ME 328: Medical Robotics
Winter 2019

Lecture 12:

The broad spectrum of medical and healthcare robotics

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Stanford University

Updates

Assignment 5: Due on Canvas this Friday, Feb. 22 at 4 pm

Project:

- Next deadline is supporting data. Due on Friday, Mar. 1 at 4 pm
- Sample proposals now posted:
  https://web.stanford.edu/class/me328/restricted/sample_r21/

Tours: (sign up TODAY, after this we will open spots to others)

- Auris Feb. 22 (meet on campus at 1:45, arrive at 2:30)
  https://tinyurl.com/AurisTour
- Intuitive Surgical Mar. 1 (meet on campus at 1:15, arrive at 2:00)
  https://tinyurl.com/IntuitiveSurgicalTour

Growing Healthcare Challenges

Regaining function & retaining independence

Caretaking for staying at home/aging–in-place

Individualized learning and training for special needs

1 in 5 children is overweight

Millions suffer from isolation and depression

6.6M special ed students

3.5M children with ADHD

1M Parkinson's patients,

50,000 new/year

750,000 strokes/year in US alone

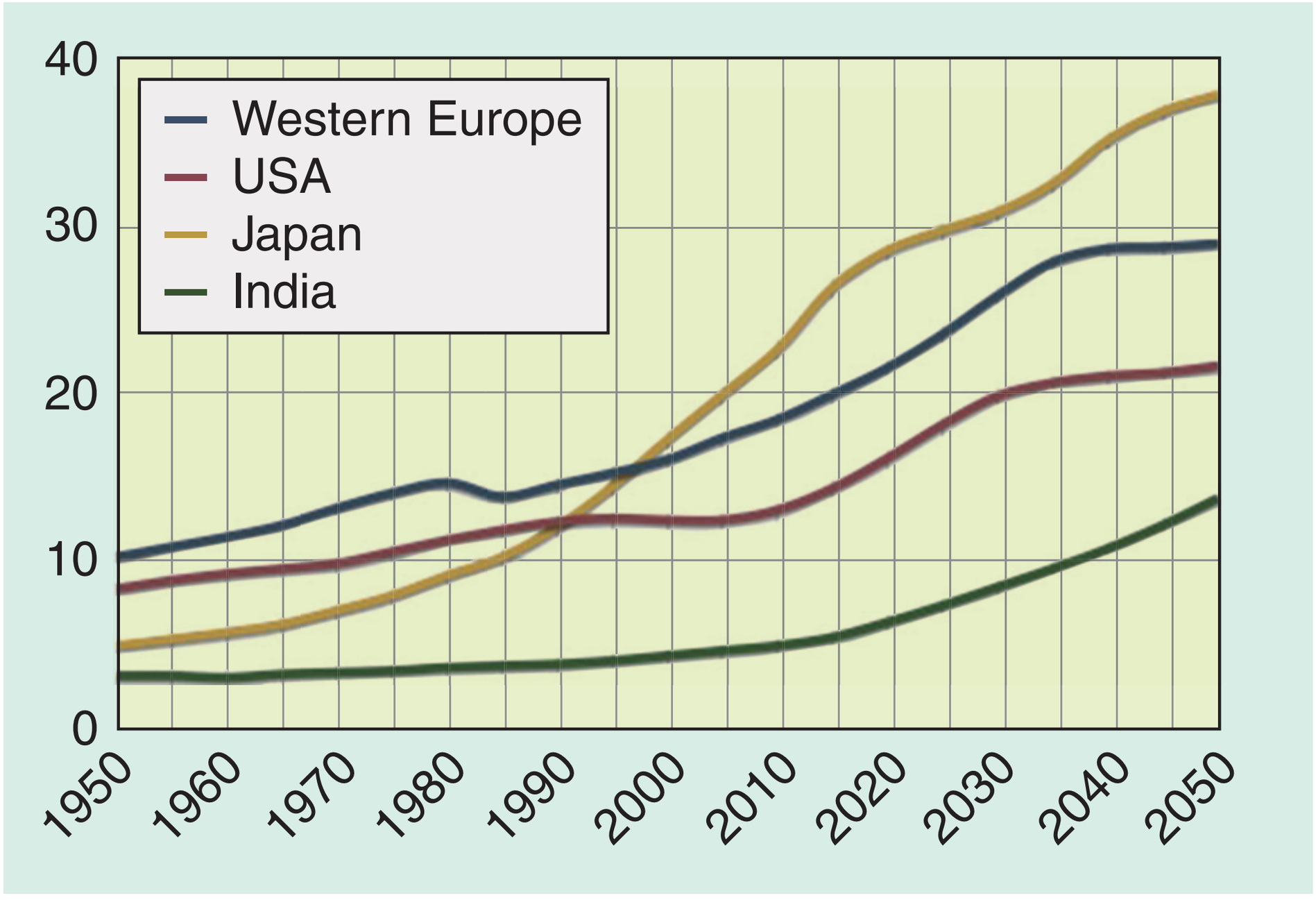
Vets with PTSD, TBI, amputations, etc.

A surging need for caregivers in-home and in-institution

6.2 to 7.5M people with mental retardation

Maja Mataric (USC)

Past and anticipated percentage of the population above age 65

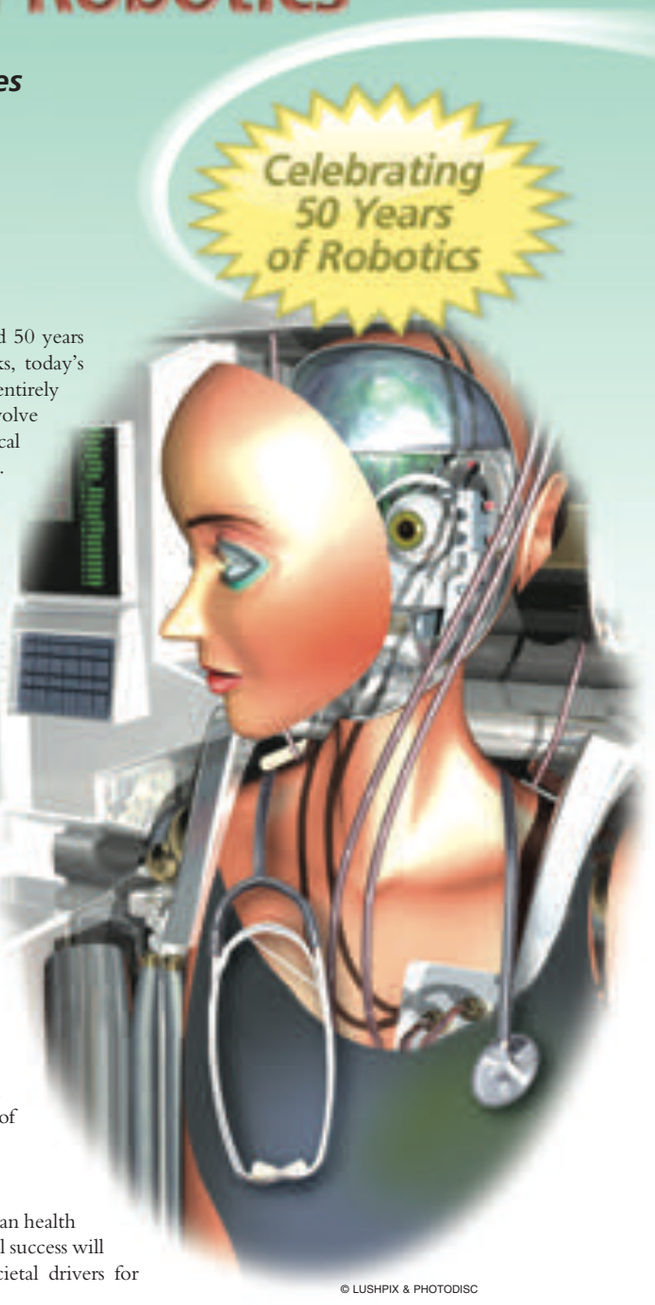


United Nations Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2008 Revision, New York, 2009.

Medical and Health-Care Robotics

Achievements and Opportunities

BY ALLISON M. OKAMURA,
MAJA J. MATARIĆ,
AND HENRIK I. CHRISTENSEN



In contrast to the industrial robots, first developed 50 years ago, to automate dirty, dull, and dangerous tasks, today's medical and health-care robots are designed for entirely different environments and tasks—those that involve direct interaction with human users in the surgical theater, the rehabilitation center, and the family room. Commercial and research interest in medical and health-care robotics has seen substantial growth in the last decade. Telerobotic systems are being routinely used to perform surgery, resulting in shorter recovery times and more reliable outcomes in some procedures. Robotic rehabilitation systems are successfully delivering physical and occupational therapy, enabling a greater intensity of treatment that is continuously adaptable to a patient's needs. Socially assistive robotic (SAR) systems are being developed for in-clinic and in-home use in physical, cognitive, and social-exercise coaching and monitoring. Technological advances in robotics have the potential to stimulate the development of new treatments for a wide variety of diseases and disorders, improve both the standard and accessibility of care, and enhance patients' health outcomes. The aim of this article is to propose some of the most important capabilities and technical achievements of medical and health-care robotics needed to improve human health and well-being. We describe application areas, societal drivers, motivating scenarios, desired system capabilities, and fundamental research areas that should be considered in the design of medical and health-care robots.

Design Considerations

Although robots are already beginning to affect human health through clinical use, further research and commercial success will be facilitated through careful consideration of societal drivers for

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For a big-picture review, see:

A. M. Okamura, M. J. Mataric, and H. I. Christensen. Medical and healthcare robotics: Achievements and opportunities. IEEE Robotics and Automation Magazine, pp. 26-37, September 2010.

For more extensive reading, see:

From Internet to Robotics:
A Roadmap for US Robotics
http://www.us-robotics.us/reports/CCC%20Report.pdf

Application areas for medical and healthcare robotics

- **medicine**: the application of science and technology to treat and prevent injury and disease
  - surgery, interventional radiology
  - physical and occupational therapy
  - replacing lost limb function
- **health care**: the availability of treatment and prevention of illness
  - therapy oversight
  - coaching and motivation

In addition...

- Creating a robotic system that mimics biology has been used as a way to study and test how the human body and brain functions
- Robots can be used to acquire data from biological systems with unprecedented accuracy, enabling us to gain quantitative insights into both physical and social behavior.

Societal drivers: Economics

What economic impact could result from increased use of robotics in medicine and healthcare?

Societal drivers: Economics

- faster recovery times lead to improved worker productivity
- new technologies improve risk-benefit and cost-benefit ratios
- lower costs to society by decreasing impact on families, caregivers, and employers
- training to lower number of medical errors and lawsuits
- objective approaches for accountability and certification/assessment

Societal drivers: Access

What how can robotics increase the access to medicine and healthcare?

Societal drivers: Access

- affordability
  - robots could reduce the cost of clinical rehabilitative care
  - in-home systems for motivating and coaching physical and cognitive exercise for prevention and rehabilitation
  - caretaking of the elderly to promote aging in place (i.e., at home), delay the onset of dementia, and provide companionship to mitigate isolation and depression
- location
  - natural and man-made disasters
  - battlefield; remote working environments (space, undersea, underground)
  - rural populations

physically assistive robots

Movement Therapy and Assistance

- Over 25% of U.S. population has some functional physical limitation that affects normal living
- 6.5M people in the US have had a stroke (by 2050, cost projected to be $2.2 Trillion)

Wheelchair robots

ibot (Dean Kamen)

Wheelchair-Mounted Robotic Arm
(Waseda University)

Household/ADL helpers

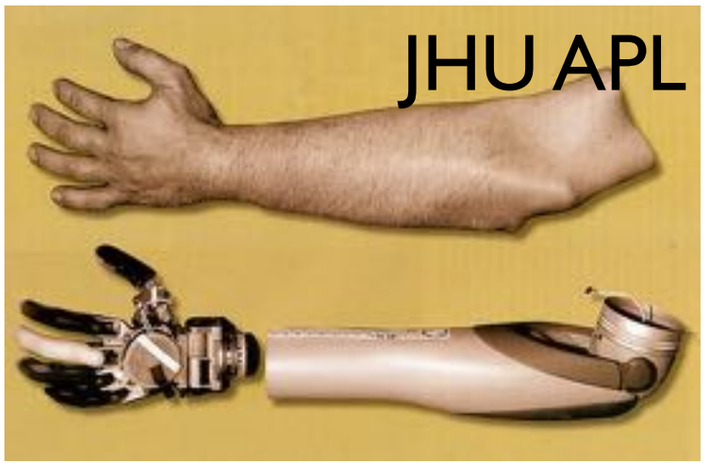
Cody

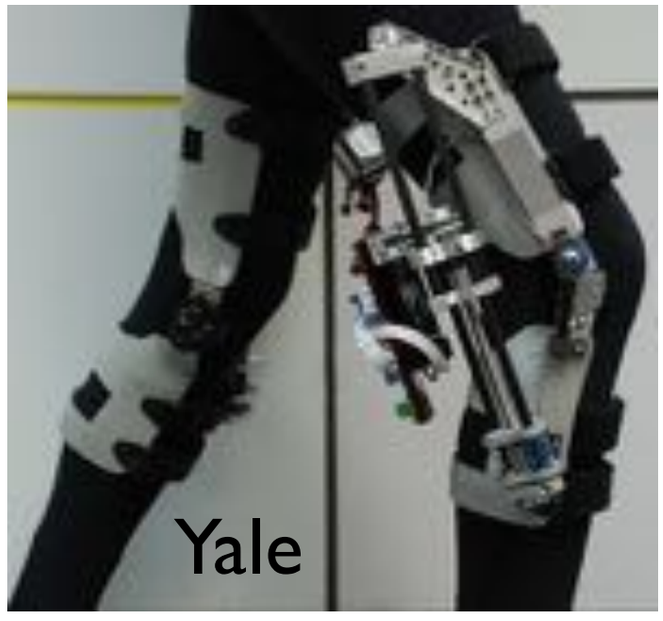
Dusty

EL-E

Robots to aid the sick and elderly
(Kemp lab, Georgia Tech)

robotic replacement of diminished/lost function (i.e., prosthetics and orthotics)

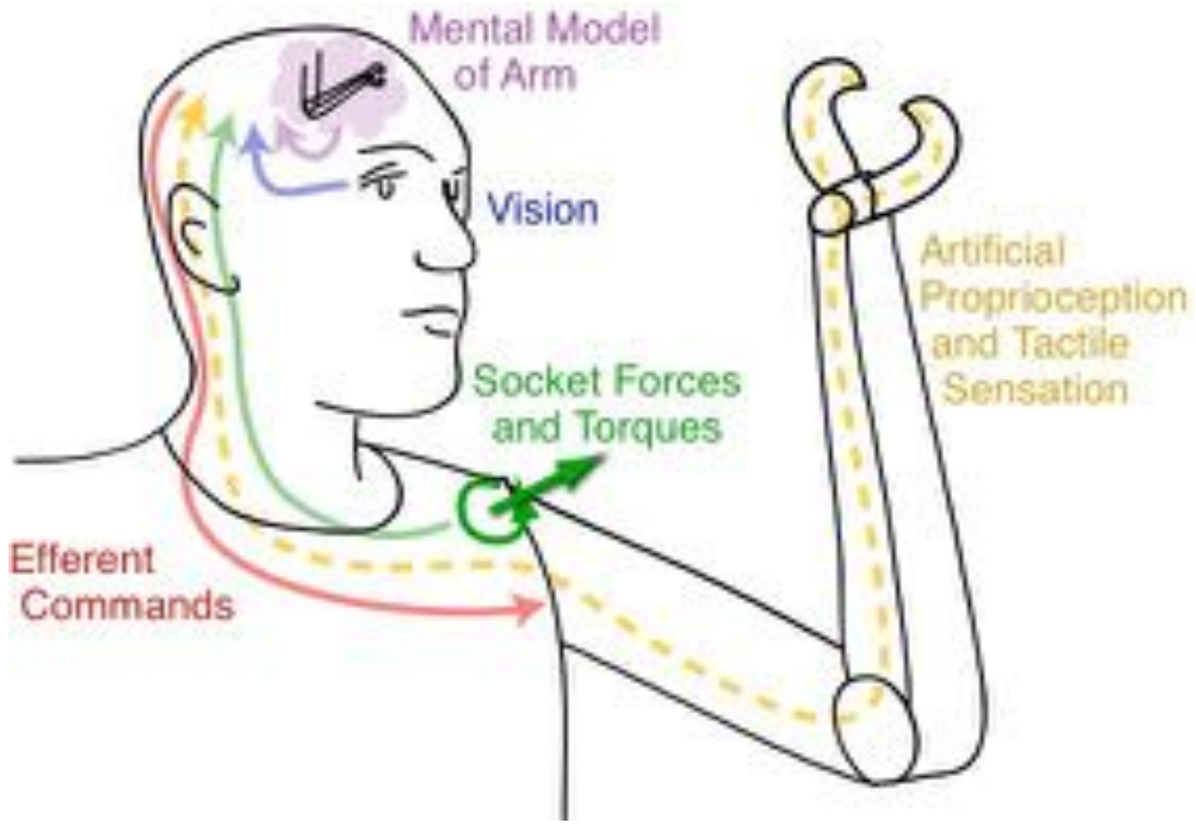




robotic replacement of diminished/lost function (i.e., prosthetics and orthotics)

Challenges include:

- cosmesis
- neural interfaces
  - control
  - communicating sensory information
- level of autonomy
- size and weight vs. functionality



socially assistive robots

slides provided by Maja Mataric

Socially Assistive Robotics

Problem: cost/population size and growth trends
Need: personalized medium to long-term care
Part of the solution: human-centered robotics to improve health outcomes

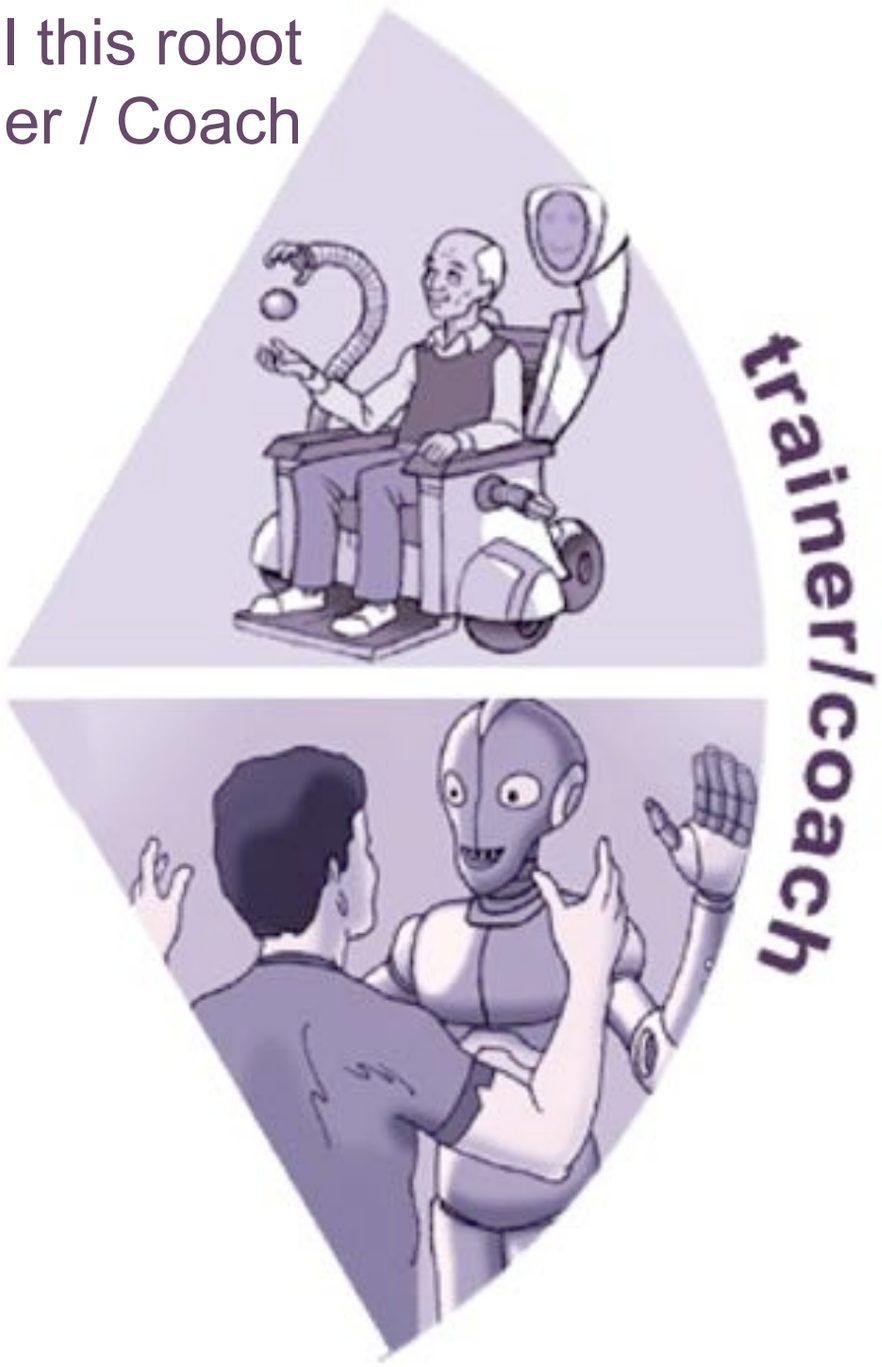
- Monitoring
- Coaching/training
- Motivation
- Companionship/socialization

Robots can be a "force multiplier" for caregivers, reducing health care costs and improving quality of life

Maja Mataric (USC)

Imagine a robot …

We call this robot
Trainer / Coach



… that can complement a physical therapist/coach

… that is enjoyable to interact with

… that minimizes embarrassment

… that is tirelessly devoted 24-7

… that can get doctor or nurse help whenever needed

… that helps numerous people regain their independence

Imagine a robot…

We call this robot
Shepherd / Guide

… that assists as a personalized caregiver

… that serves as eyes and ears

… that is easy to command and interact with

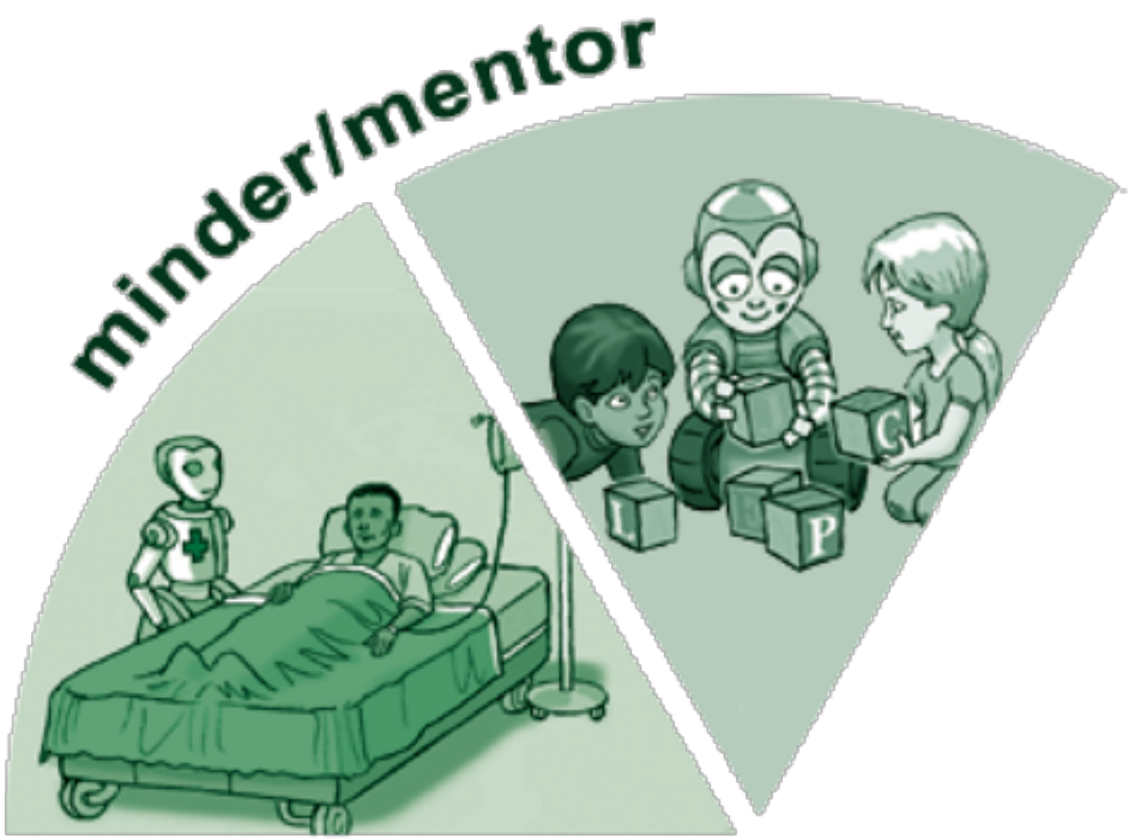
… that is unobtrusive

… that encourages socialization

… that increases human quality of life

Imagine a robot …

We call this robot
Minder / Mentor



… that can help to identify early signs of disorders

… that can provide tireless support

… that is customizable to the exact needs of each person

… that provides continuous motivation for therapies

… that helps numerous people lead fulfilled lives

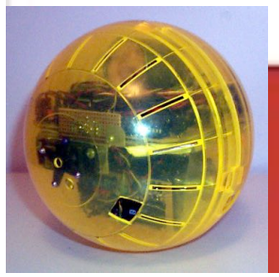
Socially Assistive Robotics

Human-centered robotics technology for healthcare across the lifespan

A significant niche for
affordable (~laptop-cost)
hands-off
non-contact
inherently-safe robotics:
robots that help via social, not physical, interaction.

➔ *Immediate impact: improved health outcomes & decreased healthcare costs*

Autism Spectrum Disorder




Eldercare, Alzheimer's Disease, and Dementia