Talk given at 9:30 am PT on February 29, 2024 at Google DeepMind in Mountain View, CA
Revised slides released on March 4, 2024

Talk Title:

Human Factors not Humanoids: Why portability, community, and ease of use will determine the future of mobile manipulation

Abstract:

Whether using mobile manipulators to pursue AGI or nearer-term applications, deploying robots in real human environments is a critical challenge. Robotics offers the potential for artificial systems to physically interact with people and their surroundings, creating new opportunities for AI and positive societal impact. Yet, much of human experience is found within homes and workplaces, which have been difficult for robots to access. In this talk, I will present Stretch, a compact and lightweight mobile manipulator that shows robots do not need to be humanoids to perform a wide variety of compelling tasks. By prioritizing portability and ease of use, Stretch has encouraged a growing community of innovators to take their robots out into the world to collect diverse data, test under real-world conditions, and discover new ways for robots to benefit society. I will give an overview of the design of Stretch, highlight community achievements, and talk about the implications for AI and societal benefit. I will emphasize the risks of attempting to bring the world to robots instead of taking robots out into the world. I will discuss the benefits of involving people who are not experts in robotics or AI, including broadening notions of worthwhile tasks. I will also give a live demo of Stretch 3, which Hello Robot released earlier this month.

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, Charlie was an associate professor with tenure at Georgia Tech where he founded the Healthcare Robotics Lab which focused on enabling intelligent mobile manipulators to assist older adults and people with disabilities. Charlie's lab developed the original prototype robot that Hello Robot subsequently commercialized and dramatically improved. He earned his B.S., M.Eng., and Ph.D. at MIT with Rod Brooks as his Ph.D. advisor. He and Dr. Aaron Edsinger (cofounder and CEO of Hello Robot) first collaborated in Rod's lab.

Human Factors not Humanoids:

Why portability, community, and ease of use will determine the future of mobile manipulation

Charlie Kemp, PhD
https://charliekemp.com

Cofounder & Chief Technology Officer
Hello Robot Inc.

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Professional Timeline

1997-2005 : Earned degrees at MIT

2006 : Joined Georgia Tech

2017 : Co-founded Hello Robot

2023 : Joined Hello Robot full-time

Professional Timeline

1997-2005 : Earned degrees at MIT

2006 : Joined Georgia Tech

2017 : Co-founded Hello Robot

2023 : Joined Hello Robot full-time

relinquished tenure & closed my lab

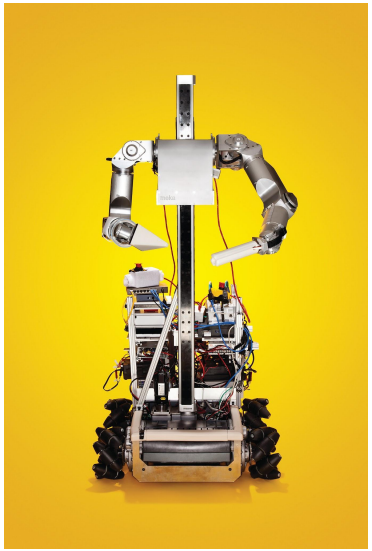
Why give up tenure? To make this a reality

research from the Healthcare Robotics Lab (healthcare-robotics.com) at Georgia Tech

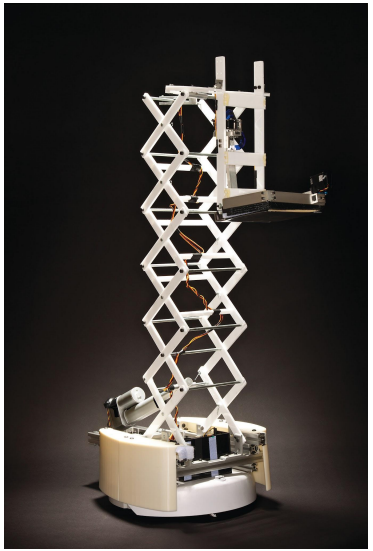
Georgia Tech

I am the lead inventor of pioneering mobile manipulators

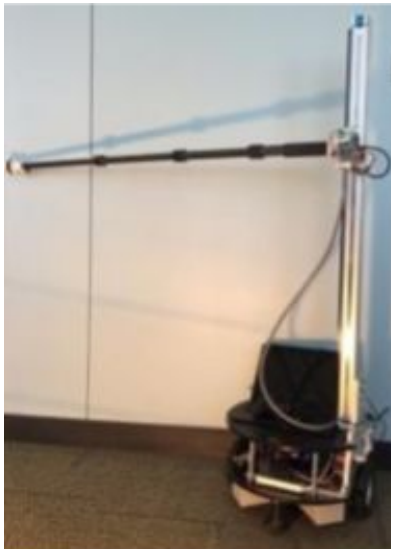
EL-E (2008)



Cody (2009)



Dusty (2010)



Early Prototype for Stretch (2016)

Commercialized by Hello Robot

Cody and Dusty Photos by Josh Meister

Georgia Tech

Stretch 3®

The world's only lightweight, capable, developer-friendly mobile manipulator

Greater dexterity

Enhanced support for Embodied AI

Ready for researchers, educators, and explorers

Now with standard gripper camera,
second head camera, and dexterous wrist!

AVAILABLE NOW
FOR $24,950

The Washington Post

"The robot was doing far more for (him) than taking care of his body. It was also feeding his soul."

The Seattle Times

"Astounding in its potential."

IEEE Spectrum

"Beautifully simple, clever robot design."

Why am I here today?

To encourage you to join the open community working with Stretch

- Mass adoption determines the future
- Human factors promote adoption
- Open communities accelerate progress

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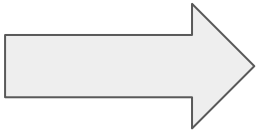
Mass Adoption of Home Robots Will Enable Embodied AI



Large Robot Foundation Model

What matters for technology adoption?

Perceived Usefulness

Perceived Ease of Use

Photo from https://ahs.illinois.edu/rogers

Prof. Wendy Rogers introduced me to this model back in 2010 when we began collaborating on home robots.

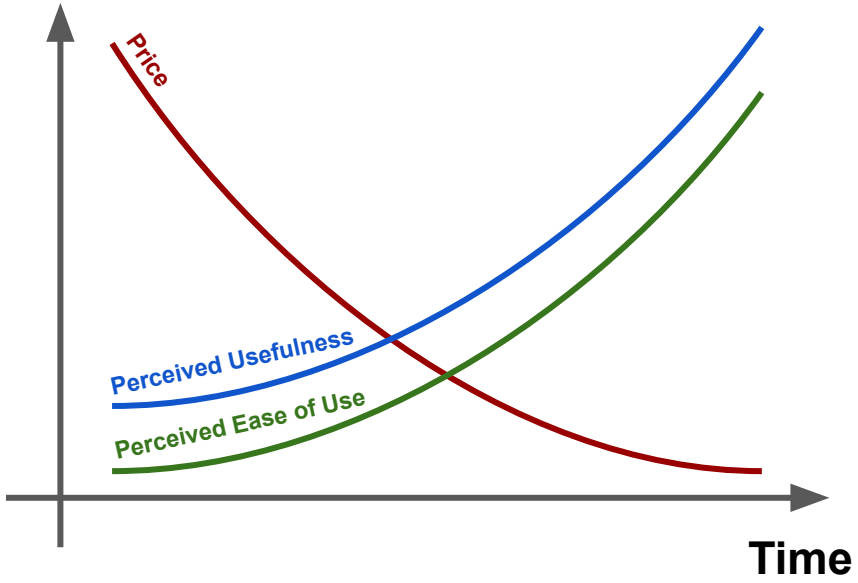
https://en.wikipedia.org/wiki/Technology_acceptance_model

A Simple Model of Technology Adoption

Perceived Usefulness

Perceived Ease of Use

Price



A Simple Model of Technology Adoption

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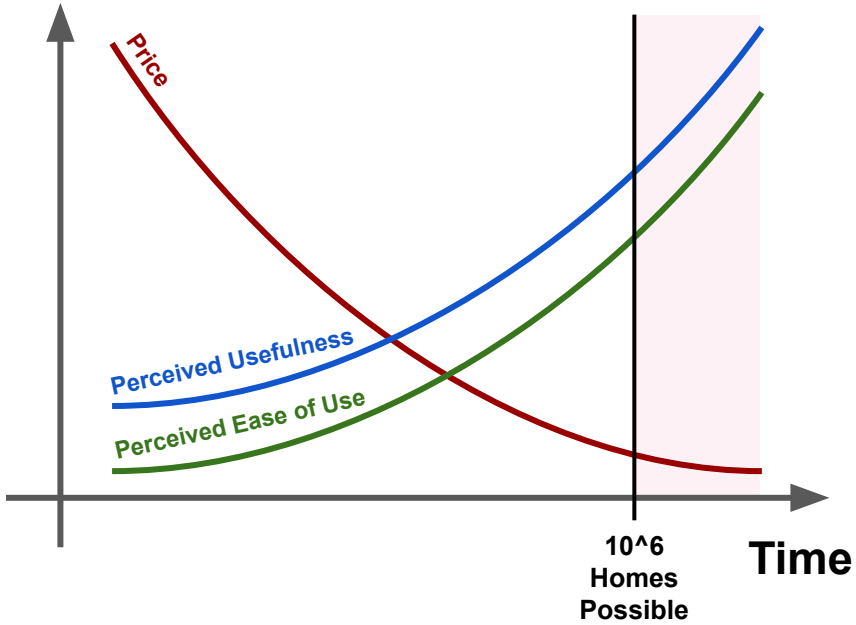
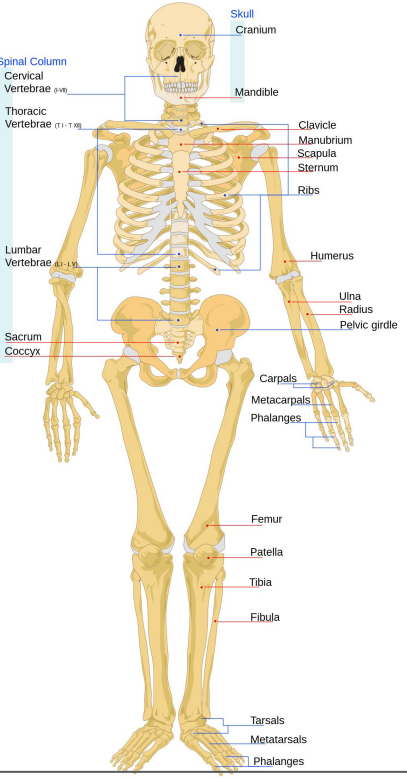


Humanoids look useful and easy to work with!

but practical considerations limit adoption in homes



More degrees of freedom → **Higher cost & more failure points**

Higher center of mass → **More energy when it falls**

Not statically stable → **Greater fall risk & awkward when off**

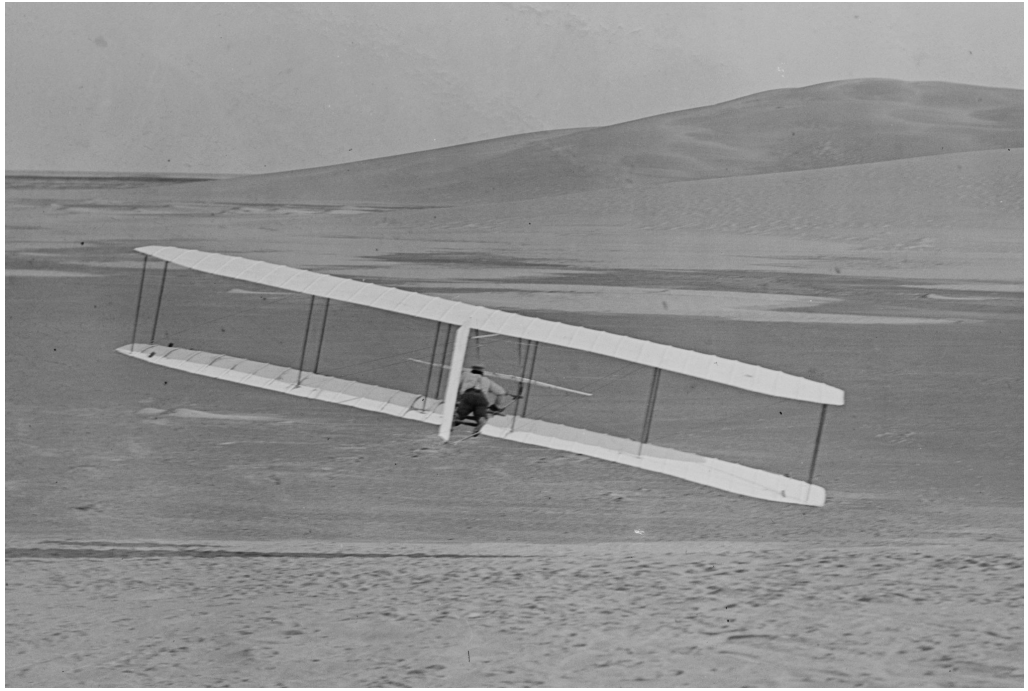
Charles C. Kemp, Paul Fitzpatrick, Hirohisa Hirukawa, Kazuhito Yokoi, Kensuke Harada, and Yoshio Matsumoto. "Humanoids.", Springer Handbook of Robotics, Springer-Verlag, edited by Bruno Siciliano, Oussama Khatib, and Torsten Kröger, 2008, pp. 1307-1333.

image from https://upload.wikimedia.org/wikipedia/commons/thumb/c/ca/Human_skeleton_front_en.svg/1060px-Human_skeleton_front_en.svg.png

Biological Inspiration Can Be Misleading

Edward Purkis Frost's ornithopter from 1902

E. P. Frost appears to have been a respected member of the Royal Aeronautical Society, since he was its president from 1908 to 1911.



Wright Glider from 1902

Sources:
https://www.onverticality.com/blog/e-p-frost-ornithopters
https://en.wikipedia.org/wiki/Edward_Purkis_Frost
https://upload.wikimedia.org/wikipedia/commons/2/23/1902_Wright_glider_turns.jpeg
https://en.wikipedia.org/wiki/Wright_brothers

:(

Your PC ran into a problem and needs to restart. We're just collecting some error info, and then we'll restart for you.

20% complete

For more information about this issue and possible fixes, visit https://www.windows.com/stopcode

If you call a support person, give them this info:

Stop code: CRITICAL_PROCESS_DIED

Have you ever?

Had a device run out of batteries unexpectedly (e.g., phone, laptop)?

Had a computer fail unexpectedly (e.g., blue screen of death)?

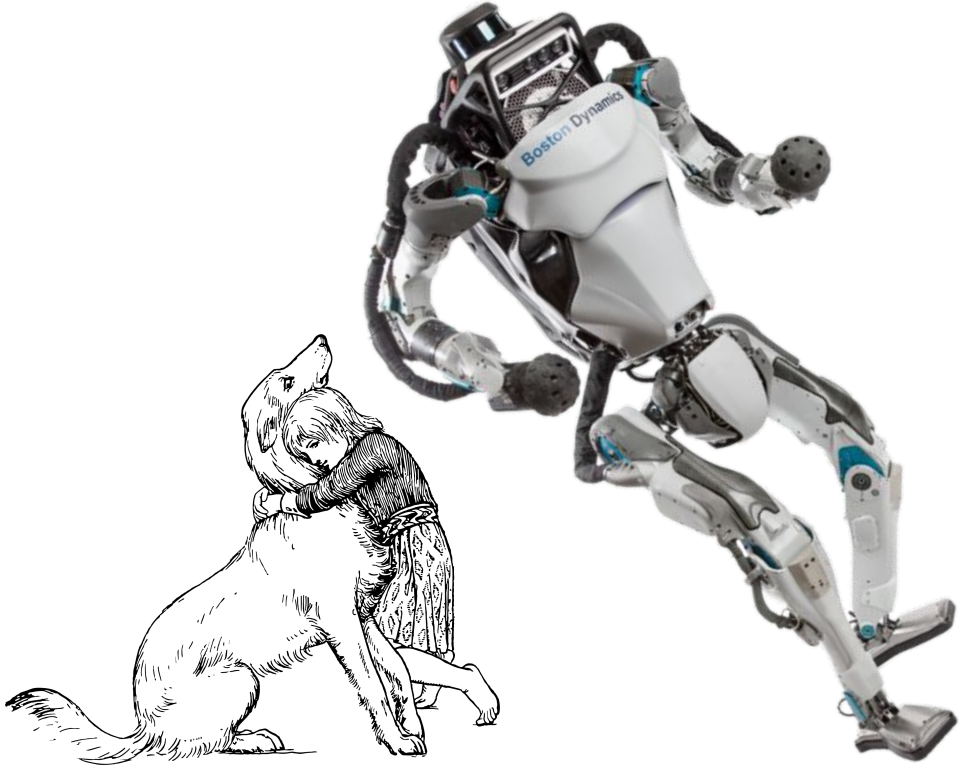
Had a kid or pet do something unexpected around you?

Been careful around an older adult due to concerns about them falling?

Stumbled in your own home?

Image in previous slide from: https://en.wikipedia.org/wiki/Screen_of_death

It Just Takes One Fall



Images from
https://openclipart.org/detail/314874/little-girl-hugging-dog
https://ozrobotics.com/tag/humanoid-robot/

Can we do better than humanoids in homes?

What matters for technology adoption?

Perceived Usefulness

Perceived Ease of Use

Photo from https://ahs.illinois.edu/rogers

Prof. Wendy Rogers introduced me to this model back in 2010 when we began collaborating on home robots.

https://en.wikipedia.org/wiki/Technology_acceptance_model

I am Only Talking about Indoor Mobile Manipulation

- Designed & Built for People
  - Flat floors
  - Cartesian structure
  - Human scale [1]
- Diverse inhabitants
  - Children
  - Older adults
  - People with disabilities
  - Pets
- Examples in the United States
  - 127M Occupied housing units [2]
  - 6M Commercial buildings [3]

[1] https://en.wikipedia.org/wiki/Human_scale
[2] https://data.census.gov/table?q=housing&tid=ACSST1Y2021.S2504
[3] https://css.umich.edu/publications/factsheets/built-environment/commercial-buildings-factsheet

Home & workplace images
https://en.wikipedia.org/wiki/House#/media/File:Noto_Emoji_v2.034_1f3e0.svg
https://www.psdgraphics.com/psd/small-store-icon-psd/

Photo from Willow Garage

The Core Design Problem

Smaller

Lighter Weight

Lower Cost

Shorter Reach

Lower Force

Less Dexterity

The Design of Stretch: A Compact, Lightweight Mobile Manipulator for Indoor Human Environments, Charles C. Kemp, Aaron Edsinger, Henry M. Clever and Blaine Matulevich, IEEE International Conference on Robotics and Automation (ICRA), 2022. [4-min video presentation]

The Design of Stretch

The Design of Stretch: A Compact, Lightweight Mobile Manipulator for Indoor Human Environments, Charles C. Kemp, Aaron Edsinger, Henry M. Clever and Blaine Matulevich, IEEE International Conference on Robotics and Automation (ICRA), 2022. [4-min video presentation]

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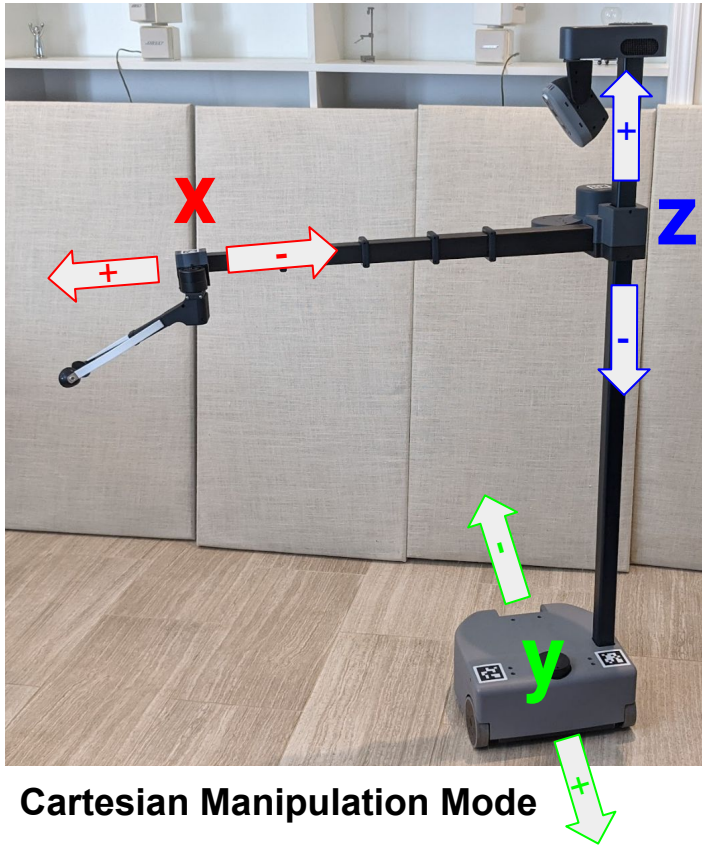
Manipulation Depends on the Mobile Base



Cartesian Manipulation Mode

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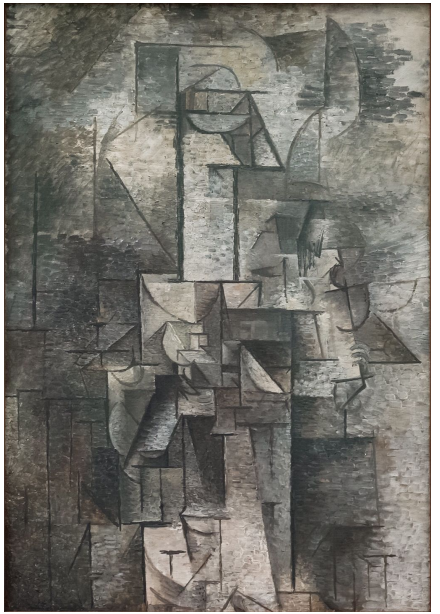
Robotic Cubism

- Dimensions matched to human environments
- The human form deconstructed and reassembled

La Femme au Violon - Pablo Picasso, 1911



“In Cubist artwork, objects are analyzed, broken up and reassembled in an abstracted form”
- https://en.wikipedia.org/wiki/Cubism

Image: https://openclipart.org/detail/260142/arms-akimbo-male

< 50th Percentile Hip Width

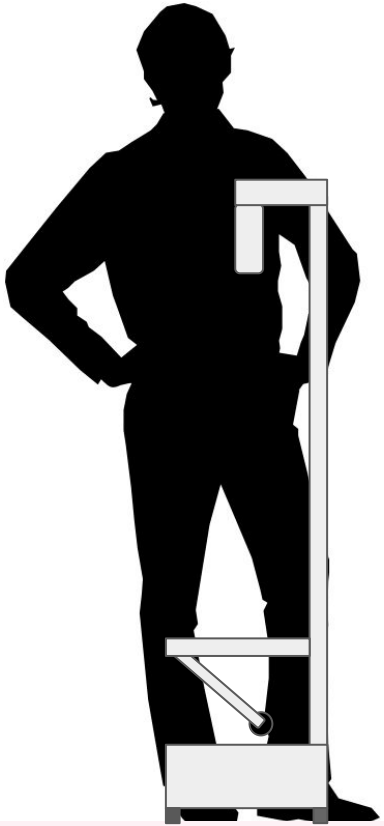
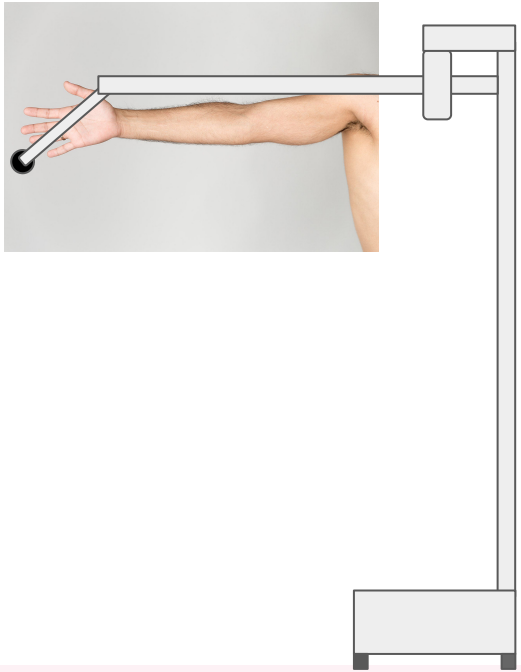
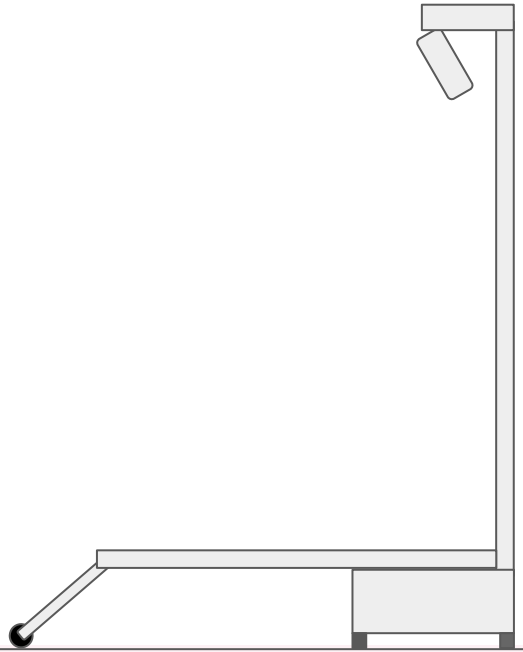


Image: https://en.wikipedia.org/wiki/Arm#/media/File:Extended_arm.jpg

50th Percentile Arm Length



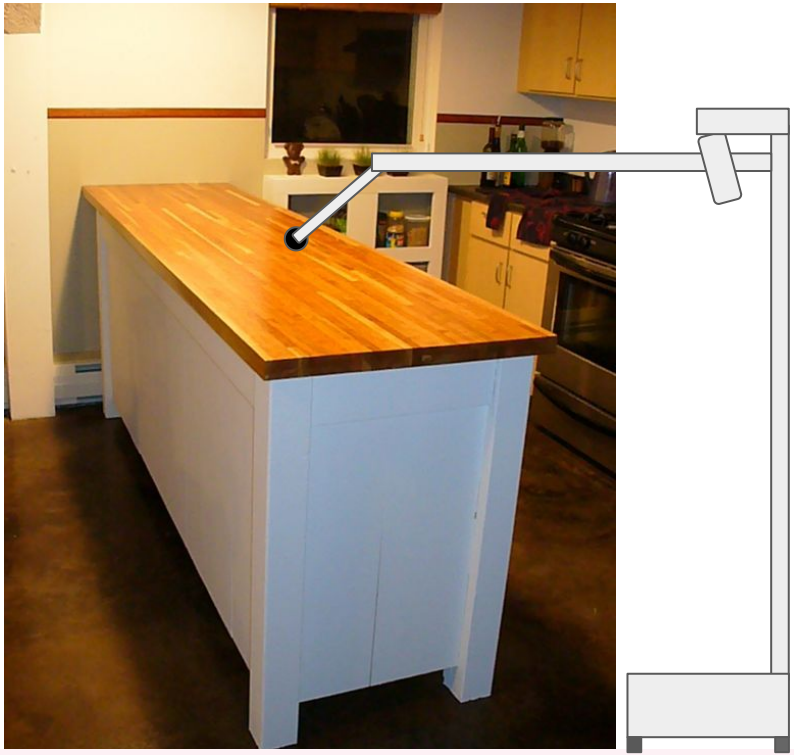
Reaches the Floor



The Design of Stretch: A Compact, Lightweight Mobile Manipulator for Indoor Human Environments, Charles C. Kemp, Aaron Edsinger, Henry M. Clever and Blaine Matulevich, IEEE International Conference on Robotics and Automation (ICRA), 2022. [4-min video presentation]

Image: https://commons.wikimedia.org/wiki/File:Butcher_block_counter_top.jpg

Reaches 36” Countertops



Soft Gripper

- Core design **tested in 1000s of homes**
  - Initially selected based on Amazon reviews
  - Used by staff at Disney World!
- Reduces consequences of unintended contact

The Design of Stretch: A Compact, Lightweight Mobile Manipulator for Indoor Human Environments, Charles C. Kemp, Aaron Edsinger, Henry M. Clever and Blaine Matulevich, IEEE International Conference on Robotics and Automation (ICRA), 2022. [4-min video presentation]

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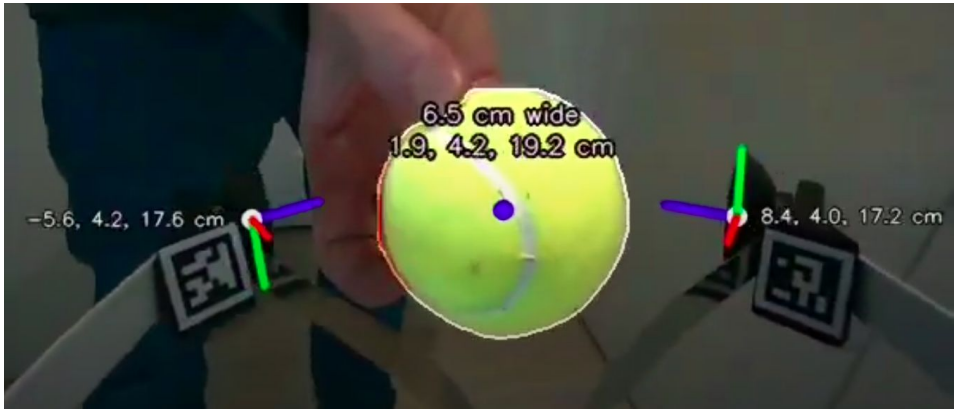
Soft Gripper

- 6 DOF pose for each fingertip
- Compliance enables visual estimation of forces, torques, and contact pressure.



Force/Torque Sensing for Soft Grippers using an External Camera, Jeremy A. Collins, Patrick Grady, Charles C. Kemp, IEEE International Conference on Robotics and Automation (ICRA), 2023.

Visual Contact Pressure Estimation for Grippers in the Wild, Jeremy A. Collins, Cody Houff, Patrick Grady, Charles C. Kemp, Accepted to IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2023.

It’s Now Easy To Try Another Gripper

Stretch 3 has

- Single-button exchange of tools
- USB port
- Dynamixel connector

Prof. Veronica Santos from UCLA
with a humanoid hand on her Stretch RE1
(It wasn’t easy back then!)

24.5 kg (54 lb)

Image: https://www.seekpng.com/ipng/u2q8y3i1o0r5a9o0_beautiful-silhouettes-of-children-boy-silhouette-transparent-background/

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Easy to Transport to Real Homes

three robots in a hatchback

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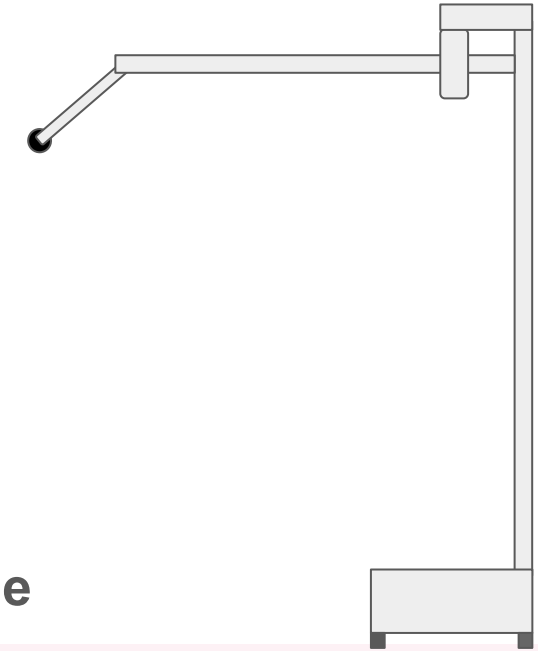
Image: https://en.wikipedia.org/wiki/Arm#/media/File:Extended_arm.jpg

Low Center of Mass

lightweight arm



heavy mobile base

The Design of Stretch: A Compact, Lightweight Mobile Manipulator for Indoor Human Environments, Charles C. Kemp, Aaron Edsinger, Henry M. Clever and Blaine Matulevich, IEEE International Conference on Robotics and Automation (ICRA), 2022. [4-min video presentation]

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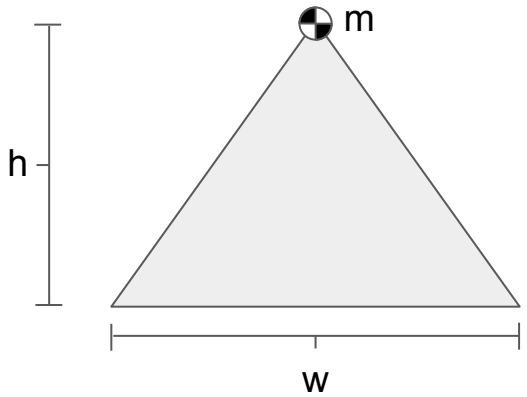
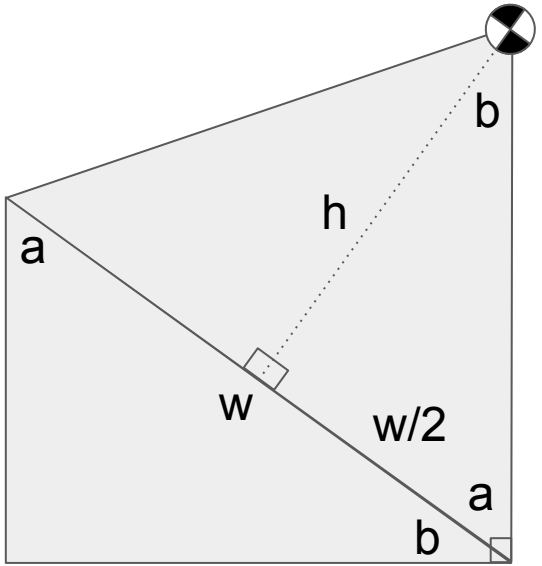
Gravitational Potential Energy as a Measure of Ease of Use

- U = mgh
  - U : gravitational potential energy
  - m : mass of the robot
  - g : gravitational acceleration (9.8 m/s^2)
  - h : height of the center of mass
  - SI unit : joule
- Fall risk
  - mgh models the energy transferred when the robot falls
- Difficulty moving the robot manually
  - m indicates how hard it would be to lift manually
- Robot's base width
  - h is proportional to w, the width of the robot's base required for static stability on a sloped surface



https://en.wikipedia.org/wiki/Gravitational_energy



h is proportional to the minimum width, w, of the robot's base of support for static stability on a slope with angle b

$$h \propto w$$

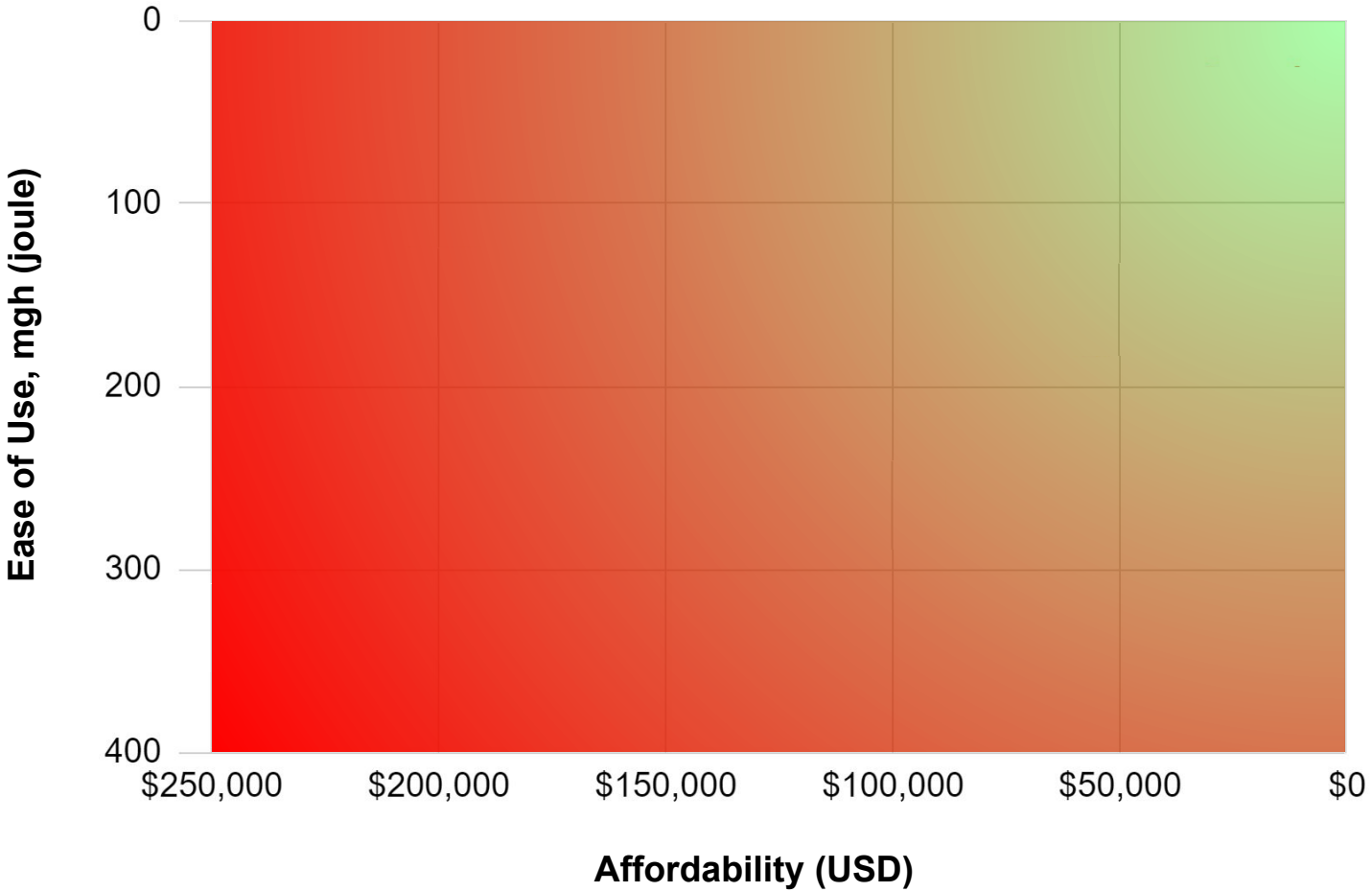
$$\frac{\frac{w}{2}}{h} = \tan(b)$$

$$h = \frac{w}{2\tan(b)}$$

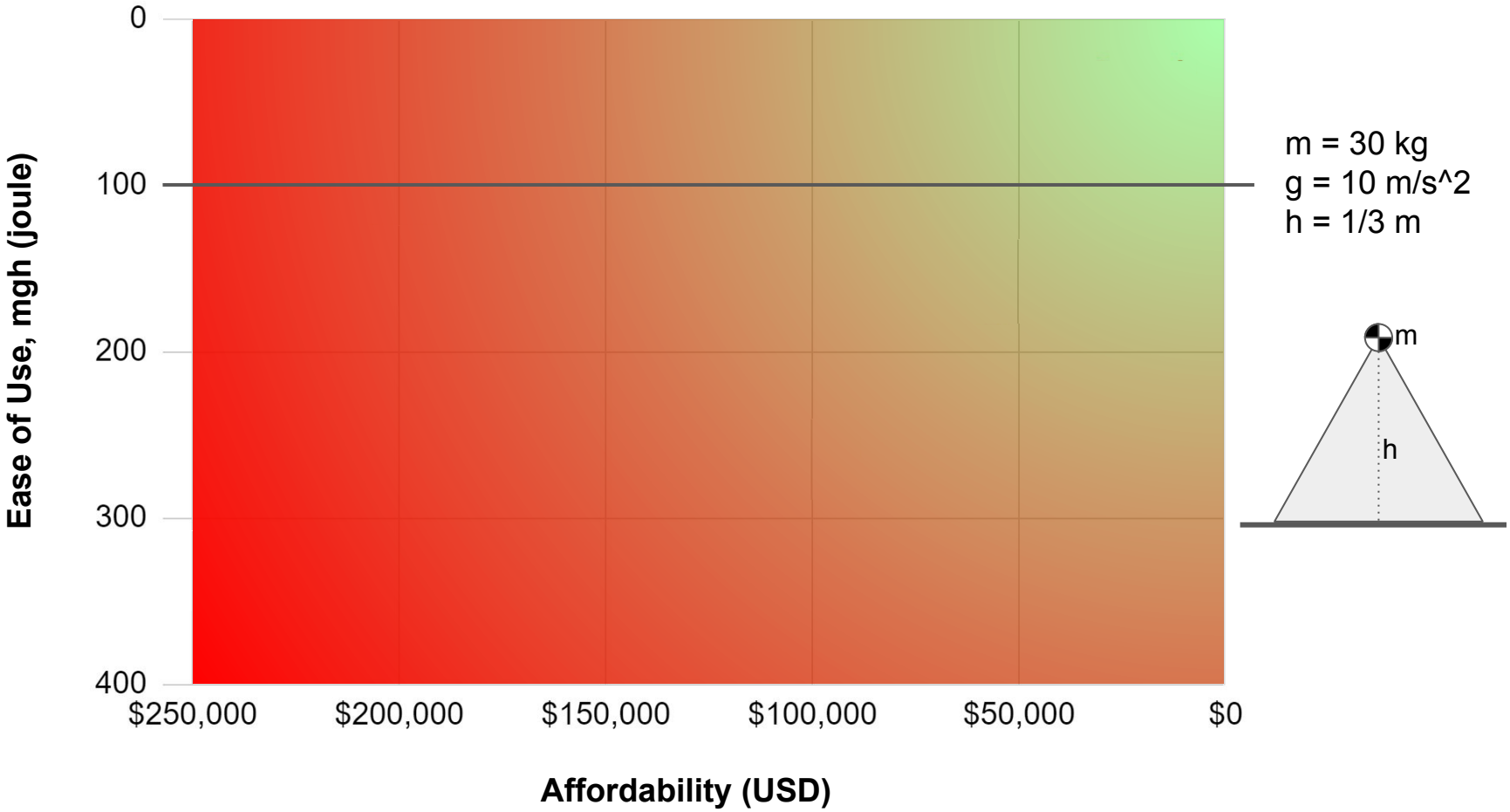
Where

b : maximum slope before tipping
w : minimum base width before tipping

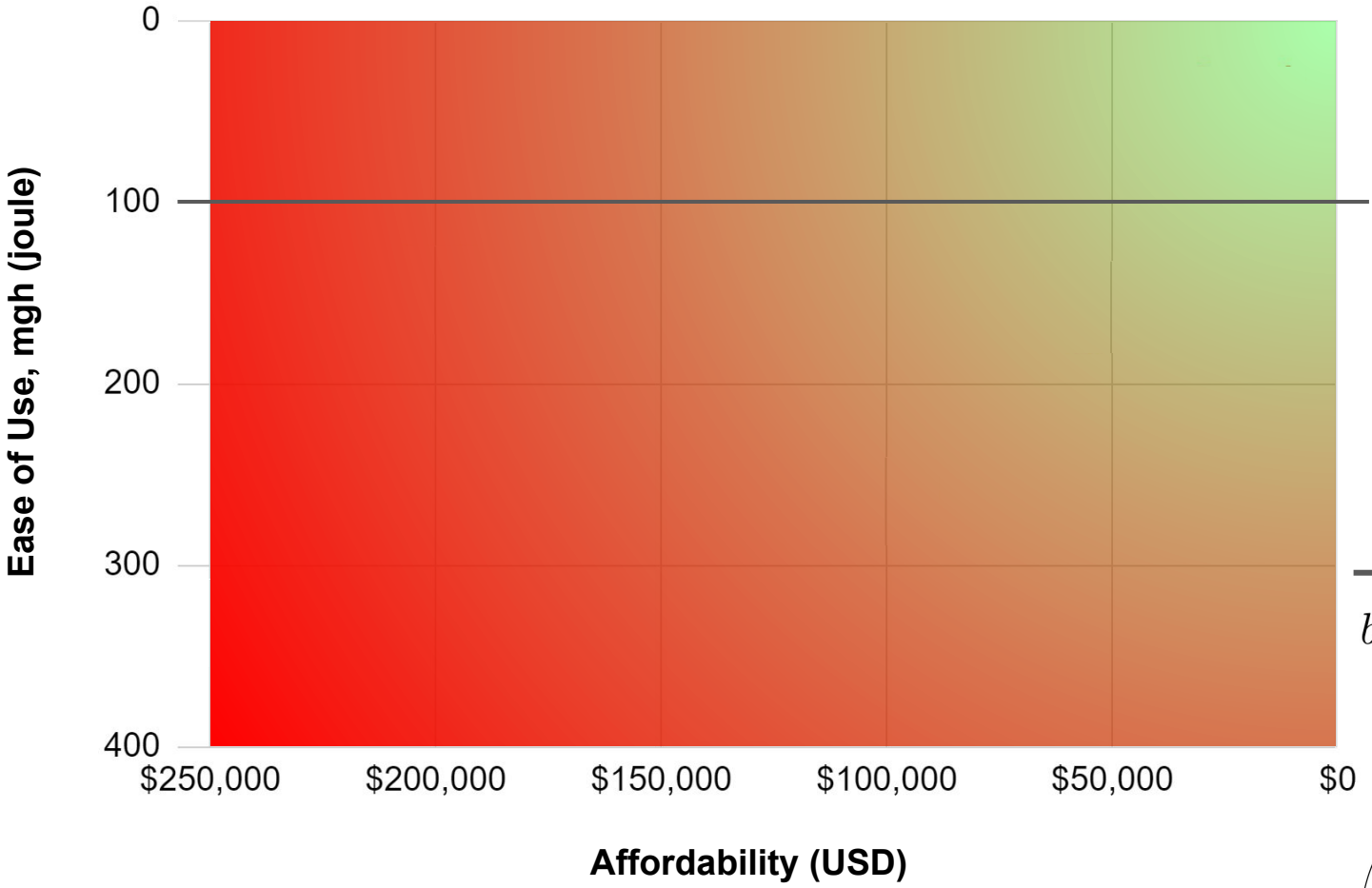
Useful Human-scale Mobile Manipulators



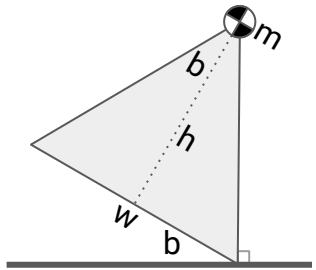
Useful Human-scale Mobile Manipulators



Useful Human-scale Mobile Manipulators

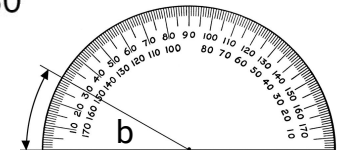


m = 30 kg
g = 10 m/s^2
h = 1/3 m



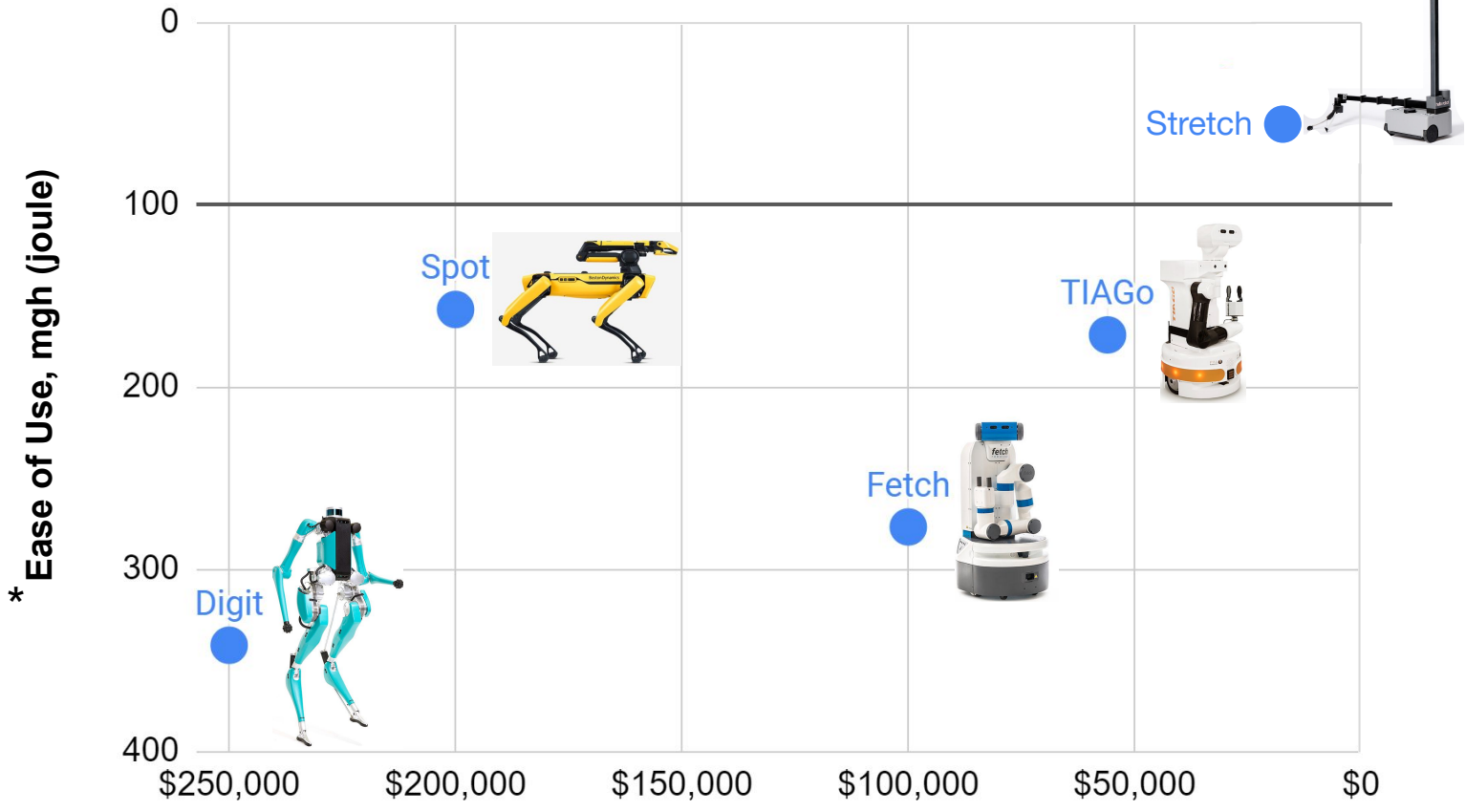
$$b = \arctan\left(\frac{w}{2h}\right)$$

w = 0.4 m
b = 31 deg



https://etc.usf.edu/clipart/42000/42005/pro_30_42005.htm

Useful Human-scale Mobile Manipulators



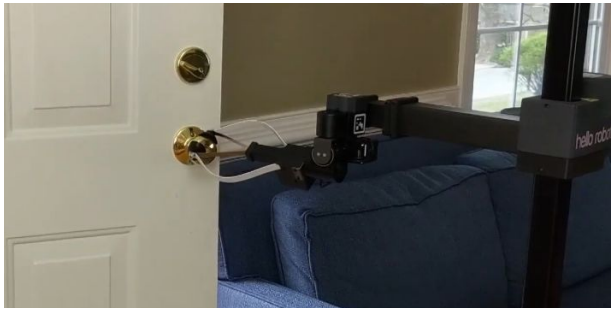
* *I estimated mgh based on published masses and dimensions with arms and lifts lowered. There could be significant errors.*

images from:
https://hello-robot.com
https://fetchrobotics.com/fetch-mobile-manipulator/
https://robotsguide.com/robots/digit https://pal-robotics.com/robots/tiago/
https://arstechnica.com/gadgets/2021/02/boston-dynamics-robot-dog-gets-an-arm-attachment-self-charging-capabilities/

Is Stretch capable?

Early Teleoperated Examples

performed in 2020, except for door opening in 2021



https://www.youtube.com/c/HelloRobot/videos
https://github.com/hello-robot

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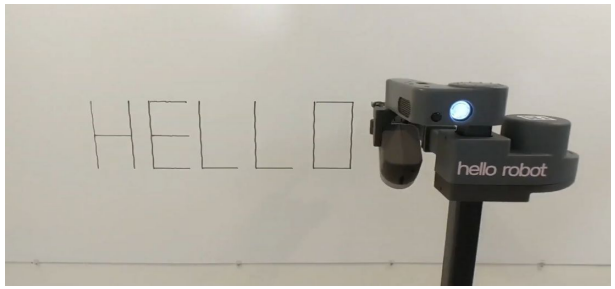
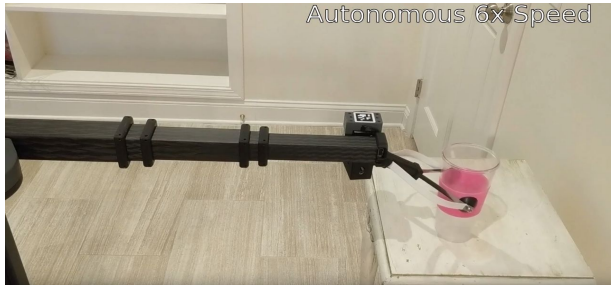
Early Autonomous Examples (2020)

from June & July of 2020





https://forum.hello-robot.com/t/autonomy-video-details

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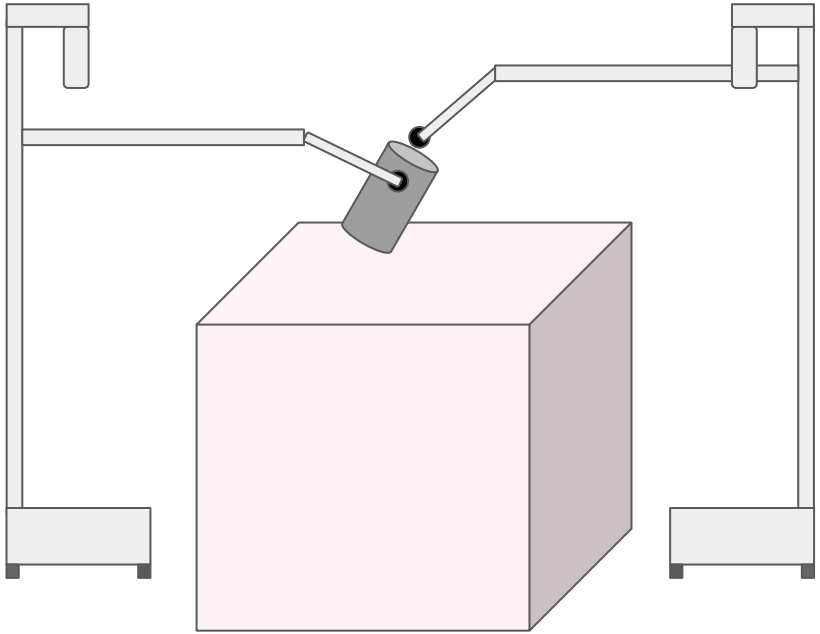
What about bimanual manipulation?

Two Stretch Robots Can Function as One

- Simplifies adoption
  - Start with one robot, which is very capable!
  - Monolithic two-armed robots are inherently bigger and more complex
- Simplifies deployment
  - Easier to move two small compact robots
- Increases versatility
  - Variable distance between the arms
  - Objects in between the arms




Teleoperated
4x Speedup

Mass adoption of new technologies determines the future

Technology Revolutions Build on One Another and Mass Adoption was Transformative

Home computers

The Internet

The World Wide Web

Smartphones

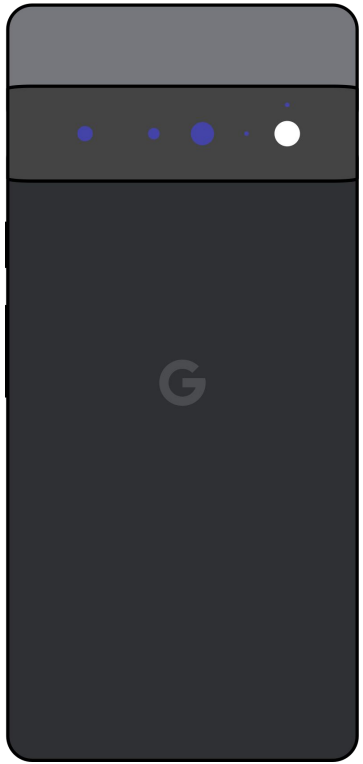
Generative AI

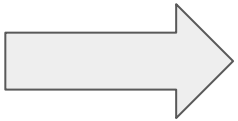
Home robots

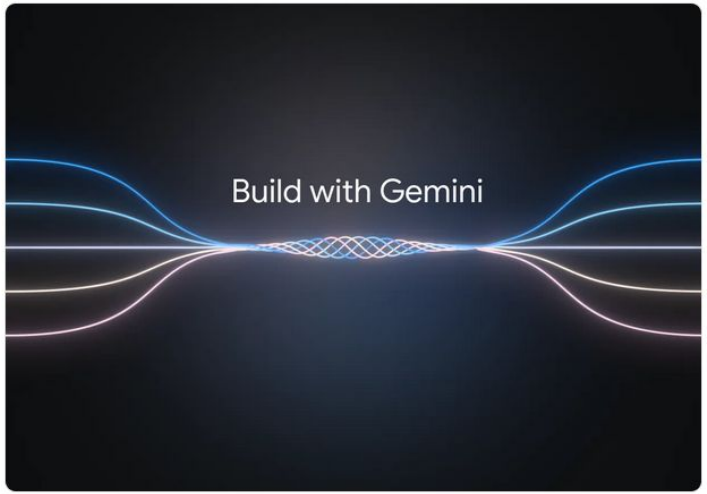
Apple IIe image from https://en.wikipedia.org/wiki/Apple_IIe#/media/File:Apple_IIe.jpg

Mass Adoption of Smartphones Enabled Generative AI

Captures the Language, Imagery and Sound of Human Experience







Pixel 6 Pro diagram from https://en.wikipedia.org/wiki/Pixel_6#/media/File:Google_Pixel_6_Pro_back_(Stormy_Black).svg
Gemini screenshot from https://ai.google/discover/generativeai/

Mass Adoption of Home Robots Will Enable Embodied AI

Captures Physical Human Experience

Large Robot Foundation Model

Embodied AI Will Enable Mass Adoption of Home Robots

Emulating Physical Human Experience

Large Robot Foundation Model

Image from https://gamerant.com/spider-man-pointing-meme-origins/

Embodied AI Will Enable Mass Adoption of Home Robots

Emulating Physical Human Experience

Small Robot Foundation Model

A Chicken-or-Egg Problem

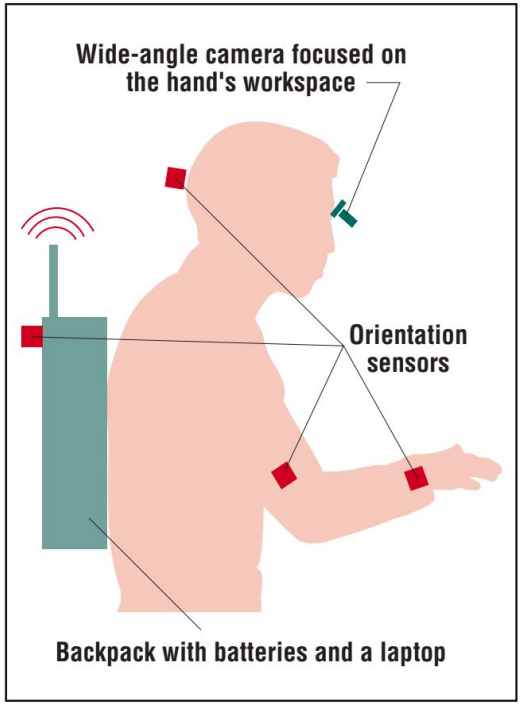
- It’s not all-or-nothing & iteration is powerful
- Home robots benefit from
  - Models trained on existing Internet-scale data
  - Small robot foundation models
- Embodied AI benefits from robots that are
  - In real homes
  - Performing real tasks
  - Working with real people
- The properties that promote mass adoption help near-term embodied AI

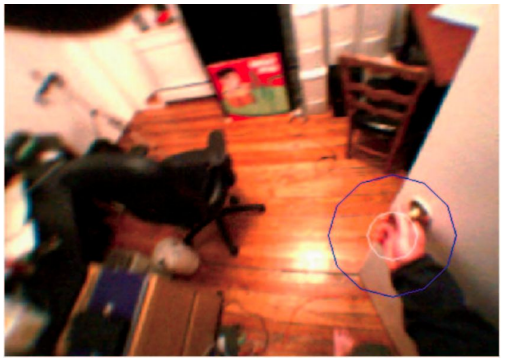
Photo from https://en.wikipedia.org/wiki/Chicken#/media/File:Eier_verschiedener_H%C3%BChnerrassen.jpg

Are real robots required for embodied AI?

I've tried to find shortcuts

data from two real homes





Wearables and robots: A shared view. Charles C. Kemp, *IEEE Pervasive Computing* 5, no. 3 (2006): 16-20.

Capturing Everyday Human Manipulation. Charles C. Kemp, Poster at the Workshop on Humanoid Manipulation, Robotics: Science & Systems. Cambridge, Massachusetts. June, 2005.

A wearable system that learns a kinematic model and finds structure in everyday manipulation by using absolute orientation sensors and a camera. Charles C. Kemp, PhD thesis, Massachusetts Institute of Technology (2005).

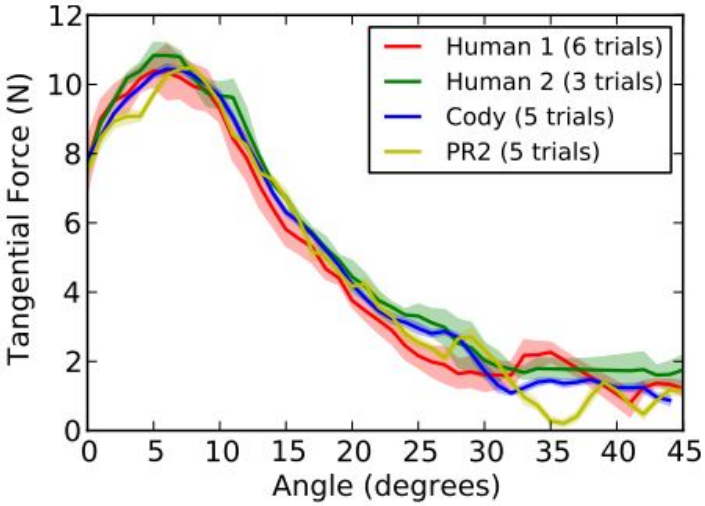
I've tried to find shortcuts

data from six real homes

(a) Human

(b) Cody

(c) PR2

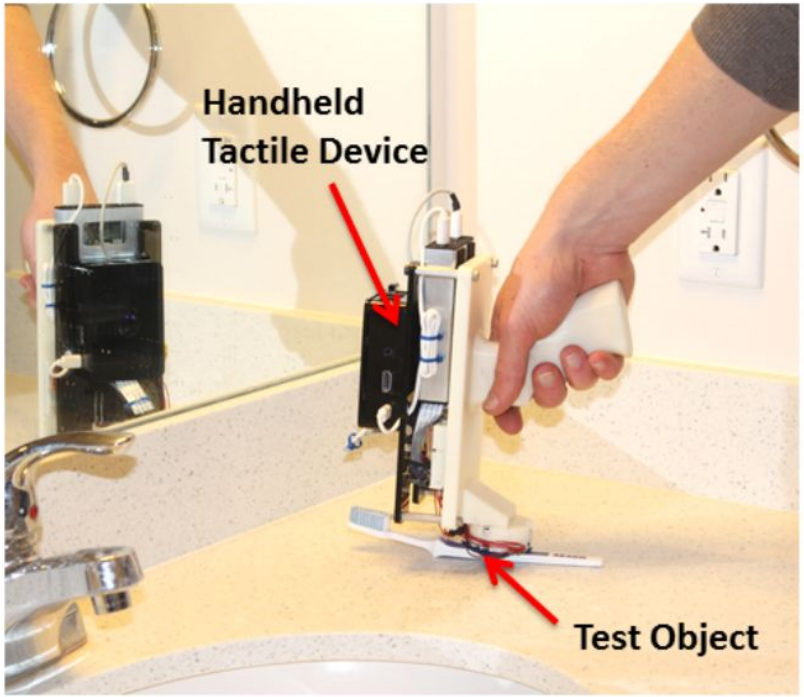


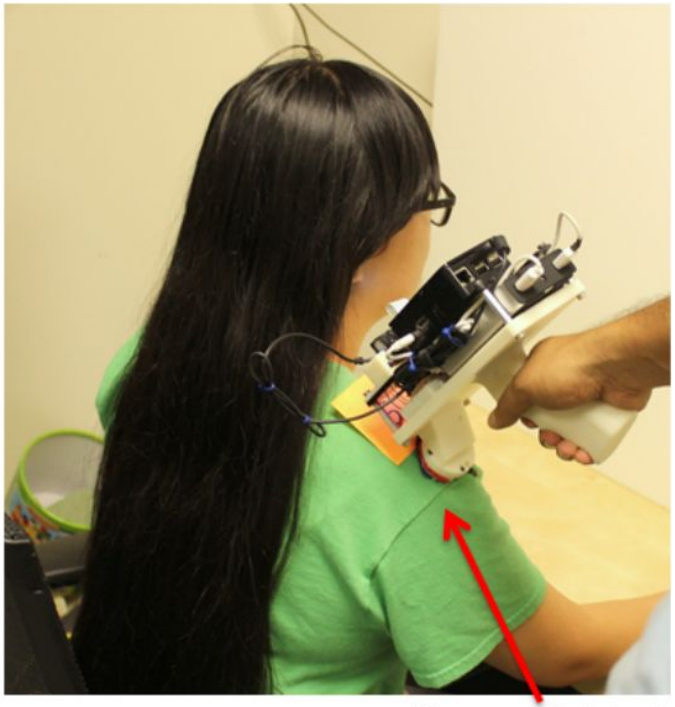
(d) Measured tangential force

Improving Robot Manipulation with Data-Driven Object-Centric Models of Everyday Forces, Advait Jain and Charles C. Kemp, Autonomous Robots, 2013.
The Complex Structure of Simple Devices: A Survey of Trajectories and Forces that Open Doors and Drawers, Advait Jain, Hai Nguyen, Mrinal Rath, Jason Okerman, and Charles C. Kemp, IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BIOROB), 2010.

I've tried to find shortcuts

data from ten real homes





Data-Driven Thermal Recognition of Contact with People and Objects, Tapomayukh Bhattacharjee, Joshua Wade, Yash Chitalia, and Charles C. Kemp, IEEE Haptics Symposium, 2016

A Handheld Device for the In Situ Acquisition of Multimodal Tactile Sensing Data, Joshua Wade, Tapomayukh Bhattacharjee, and Charles C. Kemp, IROS Workshop on See and Touch: 1st Workshop on multimodal sensor-based robot control for HRI and soft manipulation, 2015

For Home Robots, Anything Other than a Real Robot in a Real Home is an Approximation

- Artificial environments amplify biases
  - Generalizing across real world variation is critical
  - Temptation to improve performance metrics
  - Often neglect inhabitants of homes (people and pets)
- Humans and robots have distinct capabilities
  - Success with a robot may require a nonhuman strategy
  - Complementary capabilities present opportunities
  - For example, robots can be tireless and precise
- Real robots can interact with the real world
  - Active learning via autonomous actions [1]
  - Tightly couple their actions with people & environments
  - **Actually help people**

https://en.wikipedia.org/wiki/Spherical_cow

[1] Autonomously Learning to Visually Detect Where Manipulation Will Succeed, Hai Nguyen and Charles C. Kemp, Autonomous Robots, 2013

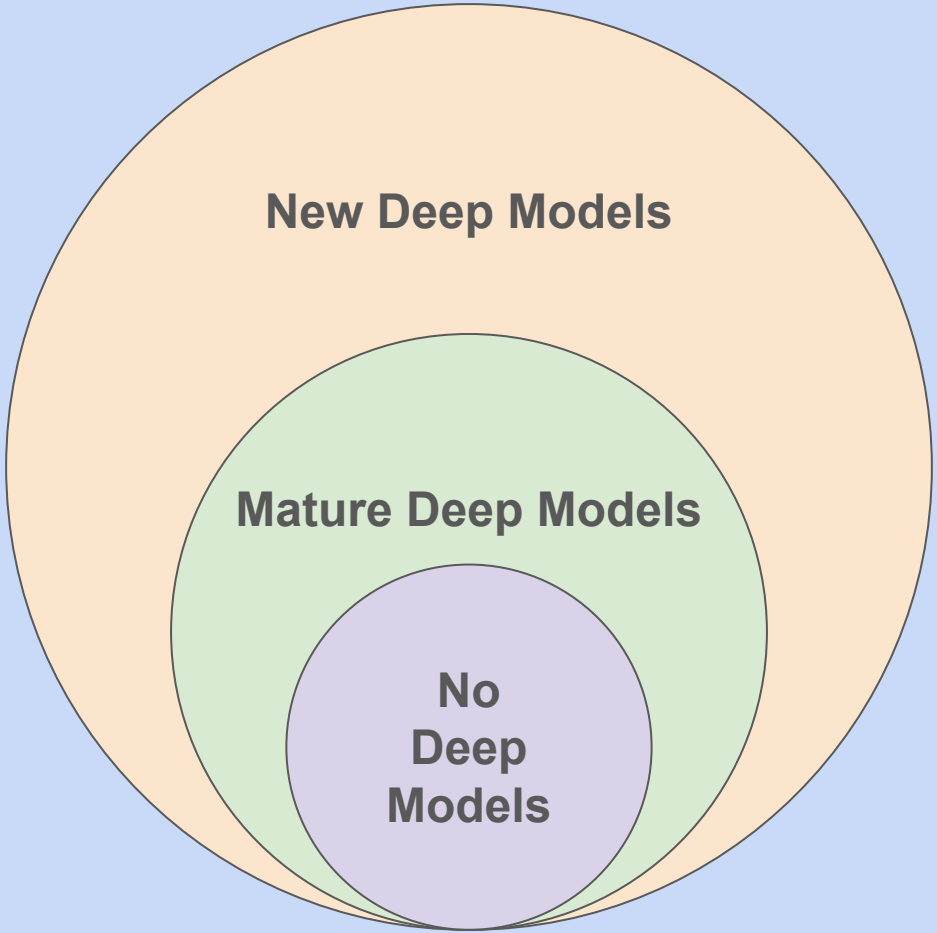
Open Communities Accelerate Progress

Examples from the Open Community Using Stretch

https://hello-robot.com/community

Home Robot Applications

AGI



Questions to Consider for Each Example

- How can society benefit?
- What AI is currently used?
- How could a foundation model help?
- What could a foundation model learn?

Dobb-E
from NYU

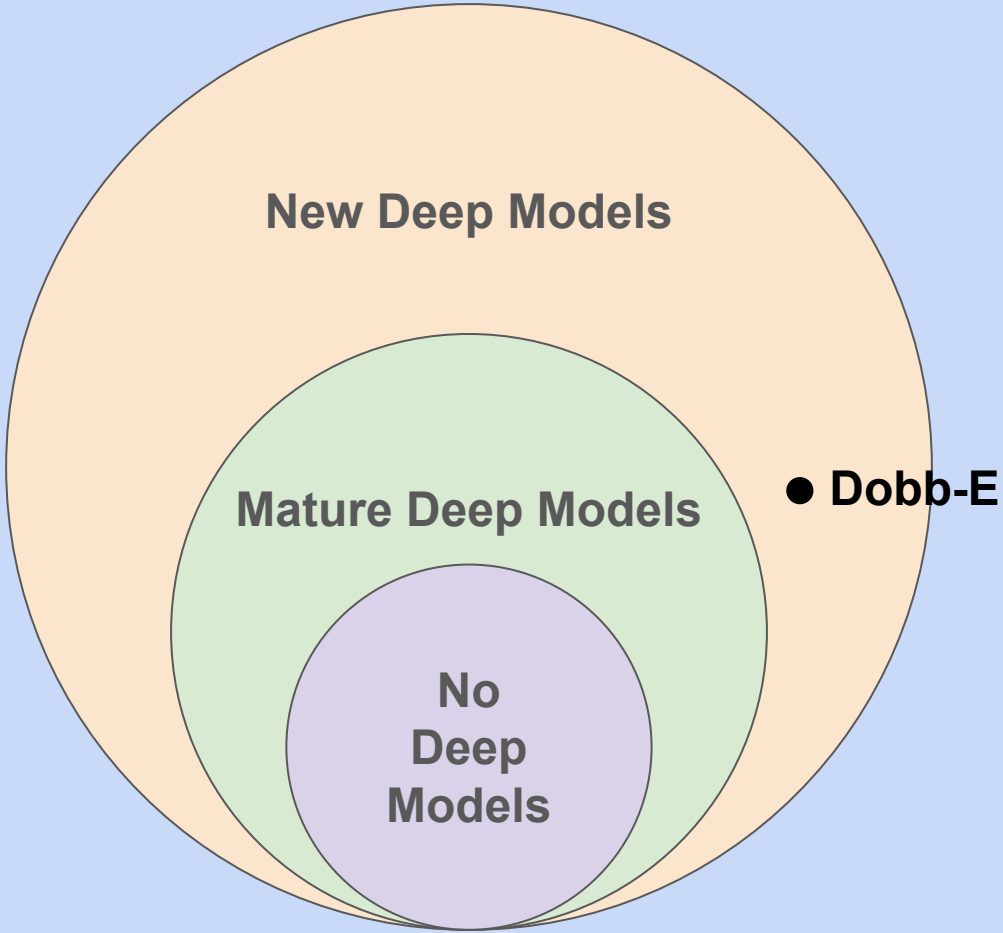
https://dobb-e.com/

Value of Portability

- Tested in real homes
- Analyzed the challenges

Home Robot Applications

AGI



Dobb·E: On Bringing Rob

dobb-e.com

DOBB·E Videos Hardware Dataset Models Paper Code Contact us Start using Dobb·E

Dobb·E

An open-source, general framework for learning household robotic manipulation

109 tasks
10 NYC homes
81% success rate
20 minutes to learn a new task

Nur Muhammad "Mahi" Shafiullah*, Anant Rai*, Haritheja Etukuru, Yiqian Liu, Ishan Misra, Soumith Chintala, Lerrel Pinto

Dobb·E in homes | Read the paper | GitHub repo

https://dobb-e.com/

Dobb·E: On Bringing Rob

dobb-e.com

DOBB·E Videos Hardware Dataset Models Paper Code Contact us Start using Dobb·E

Hardware

The Stick

https://dobb-e.com/

Dobb·E, in a nutshell:

Collect 24 demos
5 minutes

Demo

Fine-tune model
15 minutes

Robot action

Deploy!

https://dobb-e.com/

Questions to Consider for Each Example

- How can society benefit?
- What AI is currently used?
- How could a foundation model help?
- What could a foundation model learn?

Dobb-E

- How can society benefit?
  - Automate tasks that people would prefer not to do themselves
- What AI is currently used?
  - It performs behavior cloning based on human demonstrations
- How could a foundation model help?
  - It fine tunes a foundation model trained on 5620 demonstrations in 22 New York homes with a human-operated approximation to Stretch’s gripper
- What could a foundation model learn?
  - More tasks! Better performance!

Stretch with Stretch from Emory, Georgia Tech and TRI

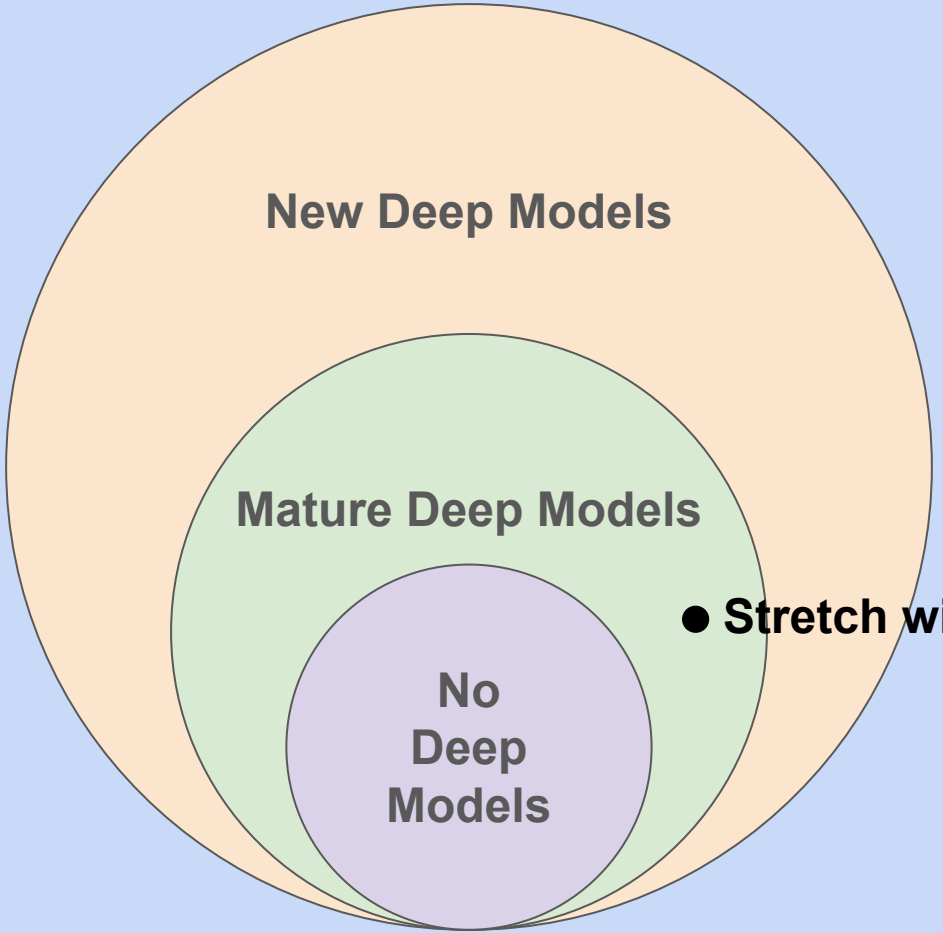
https://healthcare-robotics.github.io/sws/

Value of Ease of Use

- Multidisciplinary team
- Discovered new tasks
- Evaluated with real users

Home Robot Applications

AGI



The Original Project Team

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

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

Discovered New Task by Taking Stretch 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

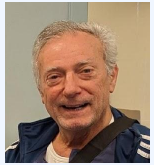
Arielle Wallenstein
Neuroscience and Behavioral Biology
Undergraduate
Emory

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

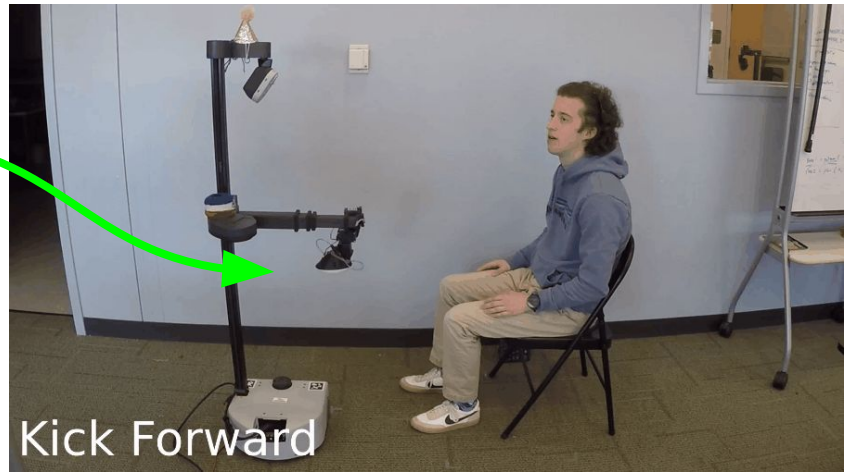
Dr. Naveen Kuppuswamy, PhD
Senior Research Scientist
Toyota Research Institute

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

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



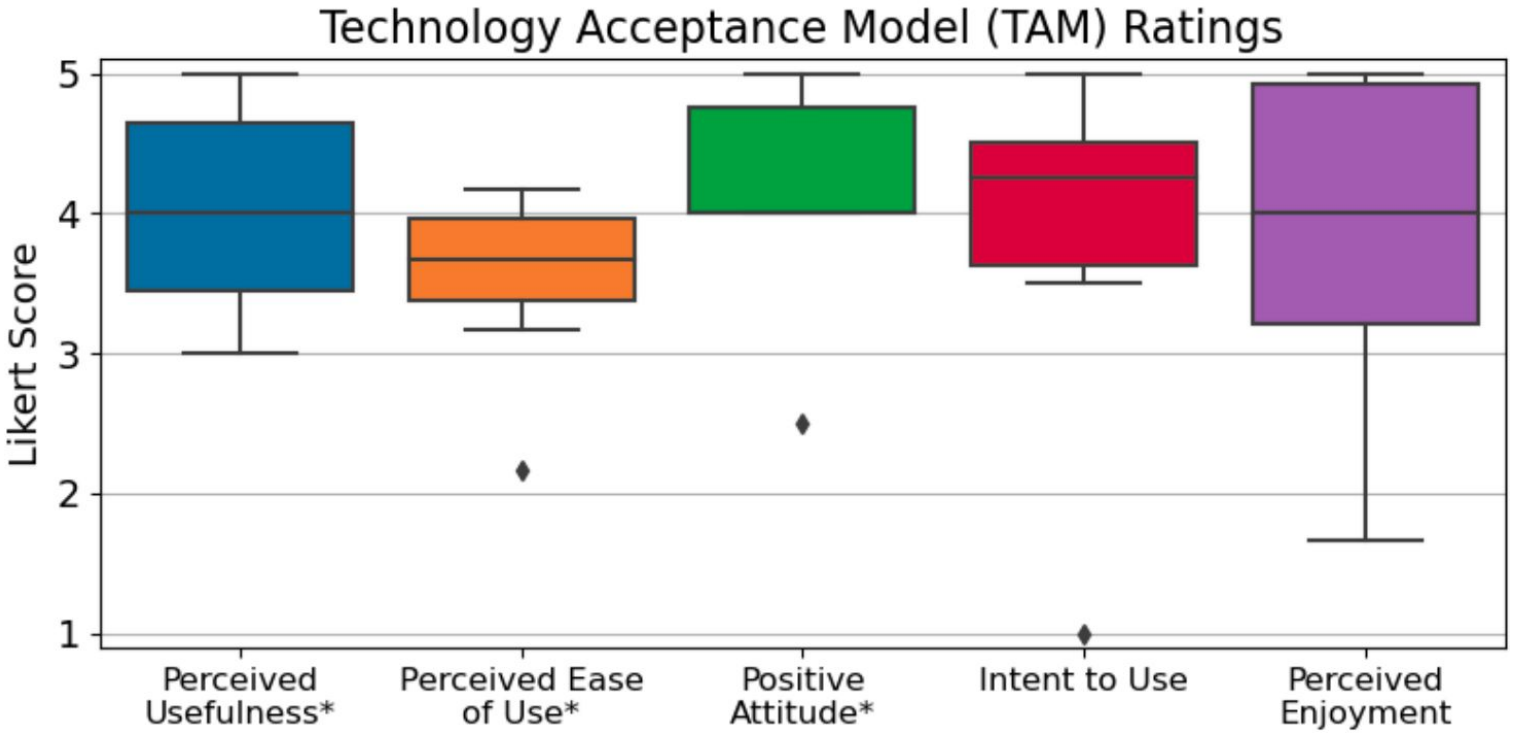
- Reduce caregiver burden in clinics and homes
- Increase frequency and quality of exercise [1]
- Quantitatively track progress and adherence
- Collect clinically-relevant functional measurements

[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



Stretch with Stretch: Physical Therapy Exercise Games Led by a Mobile Manipulator. Matthew Lamsey, You Liang Tan, Meredith D. Wells, Madeline Beatty, Zexuan Liu, Arjun Majumdar, Kendra Washington, Jerry Feldman, Naveen Kuppuswamy, Elizabeth Nguyen, Arielle Wallenstein, Madeleine E. Hackney, Charles C. Kemp, **accepted to ICRA 2024**. (**website with videos**)

Questions to Consider for Each Example

- How can society benefit?
- What AI is currently used?
- How could a foundation model help?
- What could a foundation model learn?

Stretch with Stretch

- How can society benefit?
  - Improve health of people with Parkinson's disease and reduce the workload of physical therapists
- What AI is currently used?
  - A deep model and RGBD camera estimate 3D skeletal models for personalized exercise
- How could a foundation model help?
  - Coaching, increasing engagement, creating new exercises, …
- What could a foundation model learn?
  - How people move and make contact during exercise, common errors people make, methods used by professional physical therapists, …

Robots for Humanity

from Henry & Jane Evans, UIUC, UW, Hello Robot and others!

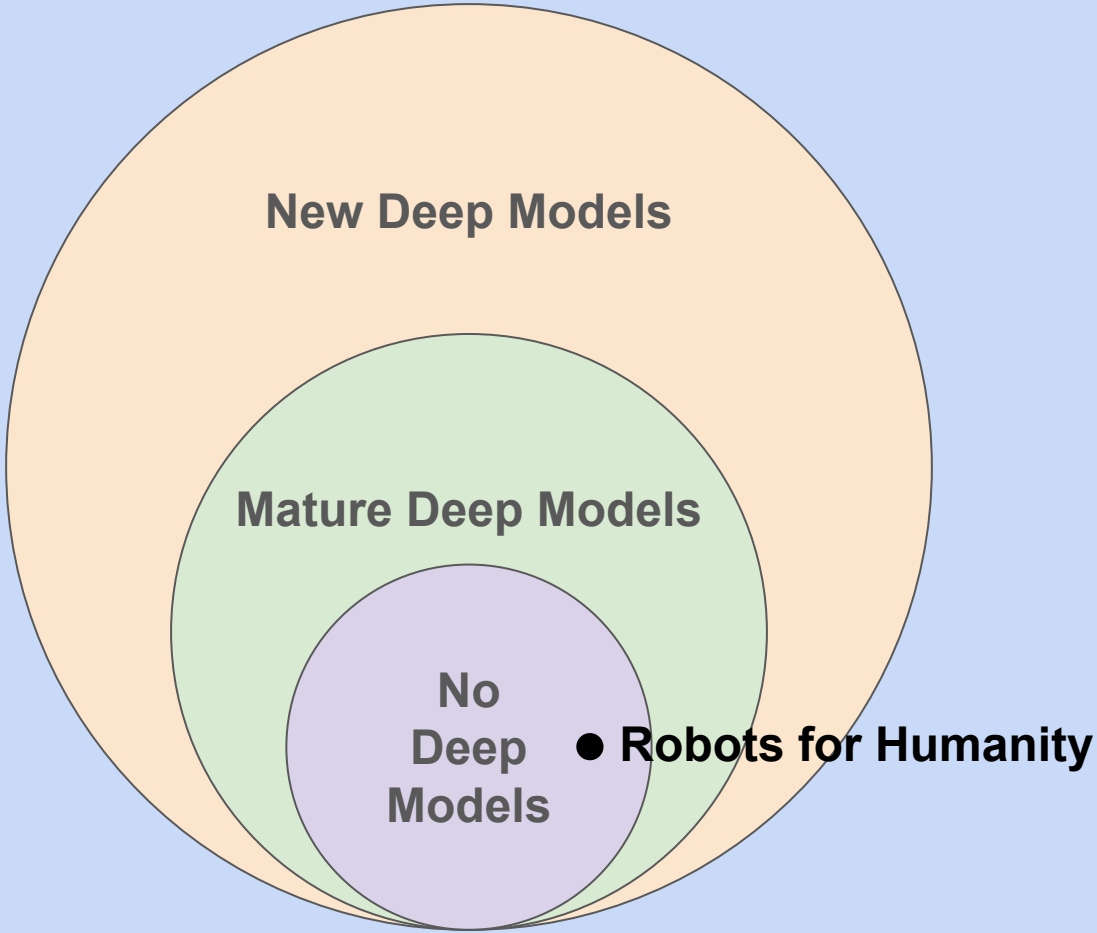
https://spectrum.ieee.org/stretch-assistive-robot

Value of an Open Community

- Large multidisciplinary team
- Discovering new tasks
- Promising for early adoption

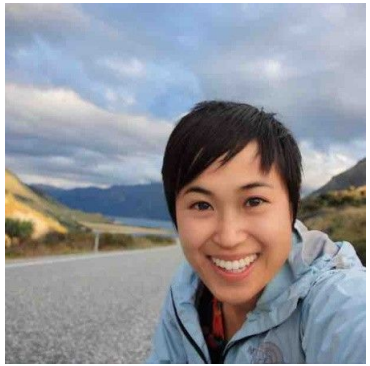
Home Robot Applications

AGI



The Power of a Community with an Open Platform

Henry & Jane Evans
Robots for Humanity leads



Dr. Vy Nguyen
Hello Robot lead

Prof. Wendy Rogers
UIUC lead

Prof. Maya Cakmak
UW lead

Vinitha Ranganeni
Web Teleop lead


Remote Teleop (4x)

Stretch Provides Meaningful Assistance

https://forum.hello-robot.com/t/summer-research-on-in-home-use-by-henry-evans
https://www.washingtonpost.com/photography/2021/11/23/my-day-with-henry/

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https://www.washingtonpost.com/photography/2021/11/23/my-day-with-henry/

Home Robots Can Enhance Life in Unexpected Ways

Photo by Peter Adams

Questions to Consider for Each Example

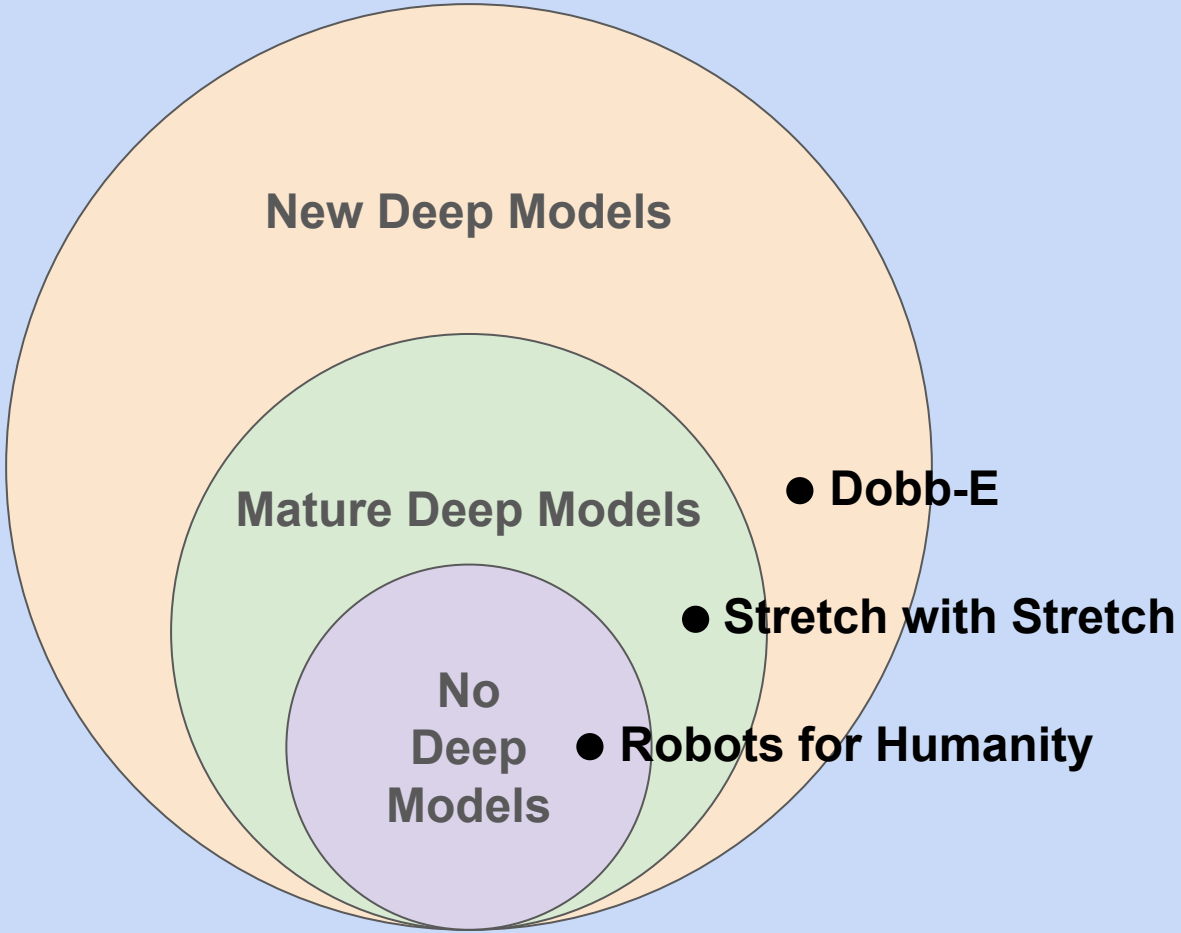
- How can society benefit?
- What AI is currently used?
- How could a foundation model help?
- What could a foundation model learn?

Robots for Humanity

- How can society benefit?
  - Improve the quality of life for people with disabilities, reduce caregiver burden, and empower people with disabilities
- What AI is currently used?
  - Deep learning is not currently used
- How could a foundation model help?
  - Increase ease of use, automate undesirable tasks for people with disabilities and their caregivers, provide peace of mind, …
- What could a foundation model learn?
  - How people care for each other and themselves, activities of daily living, fundamental aspects of being human, …

Home Robot Applications

AGI



- Mass adoption determines the future
- Human factors promote adoption
- Open communities accelerate progress

hello robot®

- Mass adoption determines the future
- Human factors promote adoption
- Open communities accelerate progress

We would love for you to join the Stretch community!

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