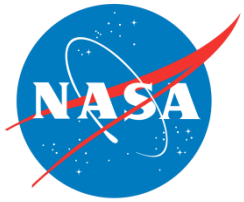
Robotics as a "Singularity": The Case for Cloud Robotics and Real-Time Big Data

Richard Voyles

Program Director, National Science Foundation

Computer & Information Science and Engineering Directorate

August 17, 2013

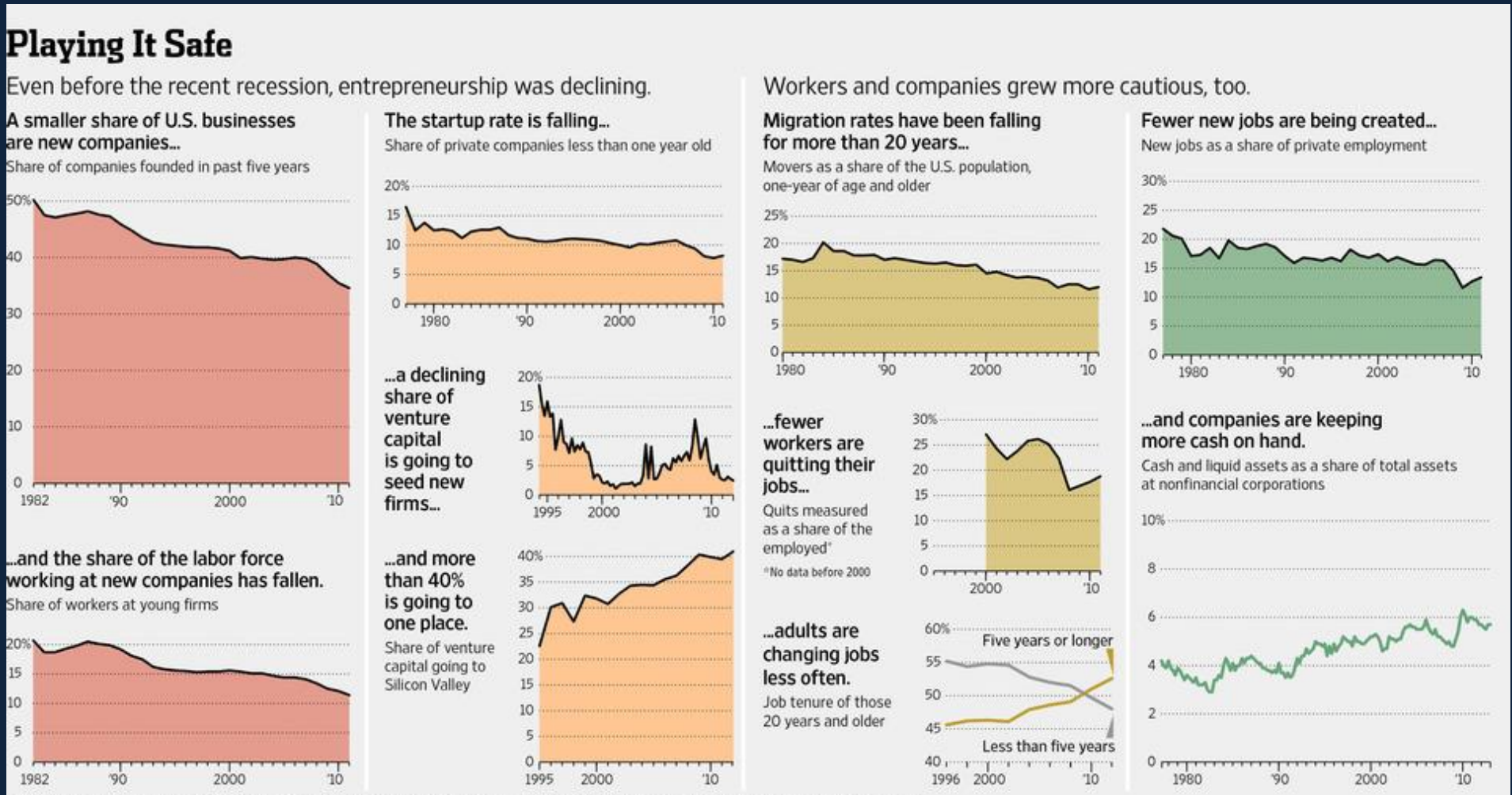


United States Department of Agriculture
National Institute of Food and Agriculture

THE WALL STREET JOURNAL.

Risk-Averse Culture Infects U.S. Workers, Entrepreneurs

Updated June 2, 2013



Unprecedented Optimism (Robotics & Manufacturing)

- Government Leaders (jobs, innovation)

- Education (all levels)
- Industry (buyers and sellers)

Rethink
Baxter
$22,000

Kuka
YouBot
$26,000

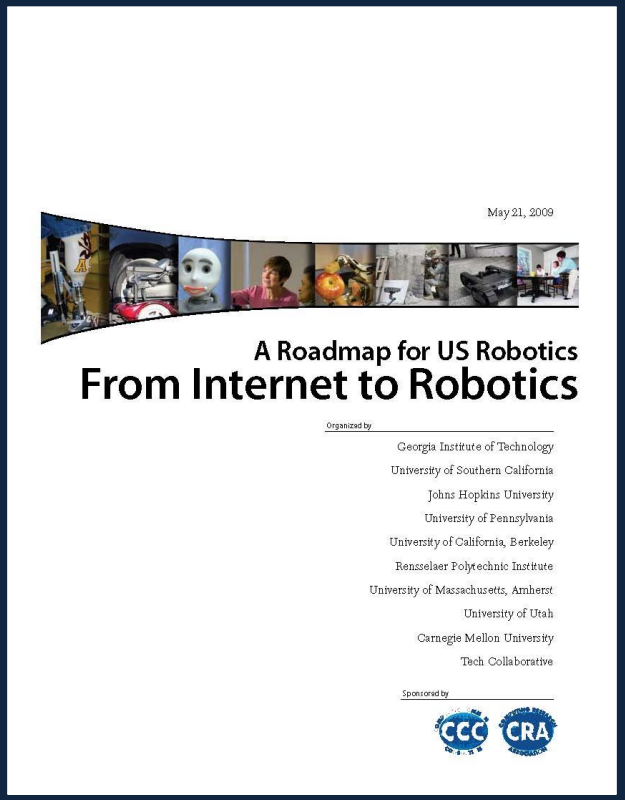
- Finance

Kiva
Systems
$775M

Rethink
Robotics
$62M

- Laypublic

(US FIRST, LegoLeague, RoboCup, Spirit/Opportunity)


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

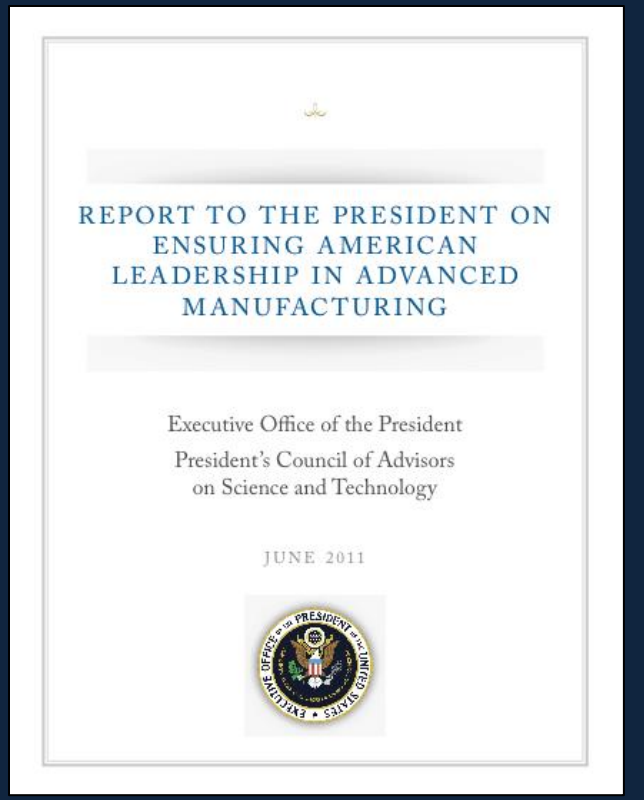
DESIGNING A DIGITAL FUTURE: FEDERALLY FUNDED RESEARCH AND DEVELOPMENT IN NETWORKING AND INFORMATION TECHNOLOGY

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

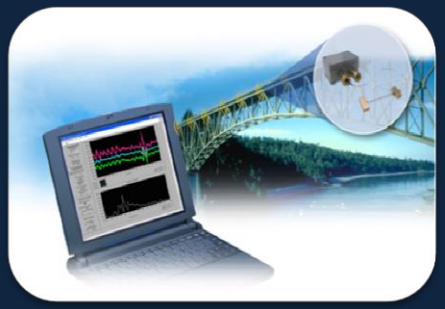
President's Council of Advisors on Science and Technology

JUNE 2011

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

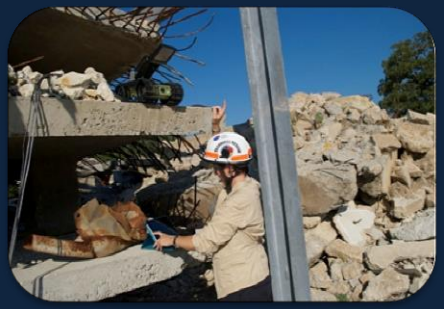
Robotics is a National Priority

NRI serves multiple key national priorities



Manufacturing & Smart Systems

Agriculture



Emergency Response & Disaster Resiliency

Health & Wellbeing

Transportation & Energy

Personal and Homeland Security

Space and Undersea Exploration

Education and Workforce Development

Snapshot of 2012 Joint Solicitation

Solicitation Released June 24, 2011
1st Round of Proposals due Nov 3, 2011

Over 700 proposals submitted

Over $1B in funding requested

Snapshot of 2013 Joint Solicitation

Solicitation Released Sept 10, 2012
1st Round of Proposals due Dec 11, 2012

Under 500 proposals submitted

About $1/2B in funding requested

What's New?

- Shift Gears from Tactical to Strategic

- Growing mix of agencies
- Growing mix of science and application (across solicitations)

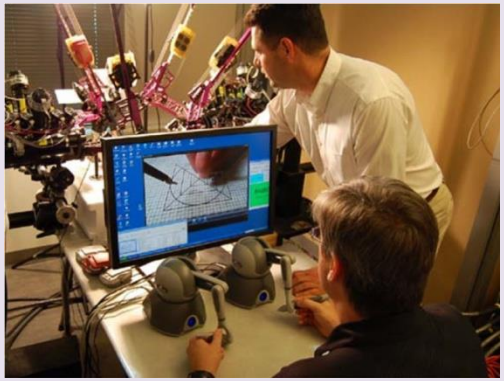
- NSF SBIR (12-605)
- NSF Basic Research (12-607)
- NRI Workshops:
  - Vertical Farming
  - Cloud Robotics
  - HRI/BMI
  - Science of Autonomy
  - Cloud Manufacturing
  - Healthcare

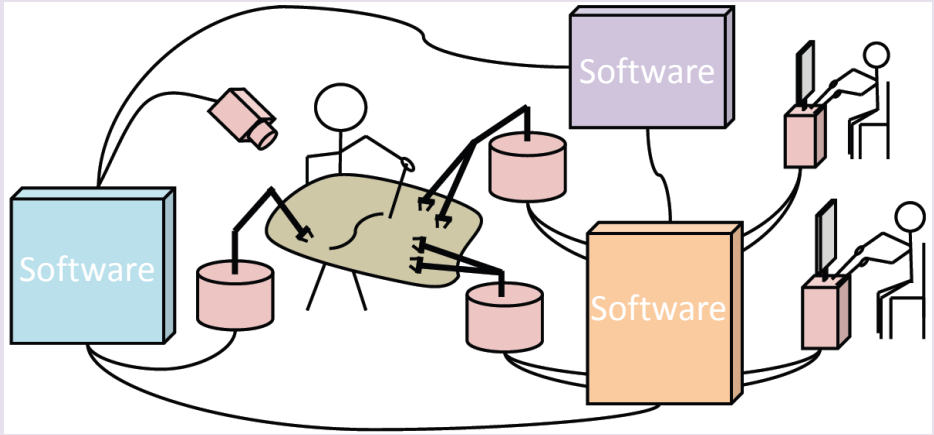
Fundamental Research into Co-Robotic Apprenticeship for Manufacturing and Surgery

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.





WHY CLOUD ROBOTICS ?

CLOUD ROBOTICS – INCORPORATING CLOUD COMPUTING FACILITY INTO ROBOTS

- AIMED AT SMARTER CHEAPER AND LIGHTER ROBOTS.
- ALLOW ROBOTS TO OFFLOAD COMPUTE-INTENSIVE CPU HEAVY TASKS.
- EXPANDS A ROBOT’S KNOWLEDGE BEYOND IT’S PHYSICAL BODY.

Robots with their heads in the cloud

Cloud-connected robots can...

perceive, understand, share, and react.

Benefits of cloud robotics

- **PROVIDES A SHARED KNOWLEDGE DATABASE**

  - organizes and unifies information about the world in a format usable by robots.

- **OFFLOADS THE HEAVY COMPUTING TASKS TO THE CLOUD**

  -cheaper,lighter,easier-to-maintain hardware

  -longer battery life

  -CPU hardware upgrades are invisible and hassle free

- **SKILL/BEHAVIOR DATABASE**

  -reusable library of skills or behaviors that map to perseived task requirements/complex situations.

  -data mining the history of all cloud enabled robots

Limitations of Cloud Robotics

Cloud is not the solution to all of robotics' difficulties.

- controlling a robot's motion—which relies heavily on sensors and feedback—won't benefit much from the cloud.
- cloud-based applications can get slow or unavailable If a robot relies too much on the cloud, a hitch in the network could leave it "brainless."
- "Tasks that involve real-time execution require onboard processing

Possible solutions and future scope

- By making the robots remember the conversation with the cloud robot-going-brainless scenario can be avoided.
- Cloud Aware Android Robots is the next big thing
- An app store for robots -The app paradigm is one of the crucial factors behind the success of smartphones

2013 NRI Workshop on Cloud Robotics

Volkan Isler
University of Minnesota
M. Ani Hsieh
Drexel University

Background

Workshop was held on Feb. 27-28 (1.5 Days)

Workshop Participants (34 Participants)

- Federal Agencies
  - National Science Foundation (NSF)
  - Army Research Lab (ARL)
  - Defense Advanced Research Projects Agency (DARPA)
  - Office of Science & Technology Policy (OSTP)
- Industry
  - Google, Kiva Systems, Lockheed Martin ATL, Microsoft, Open Source Robotics Foundation (OSRF), Willow Garage
- Academia
  - Researchers from 18 Universities across entire USA

Workshop Objective

Brought together *robotics*, *cloud computing* and *big-data* researchers to explore the opportunities & challenges in Cloud Robotics.

Workshop Format:

- 30 min keynote talks
- 15 min short talks
- 1-3 hour break-out sessions

Opportunities

- Faster Computation
- More Data
- Smarter and More Adaptive Systems
- Increased Access
- New Paradigms in Networked Systems

Technical Challenges

- Connectivity to the Cloud
- Privacy and Security
- Workload Sharing
- Standards and Protocol

Areas for Investment

- Basic Research
- Challenges/Competitions
- Shared Infrastructure

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- Basic Research
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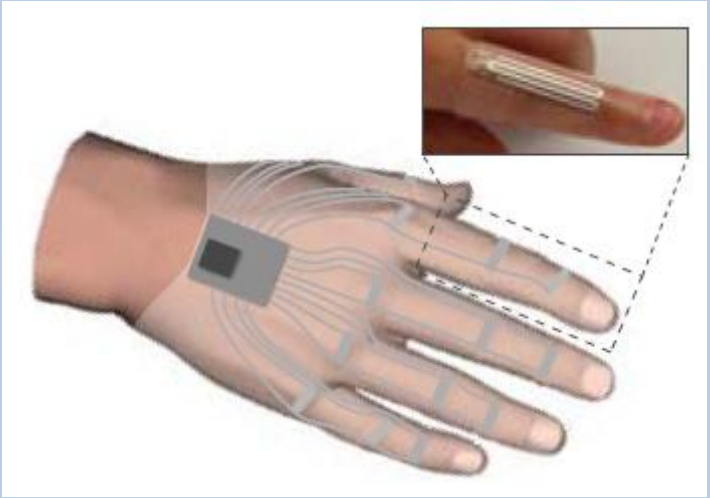
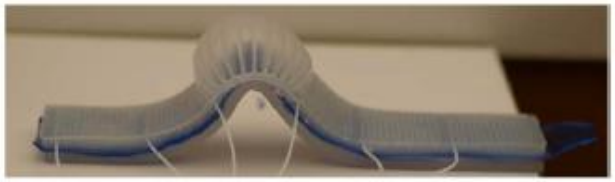
Fundamental Research into Safe, Soft Actuators for Co-Robots

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.



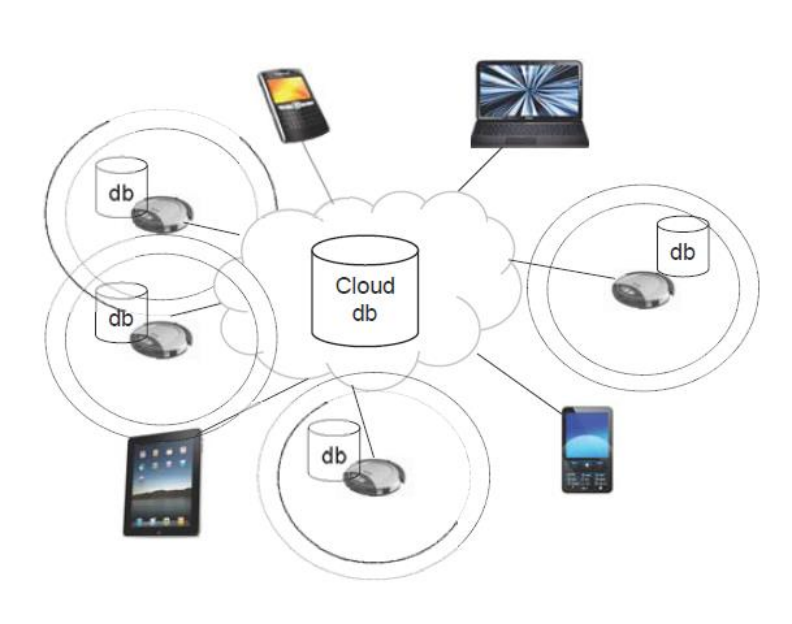


Innovative Teaching and Learning with Co-Robots for Undergraduates

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

Rochester Institute of Technology

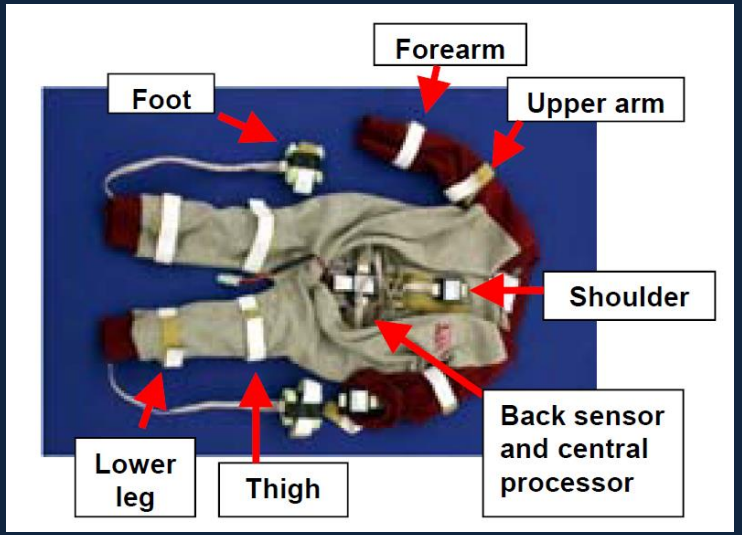
Robots are already being used to teach programming concepts to K-12 students and entry-level undergraduates. This project attempts to leverage the intrinsic interest in co-robots to teach more complex concepts to advanced undergraduates. Topics of interest include cloud computing, data mining, mobile-app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

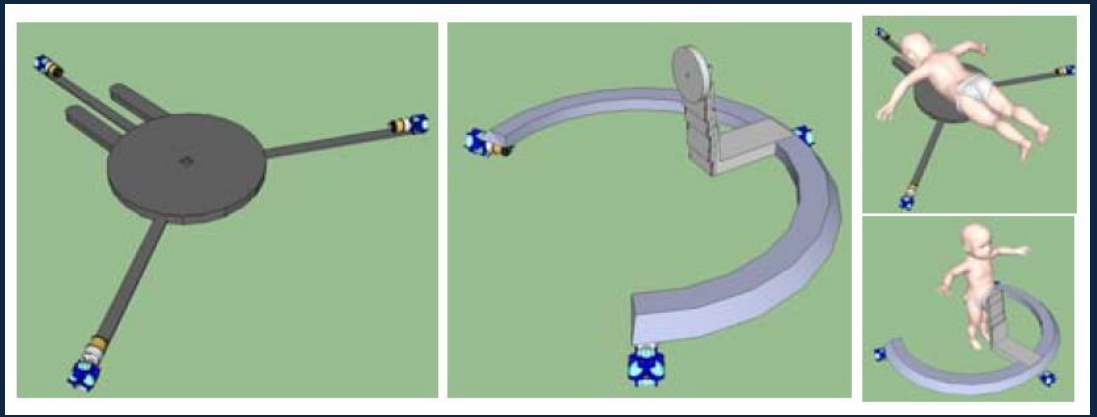


Fundamental Research into Co-Robots for Rehabilitation

University of Oklahoma, Health Sciences Center

Children with disabilities or at risk for disabilities can benefit from motor and sensory assistance from co-robotic devices. Early crawling and walking behaviors in infants have long-term implications even into adulthood. Co-robotic assistance for motor-delayed infants, such as those suffering from cerebral palsy, can reduce long-term maladies and healthcare costs and lead to better quality of life.





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.