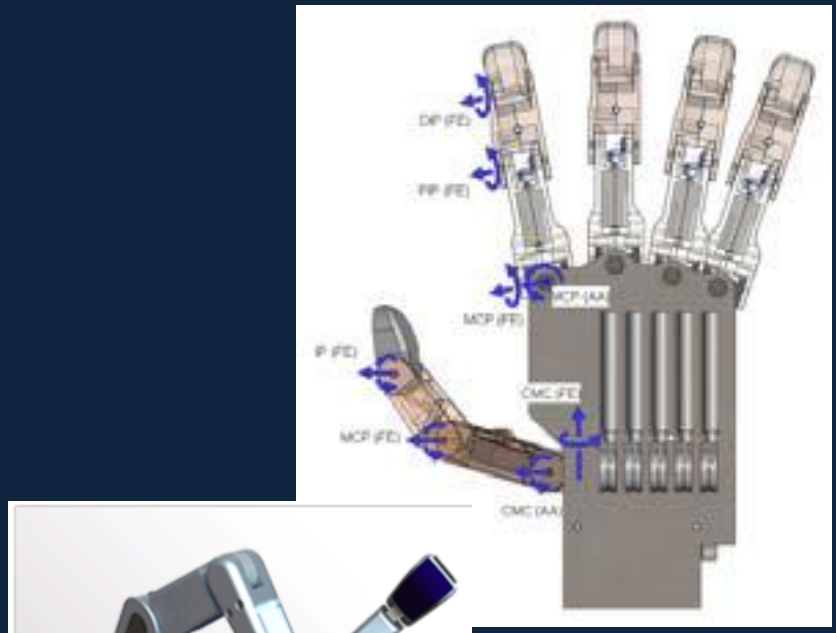


The goal: Human-robot collaboration

Fundamental Research into the Design of Co-Robotic Hands

Idaho State University, UC Irvine, National Instruments

The human hand is one of the most complex mechanisms in the biological world and is a testament to the intricacies of manipulation. Designing robotic hands and grippers for home tasks or factory tasks to grasp, lift, carry, and assemble various objects is difficult in the presence of uncertainty. This work investigates the design of grippers for research and manufacturing.

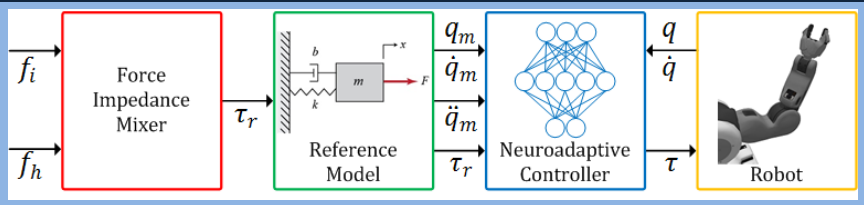


Multi-Modal Skin and Garments for Healthcare and Home Robots

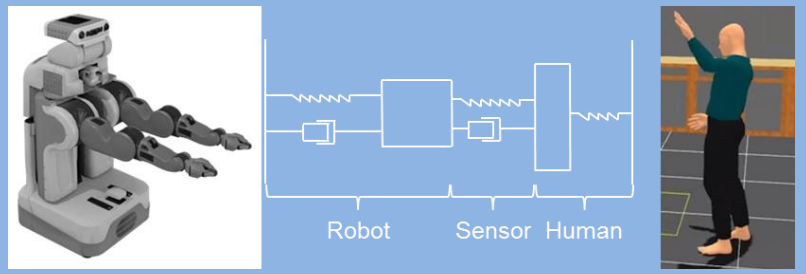
Univ. of Texas at Arlington, Univ. of North Texas Health Sciences,
Partners: Hanson Robotics, Advanced Arm Dynamics, National Instruments

In this project we create novel design and learning control tools for sensorized robot skin and clothes with applications in assisted living and upper limb prosthetics. We answer fundamental research questions related to:

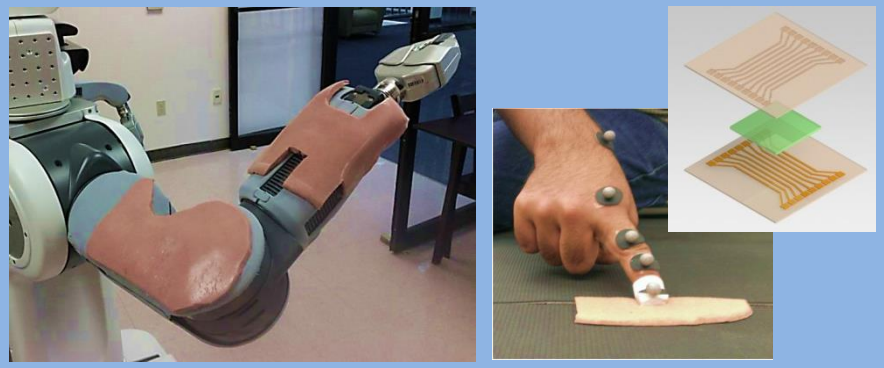
1. System Design: “where to place sensors on robot?”
2: Control and Learning: “both human and robot learn during interaction”
3: Devices: “distributed robot skin sensors embedded in flexible substrates”
4: Co-Robot performance: “how does this technology help humans?”



Neuroadaptive Impedance Control



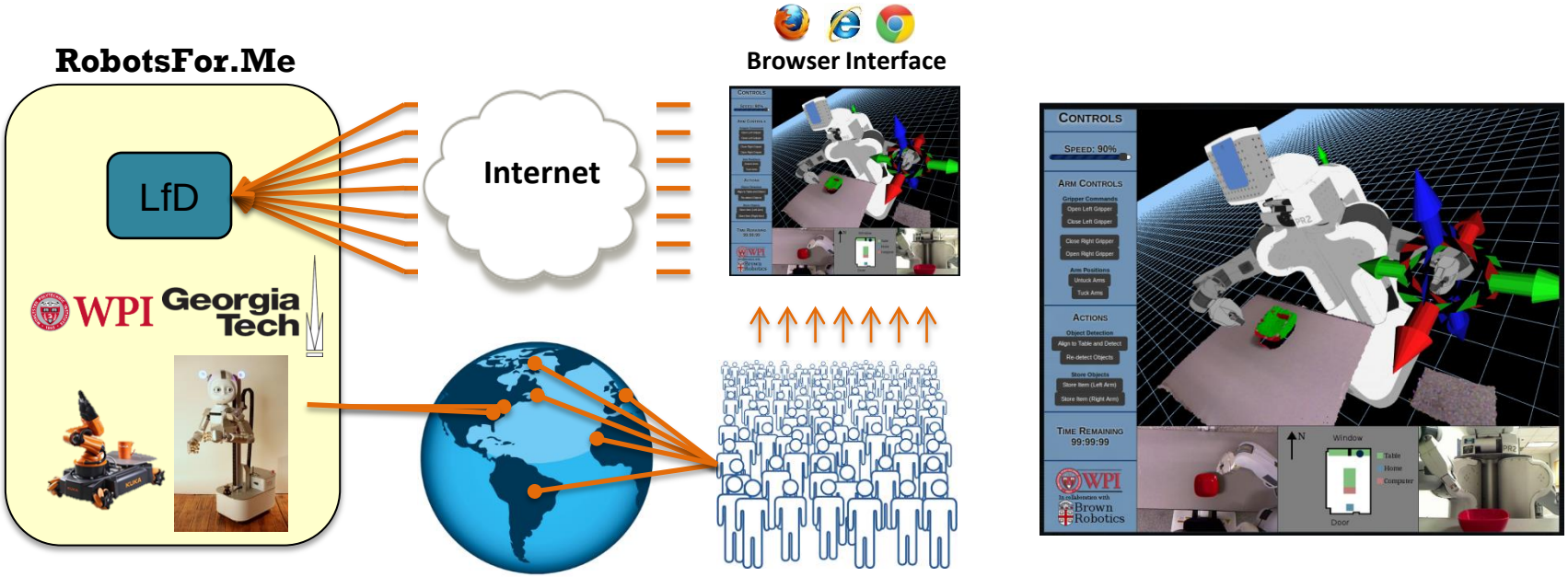
SkinSim – pHRI simulator



Learning from Demonstration for Cloud Robotics

Andrea Thomaz *Georgia Tech,* ***Sonia Chernova*** *Worcester Polytechnic Institute*

This work seeks to leverage cloud computing to enable robots to efficiently learn from remote human domain experts – Cloud LfD. Building on *RobotsFor.Me*, a remote robotics research lab, this research will unite Learning from Demonstration (LfD) and Cloud Robotics to enable anyone with Internet access to teach a robot household tasks. This research will result in policy learning and HRI research at an unprecedented scale, allowing for the collection of larger and more diverse volumes of data and leading to more general and robust task policies.



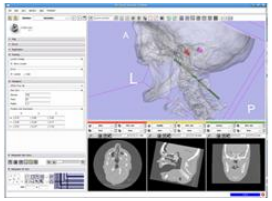
Managing Uncertainty in Human-Robot Cooperative Systems

Johns Hopkins University

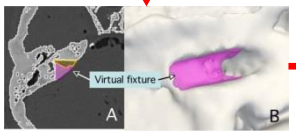
While robots are often used in highly-structured manufacturing tasks, it remains challenging to apply them to less structured tasks, such as surgery and machine servicing, due to the uncertainty arising in these tasks and environments. By combining human strengths in reasoning with machine capabilities in precise sensing and motion, we can overcome the uncertainty and achieve successful human-robot partnerships to perform complex tasks that were previously considered impractical or infeasible.

Robotic Assistant for Neurosurgery

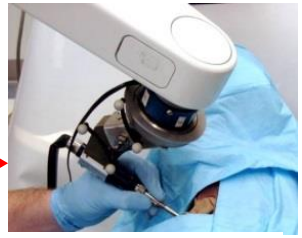
CT scan



Uncertainty in alignment (registration) between CT and patient



Safety boundaries



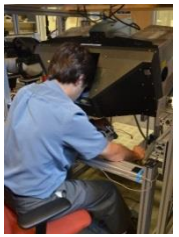
Robotic assistance

Telerobotic Satellite Servicing

remote (on-orbit) robot

Uncertainty due to time delay

ground-based test platform



master controller

Co-Robots for STEM Education in the 21st Century

University of California, Davis

This project studies how to use co-robot systems and math-oriented co-robotics competitions to enhance student engagement, increase student motivation in learning Algebra and subsequent STEM subjects, and interest in pursuing STEM related careers and post-secondary.

Introducing computing and robotics into the Algebra curriculum helps make abstract ideas concrete and allows students to apply mathematical concepts to real world problems.

RoboPlay Competition is designed for K-12 students to play with robots while having fun and exploring their creativity in writing, art, music, choreography, design, video editing, and film production while at the same time seamlessly learning STEM subjects.

Innovative Teaching and Learning with Co-Robots for Undergraduates

Using Co-Robots to Teach Complex Concepts in the Computer Science Curriculum

Rochester Institute of Technology

Robots are already being used to teach programming concepts to K-12 students and entry-level undergraduates. This project attempts to leverage the intrinsic interest in co-robots to teach more complex concepts to advanced undergraduates. Topics of interest include cloud computing, data mining, mobile-app programming.