This is a revised version of the slides Charlie Kemp presented at the following workshop.

https://sites.google.com/view/hri-aip2024/home

HRI for Aging in Place

HRI 2024 Workshop
Monday, March 11, 2024
Boulder, CO

9:40-10:10 am MT
Invited Speaker: Charlie Kemp
"Glimpses of a Future Where Mobile Manipulators Support Aging in Place"
25 min + 5 min Q&A

Speaker Bio
Dr. Charlie Kemp is a cofounder and the chief technology officer (CTO) of Hello Robot Inc., which is working toward a future where mobile manipulators enhance life for everyone. Hello Robot sells Stretch, a compact, lightweight, and capable mobile manipulator that is empowering a growing community of innovators to create a better future. Prior to joining Hello Robot full time in September of 2023, Dr. Kemp was a tenured faculty member at Georgia Tech where beginning in 2006 his research focused on enabling intelligent mobile manipulators to assist older adults and people with disabilities. He sees Hello Robot as the next step in this long-term mission.

Glimpses of a Future Where Mobile Manipulators Support Aging in Place

Charlie Kemp, PhD

https://charliekemp.com

Cofounder & Chief Technology Officer
Hello Robot Inc.

hello robot®

Stretch 3

Societies are Getting Older
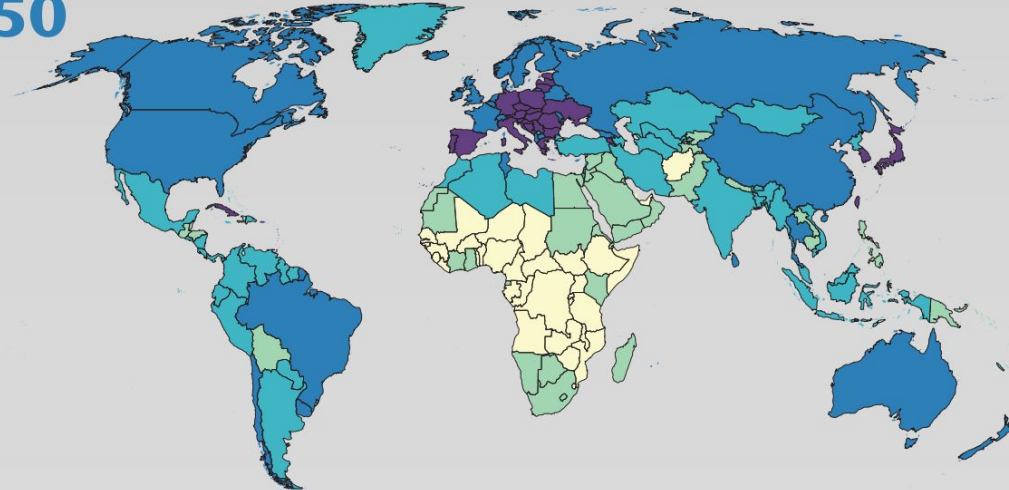
Percentage of Population Age 65+
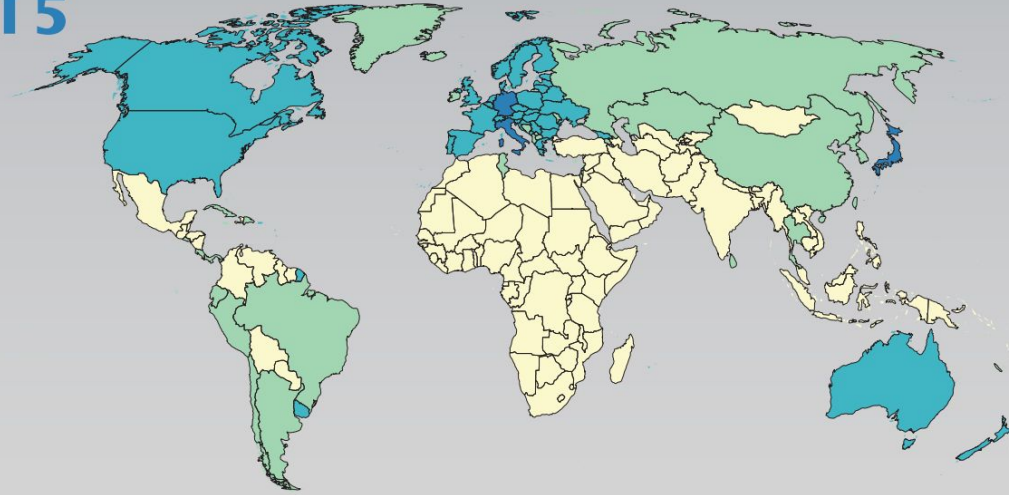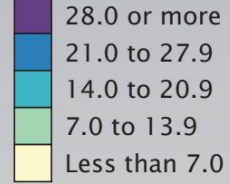
Societal Challenges

- More demand for healthcare
- Shortages of care providers
- Later retirement
- Lower aggregate quality of life

"Protests in France Over Plan to Raise Retirement Age to 64" from January 2023

Image from https://www.wsj.com/video/protests-in-france-over-plan-to-raise-retirement-age-to-64/6F4E09AF-9540-4F89-B75D-1053BB7714BB.html

Robots are unlikely to solve all of these challenges, but they may be able to help.

For this Talk, Imagine a Home Robot Revolution has Occurred and Mobile Manipulators are Common in Homes

- Human-scale
- Affordable
- Inclusive
  - Used by children, older adults, people with disabilities, pets, …
- Versatile
  - There is an app store
  - Popular apps are available
  - App development is widespread

Given this premise, what apps might older adults use?

Some future apps look crazy today!

Spacewar!

1962 : Created at MIT
1971 : 1st arcade video game
2023 : $188B industry

Nolan Bushnell was directly inspired by Spacewar! at the Stanford Artificial Intelligence Laboratory (SAIL), which led to the first arcade video game in 1971 and founding Atari in 1972, which released Pong in 1972 and the Atari 2600 home video game system in 1977.

Lowood, Henry. "Videogames in computer space: The complex history of pong." IEEE Annals of the History of Computing 31, no. 3 (2009): 5-19.

https://youtu.be/1EWQYAfuMYw?t=875
https://en.wikipedia.org/wiki/Spacewar!
https://en.wikipedia.org/wiki/Computer_Space
https://en.wikipedia.org/wiki/Galaxy_Game
https://en.wikipedia.org/wiki/Nolan_Bushnell
https://en.wikipedia.org/wiki/Atari,_Inc.
https://en.wikipedia.org/wiki/Video_game_industry
https://en.wikipedia.org/wiki/Film_industry
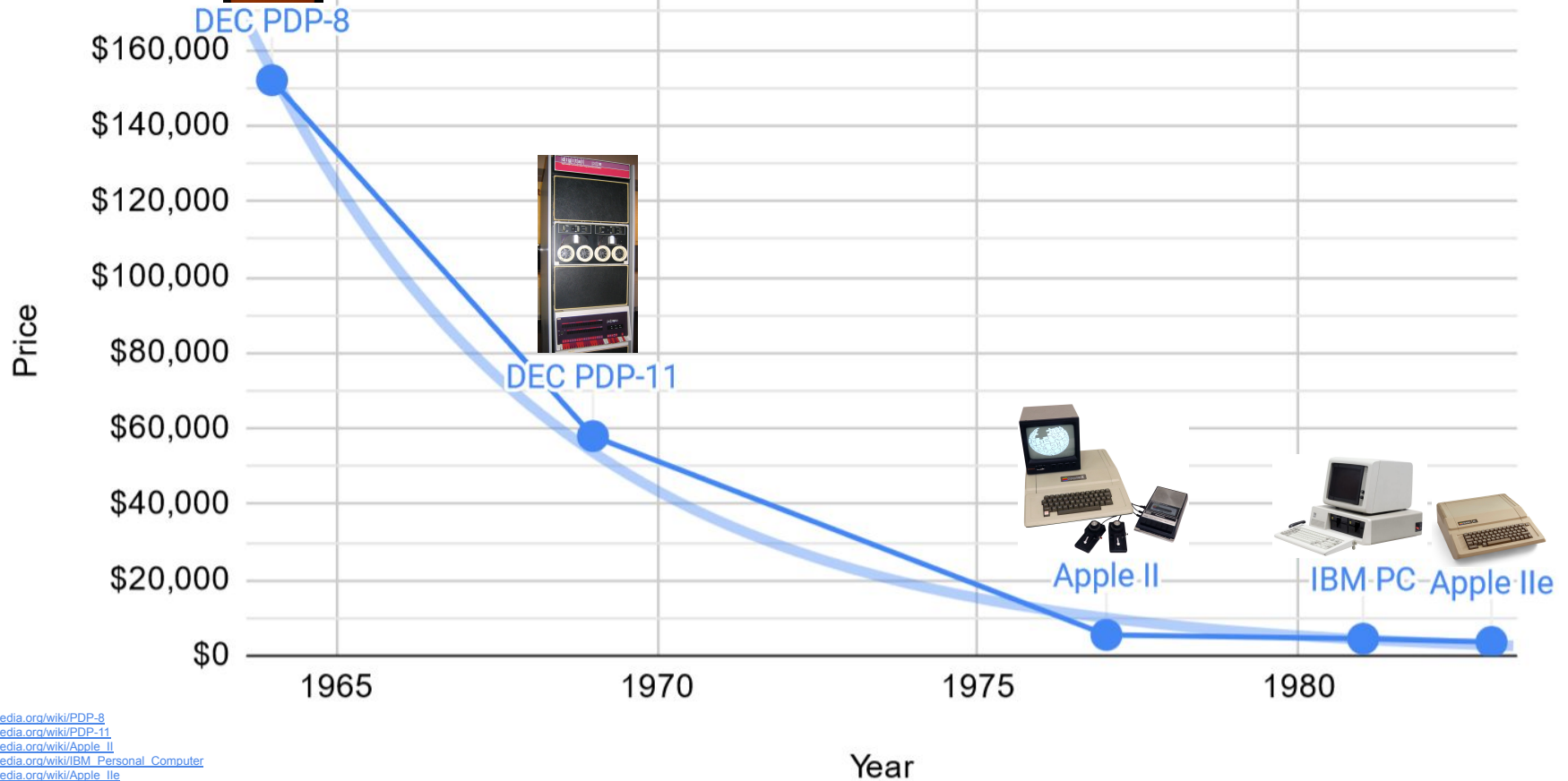https://en.wikipedia.org/wiki/Music_industry

**In 1962
Spacewar!
looked crazy!**

DEC PDP-1
$1.3M
(today's dollars)
1959 release
53 shipped

Applications Look Less Crazy Over Time

DEC PDP-8

DEC PDP-11

Apple II

IBM PC Apple IIe

Price

$160,000

$140,000

$120,000

$100,000

$80,000

$60,000

$40,000

$20,000

$0

1965   1970   1975   1980

Year

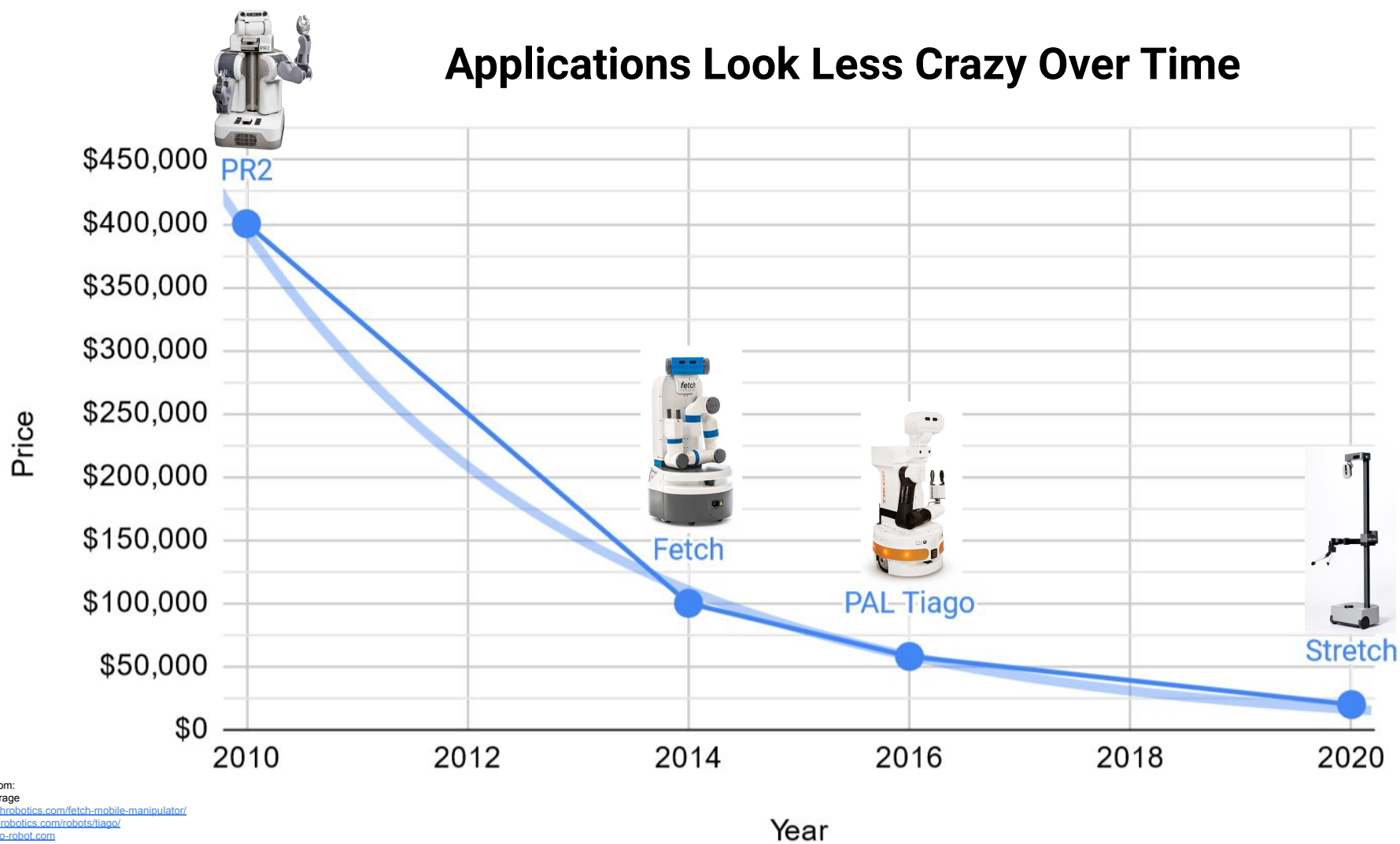# Autonomous Delivery of Medicine to Older Adults Using RFID (N=12)

Akanksha Prakash, Jenay M. Beer,Travis Deyle, Cory-Ann Smarr, Tiffany L. Chen, Tracy L. Mitzner, Charles C. Kemp, and Wendy A. Rogers, *Older Adults Medication Management in the Home: How can Robots Help?*, 8th ACM/IEEE International Conference on Human-Robot Interaction (HRI), 2013

Boldness & Creativity Overcome Impracticalities

	Willow Garage PR2	Digital Equipment Corporation PDP-1
Price (inflation adjusted)	$540,000	$1,300,000
# of units	~50	~53
Weight	227 kg (500 lb)	730 kg (1,600 lb)
Width	0.67 m	2 m
Date released	2010	1959
Link	https://robotsguide.com/robots/pr2	https://en.wikipedia.org/wiki/PDP-1

Applications Look Less Crazy Over Time

PR2

Fetch

PAL Tiago

Stretch

Price

Year

$450,000
$400,000
$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0

2010   2012   2014   2016   2018   2020

The Open Community Working with Stretch
many groups are doing work relevant to aging in place

Robotic Caregivers – Spring 2023

BMED 4833 ROB & BMED 8813 ROB at Georgia Tech

Overview

Robotic Caregivers is a project-based class in which teams work with real robots to explore the future of robotic caregivers. *

Robotics researchers and futurists have long dreamed of robots that can serve as caregivers. In this project-based course, students learn about future opportunities and present realities for robots that contribute to caregiving. They gain hands-on experience with teleoperation, autonomy, perception, navigation, manipulation, human-robot interaction, and machine learning. They also learn about robot design, healthcare robotics, and entrepreneurship.

Students are Bold and Creative!

Website
https://sites.gatech.edu/robotic-caregivers/

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Awards for Spring Term 2023

2023 Student Recognition of Excellence in Teaching: Annual CIOS Award

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Award for Fall Term 2021

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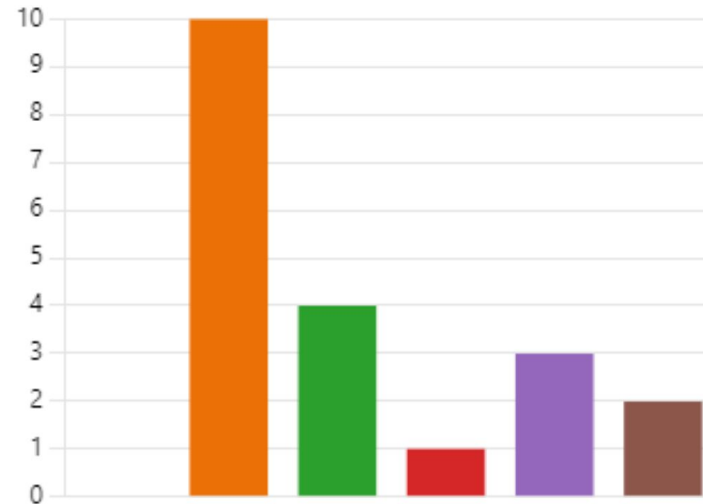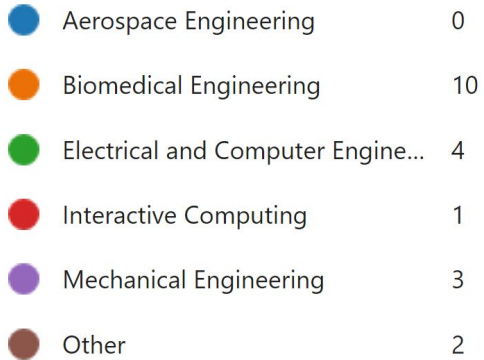# Three Teams - Each with a Dedicated Robot

Easy to Transport to Real Homes
three robots in a hatchback

24.5 kg (54 lb)

hello robot™

🔵 Undergraduate Program	7
🟠 Master's Program	11
🟢 PhD Program	2

🔵 Aerospace Engineering	0
🟠 Biomedical Engineering	10
🟢 Electrical and Computer Engine…	4
🔴 Interactive Computing	1
🟣 Mechanical Engineering	3
🟤 Other	2

"Other" responses are School of Computer Science and the School of Physics.
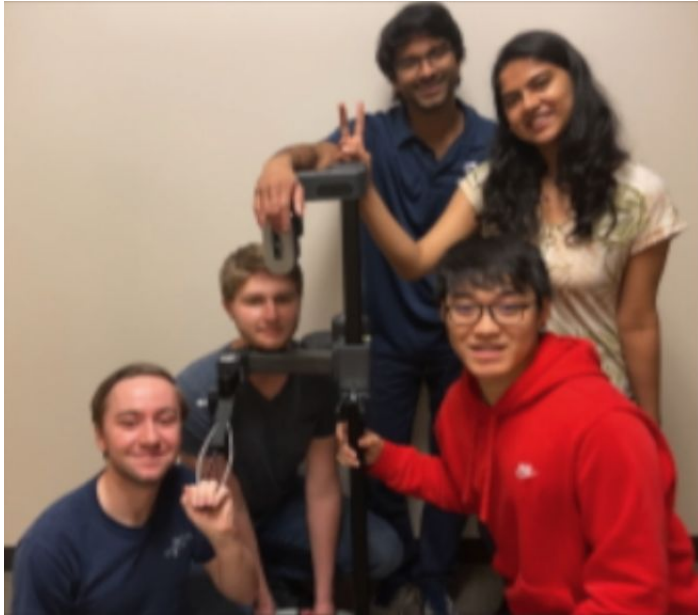
A Project-Based Teaching Community

- Prof. Maru Cabrera
  - UMass Lowell
  - Assistive Robotics (COMP.5500)
- Prof. Maya Cakmak
  - University of Washington
  - Robotics Capstone (CSE 481C)
- Prof. Zackory Erickson
  - Carnegie Mellon University
  - Robotic Caregivers and Intelligent Physical Collaboration (16-887)
- Prof. Naomi Fitter
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  - Assistive HRI (ROB 599)
- Prof. Charlie Kemp (before Sept. 2023)
  - Georgia Tech
  - Robotic Caregivers (BMED 4833 ROB & BMED 8813 ROB)

AI CARING
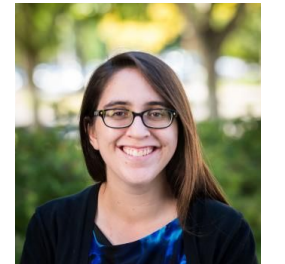
Midnight Stretch - Nighttime Fall Assistance

https://youtu.be/yqKOwHO42N4

Midnight Stretch

- Jeremy Collins
- Mark Putman
- Stuart Song
- Aparna Subramaniam
- Prathic Sundararajan

https://www.aarp.org/health/healthy-living/info-2023/how-to-safely-get-up-from-falls.html

Swancutt DR, Hope SV, Kent BP, Robinson M, Goodwin VA. Knowledge, skills and attitudes of older people and staff about getting up from the floor following a fall: a qualitative investigation. BMC Geriatr. 2020 Oct 6;20(1):385. doi: 10.1186/s12877-020-01790-7. PMID: 33023509; PMCID: PMC7542342.
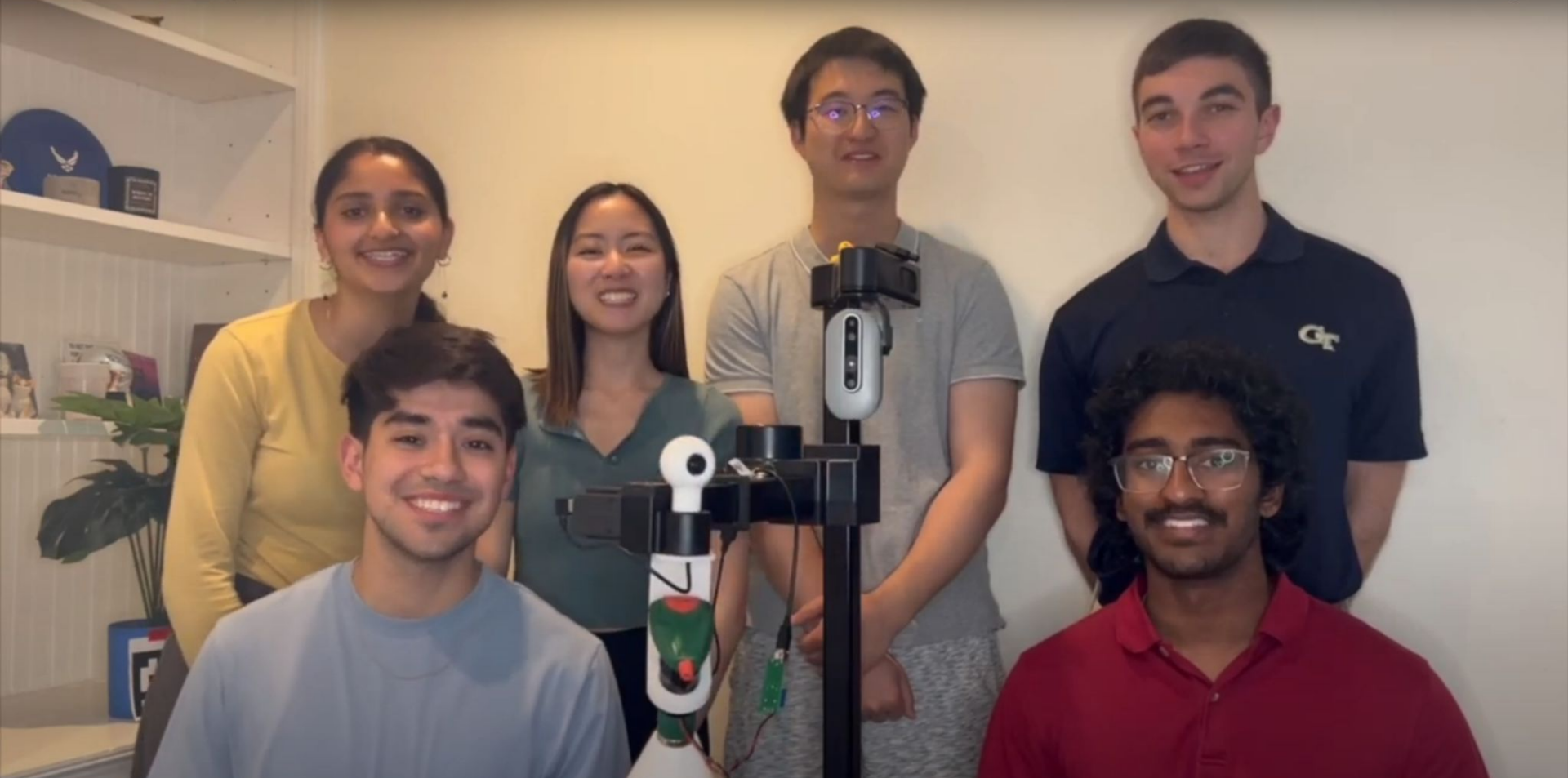
All persons pictured are able-bodied

https://youtu.be/yqKOwHO42N4

https://youtu.be/yqKOwHO42N4

10x Speed

https://youtu.be/yqKOwHO42N4

https://youtu.be/yqKOwHO42N4

Sprout – Robot-Assisted Horticultural Therapy for People with Mobility Impairments

https://youtu.be/0LqbrnJNvPA

Netra Gandhi, Alejandro Vasquez, Fiona Cheung, Kefan Song, Girish Hari, Joshua Shafran
https://youtu.be/0LqbrnJNvPA

"the engagement of a person in gardening and plant-based activities, facilitated by a **trained therapist**, to achieve specific therapeutic treatment goals"

- Wikipedia

Students Found Experts

Kirk W. Hines, HTR
Director of Horticultural Therapy

Experience

A.G. Rhodes
10 years 5 months

Director of Horticultural Therapy
Nov 2020 - Present · 3 years 5 months
Atlanta Metropolitan Area

Horticultural Therapist
Nov 2013 - Present · 10 years 5 months
Greater Atlanta Area
Program founder/manager for the Horticultural Therapy Program responsible for delivery of service, development of programming and therapeutic gardens at the three A.G. Rhodes Health & Rehab facilities.

Horticultural Therapist
Emory Healthcare
Apr 1993 - Nov 2013 · 20 years 8 months
Registered Horticultural Therapist (HTR). Founded and directed the Horticultural Therapy program at Wesley Woods Hospital of Emory Healthcare. Program closed November 2013.

https://www.linkedin.com/in/kirkhines
https://youtu.be/0LqbrnJNvPA

Students Got Feedback from Older Adults

https://youtu.be/0LqbrnJNvPA

Time Speed: 1x

https://youtu.be/0LqbrnJNvPA

https://youtu.be/0LqbrnJNvPA

Helping People with Mild Cognitive Impairment (MCI) Find Misplaced Objects

https://youtu.be/QUB79UTbwvE

Robotic Assistant for Finding Misplaced Objects

Kanishk .

Oluwatofunmi Sodimu

Nikhil Chittaluru

Thanapol Tantagunninat

Erin Kelly

Daniel Lewis

Juan Antonio Robledo

# The Team Worked with the Cognitive Empowerment Program

a collaboration between Emory University's Brain Health Center and the Georgia Institute of Technology

The program "aims to provide people with Mild Cognitive Impairment (MCI) and their Care Partners and families an opportunity to participate in comprehensive lifestyle programs that promote joy, purpose, health, and wellness." - from the website

- The team engaged program participants from the beginning
- They acquired structured and unstructured feedback
- Stakeholders included
  - People diagnosed with MCI
  - Care partners
  - Clinicians
  - Health professionals

The Way Forward
Living with Mild Cognitive Impairment

EMORY
BRAIN HEALTH CENTER

Cover of the program's resource guide for people diagnosed with MCI and their care partners
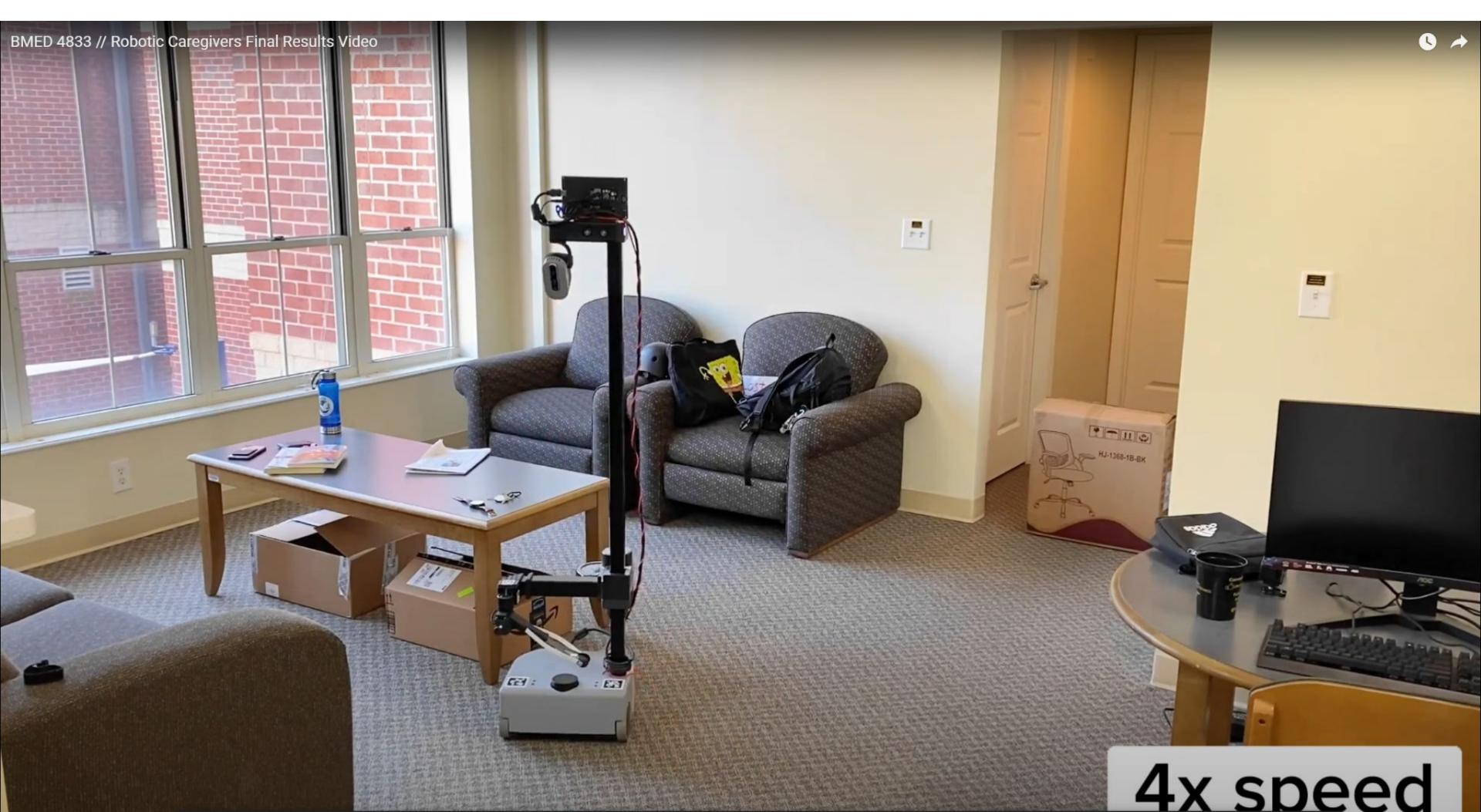
4x speed
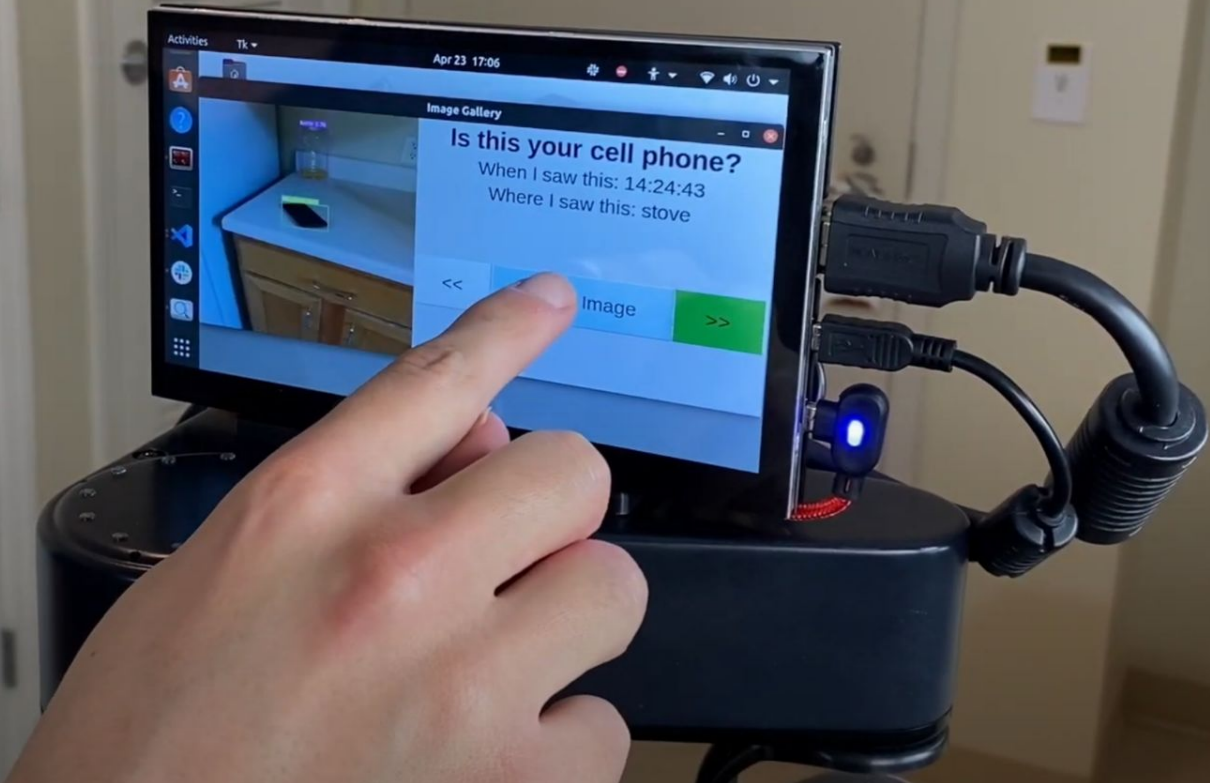
here is where I took the photo

Benefits of their Approach

- The robot and the person with MCI work together
  - The robot has perfect memory
  - The person knows what they're looking for
  - They can find the object interactively
- Working together should
  - reduce errors
  - reduce delays
- Future opportunities
  - Provide option to retrieve the object
  - Recognize misplaced objects and place them in a lost-and-found box
  - Interpret imprecise language
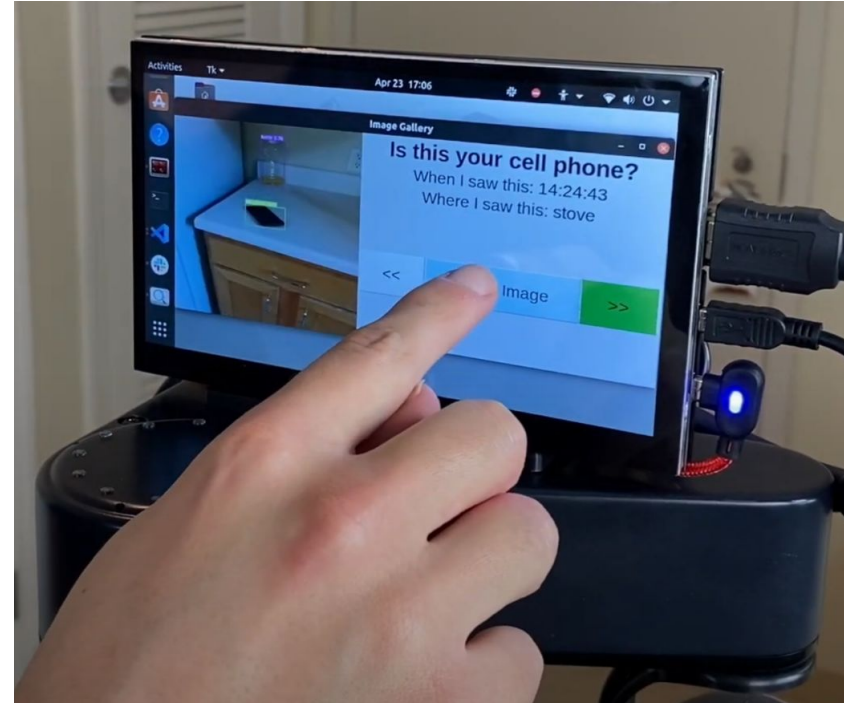
Stretch with Stretch: Robot-led Physical Therapy for Individuals with Parkinson's Disease

https://youtu.be/33iy9St0hBw

The Original Project Team from Fall 2021
grad & undergrad students - robotics, CS, and BME

Zexuan Liu, Kendra Washington, Madeline Beatty, Arjun Majumdar, and Matt Lamsey
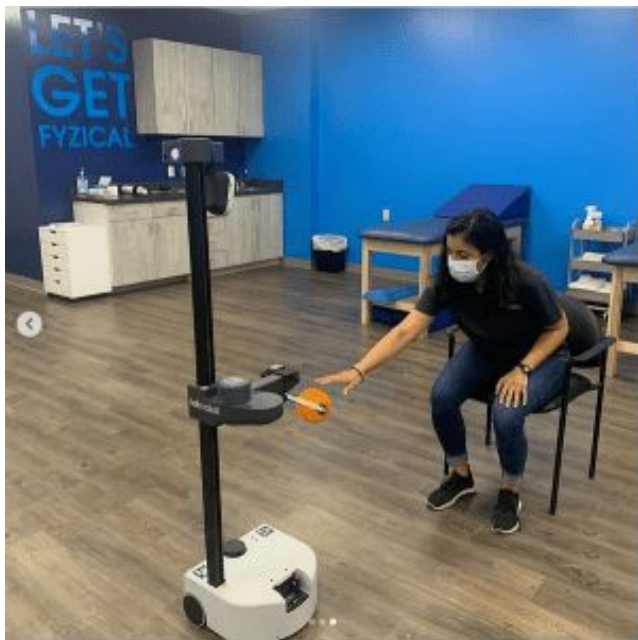https://youtu.be/33iy9St0hBw

A Novel Exercise Game for People with Parkinson's Disease

They Took Their Robot Into the Real World

fyzical_chastain Last week, we had the awesome opportunity to meet with a research group from @georgiatech and discuss the future of technology in physical therapy - and test out this cute little robot named "Stretch"! For people who have Parkinson's Disease (PD), physical therapy involves retraining the brain to correctly perceive the amplitude of the body's movements. External targets provide feedback - did you reach/ lean/ kick far enough or not? This team is working on optimizing a robot to generate an external target, measure outcomes, and provide consistent repetitions. We are looking forward to seeing their progress! Thanks guys!

https://sites.gatech.edu/robotic-caregivers/2021-fall/

The Team Grew After the Class

Prof. Madeleine Hackney
Project Lead
Neurokinesiology Lab
Emory School of Medicine
Department of Medicine
Division of Geriatrics and Gerontology
Atlanta VA

Dr. Meredith Wells, PhD
Post-doctoral Research Fellow
Emory School of Medicine
Division of Geriatrics and Gerontology

Elizabeth Nguyen
Biology / Biological Sciences
Undergraduate
Emory

Arielle Wallenstein
Neuroscience and Behavioral Biology
Undergraduate
Emory

Until September 2023
Prof. Charlie Kemp
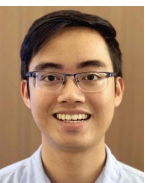Georgia Institute of Technology
Department of Biomedical Engineering

Matt Lamsey
Technical Lead
Robotics PhD student
Georgia Tech

You Liang Tan
Computer Science
MS student
Georgia Tech

Louis Nguyen
Computer Science and Engineering
MS student
Georgia Tech

Jerry Feldman
Test Pilot & Domain Expert
Ambassador for the
Parkinson's Foundation

Dr. Naveen Kuppuswamy, PhD
Senior Research Scientist
Toyota Research Institute

Team that developed the original concept
Class: Robotic Caregivers, Fall 2021
Team Members: Zexuan Liu, Kendra Washington,
Madeline Beatty, Arjun Majumdar, and Matt Lamsey

Opportunities for Robot-assisted Physical Therapy

Soft-bubble end effector from the Toyota Research Institute (TRI)

A. Alspach, K. Hashimoto, N. Kuppuswamy and R. Tedrake, "**Soft-bubble: A highly compliant dense geometry tactile sensor for robot manipulation**," 2019 2nd IEEE International Conference on Soft Robotics (RoboSoft), Seoul, Korea (South), 2019, pp. 597-604

Kick Forward

- Reduce caregiver burden in clinics and homes
- Increase frequency and quality of exercise [1]
- Quantitatively track progress and adherence
- Collect clinically-relevant functional measurements

[1] Mak, M. *et. al.* "**Long-term effects of exercise and physical therapy in people with Parkinson's Disease**." *Nature Reviews Neurology 13*, 689-703 (2017).
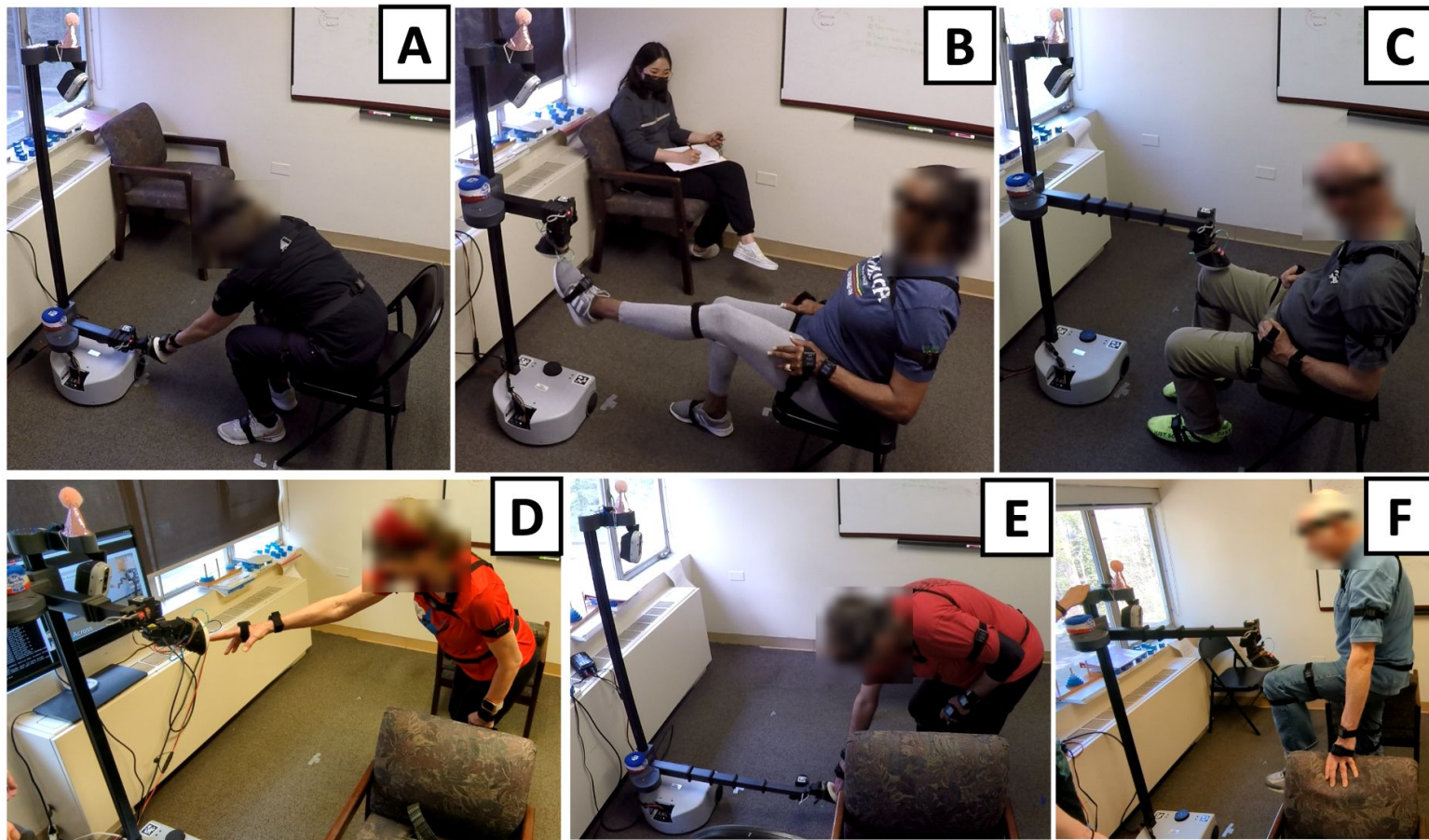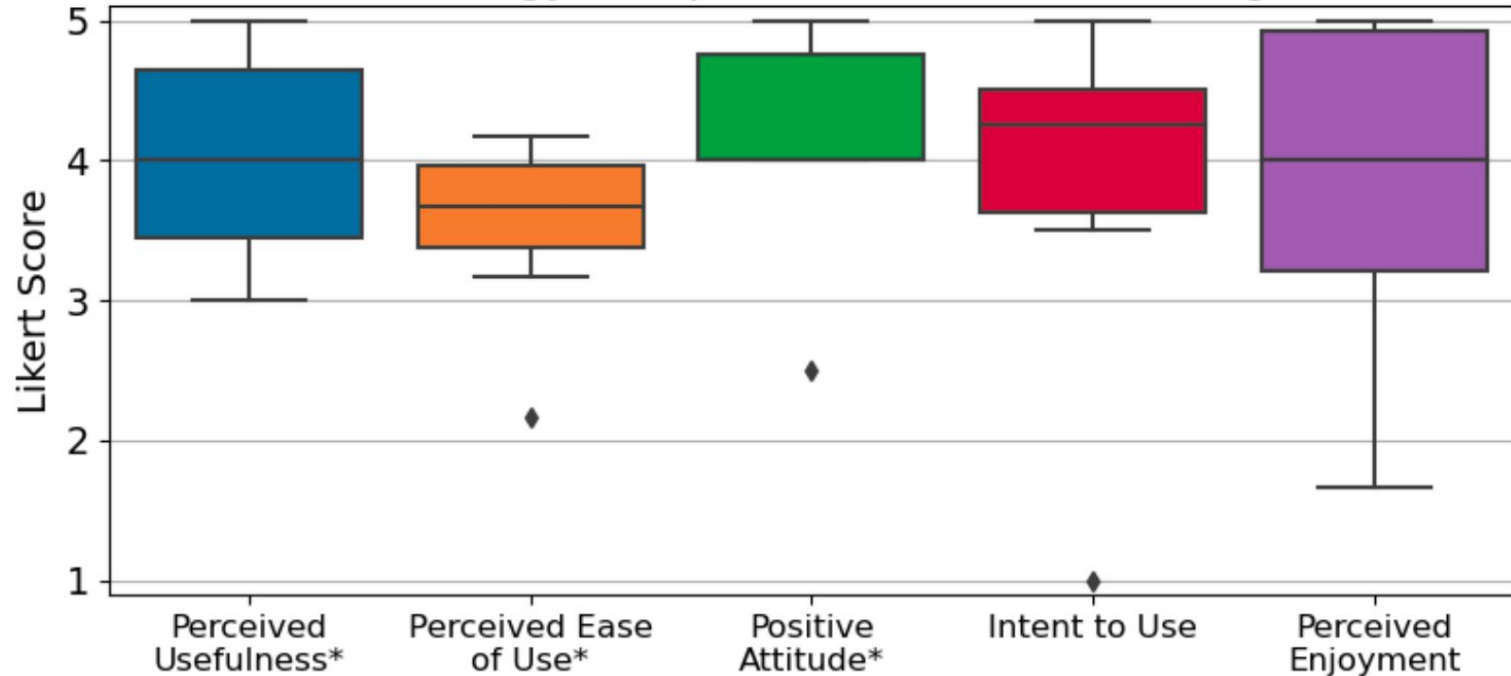
Fig. 4: We performed a user study with 10 people with PD. (**A-C**) Participants performing seated reaching, kicking, and calf raise exercises. (**D-F**) Participants performing standing reach across, reach down, and high knees exercises. Chairs were placed near the participant as safety devices for the standing exercises.

First Published Results

10 people with Parkinson's disease, 1 hour each, 6 exercises

Technology Acceptance Model (TAM) Ratings

Kindergartners Through Fifth Graders Like it Too

Family Science Night at Morningside Elementary School on Feb 13th & 15th

Nighttime Fall Assistance
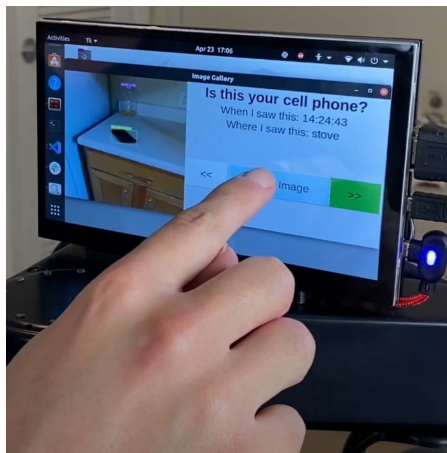
10x Speed

Horticultural Therapy Assistance

Time Speed: 1x

Assistance Finding Misplaced Objects

Is this your cell phone?
When I saw this: 14:24:43
Where I saw this: stove

the photo

Personalized Exercise Game

Kick Forward

How might a home robot revolution help?

- Reduce risks
- Increase social connection
- Increase personal autonomy
- Encourage healthy activities

hello robot®

[My Class Website](#) has Thorough Documentation and Open Materials
you can use them to create your own course

Georgia Tech — Robotic Caregivers

2023 Spring | 2021 Fall | 2021 Spring | 2020 Spring   Search

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The Project-Based Teaching Community is Helpful and Welcoming
you can reach out to me and others to learn more

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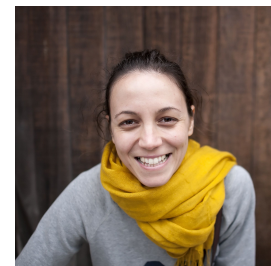
What future apps do you imagine?

What future apps would your students discover?

What future apps would your students discover?
My students surprised me!