Week 03 | Lecture 04
Robots & AI for Social Good

Wan Fang

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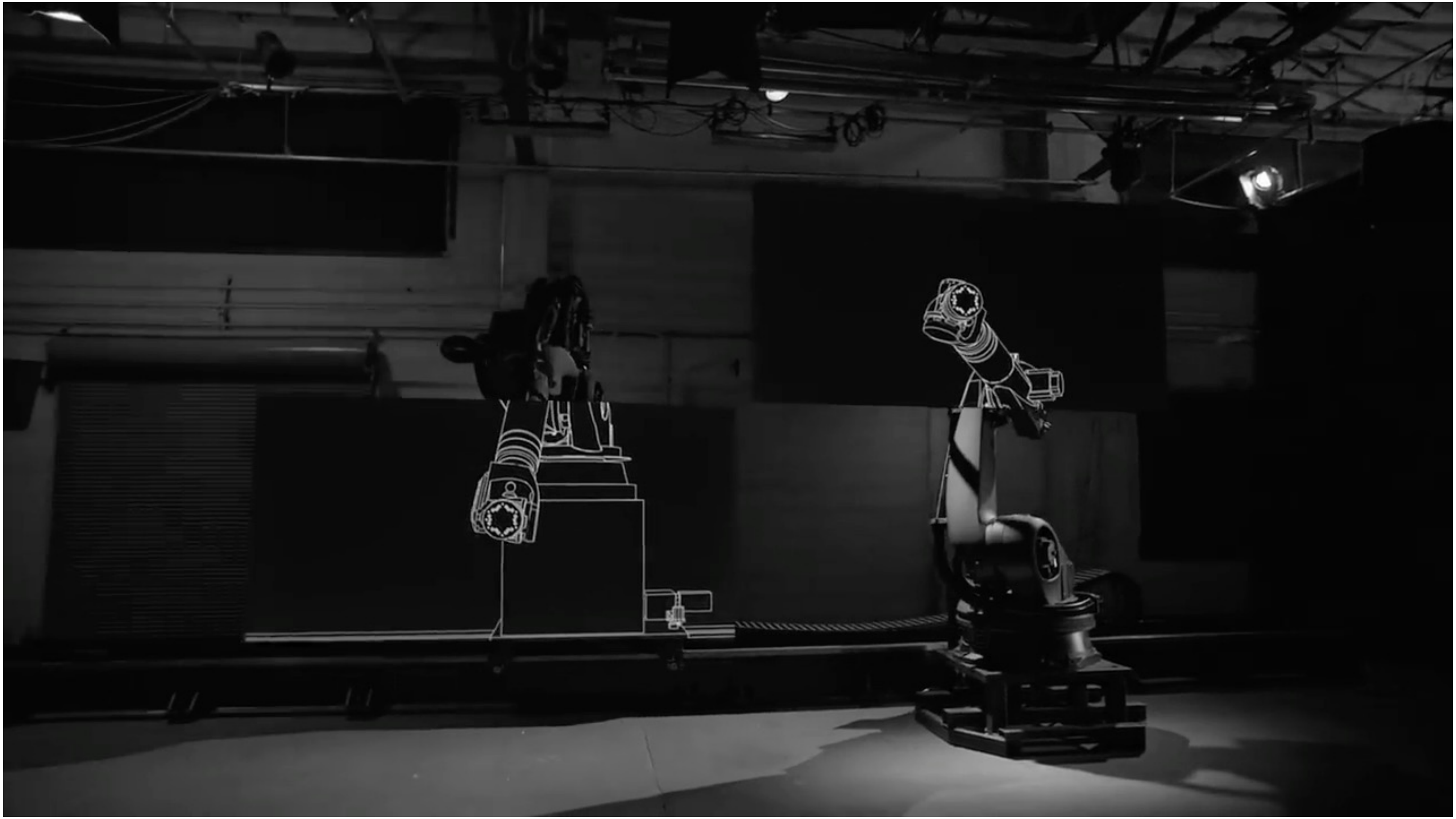
Robots & AI for Social Good

- AI4SG = AI × SDGs
- Robots4SG Exemplified
  - TeachBot for Industry, Innovation and Infrastructure
  - DeepClaw for Quality Education
  - SuperCane for Good Health and Well-being
  - Wasteless for Responsible Consupmtion and Production

- Guest talk by Zhang Rongzheng

Robot of the Day



Box by BotnDolley: https://www.youtube.com/watch?v=lX6JcybgDFo

AI for Social Good

<u>The challenges facing our world today have grown in *complexity* and increasingly require *large, coordinated efforts*</u>: between countries; and across a broad spectrum of governmental and non-governmental organisations (NGOs) and the communities they serve.

Guidelines for AI4SG collaborations

G1	Expectations of what is possible with AI need to be well-grounded.
G2	There is value in simple solutions.
G3	Applications of AI need to be inclusive and accessible, and reviewed at every stage for ethics and human rights compliance.
G4	Goals and use cases should be clear and well-defined.
G5	Deep, long-term partnerships are required to solve large problems successfully.
G6	Planning needs to align incentives, and factor in the limitations of both communities.
G7	Establishing and maintaining trust is key to overcoming organisational barriers.
G8	Options for reducing the development cost of AI solutions should be explored.
G9	Improving data readiness is key.
G10	Data must be processed securely, with utmost respect for human rights and privacy.

nature communications
10.1038/s41467-020-15871-z

AI4SG = AI × SDGs

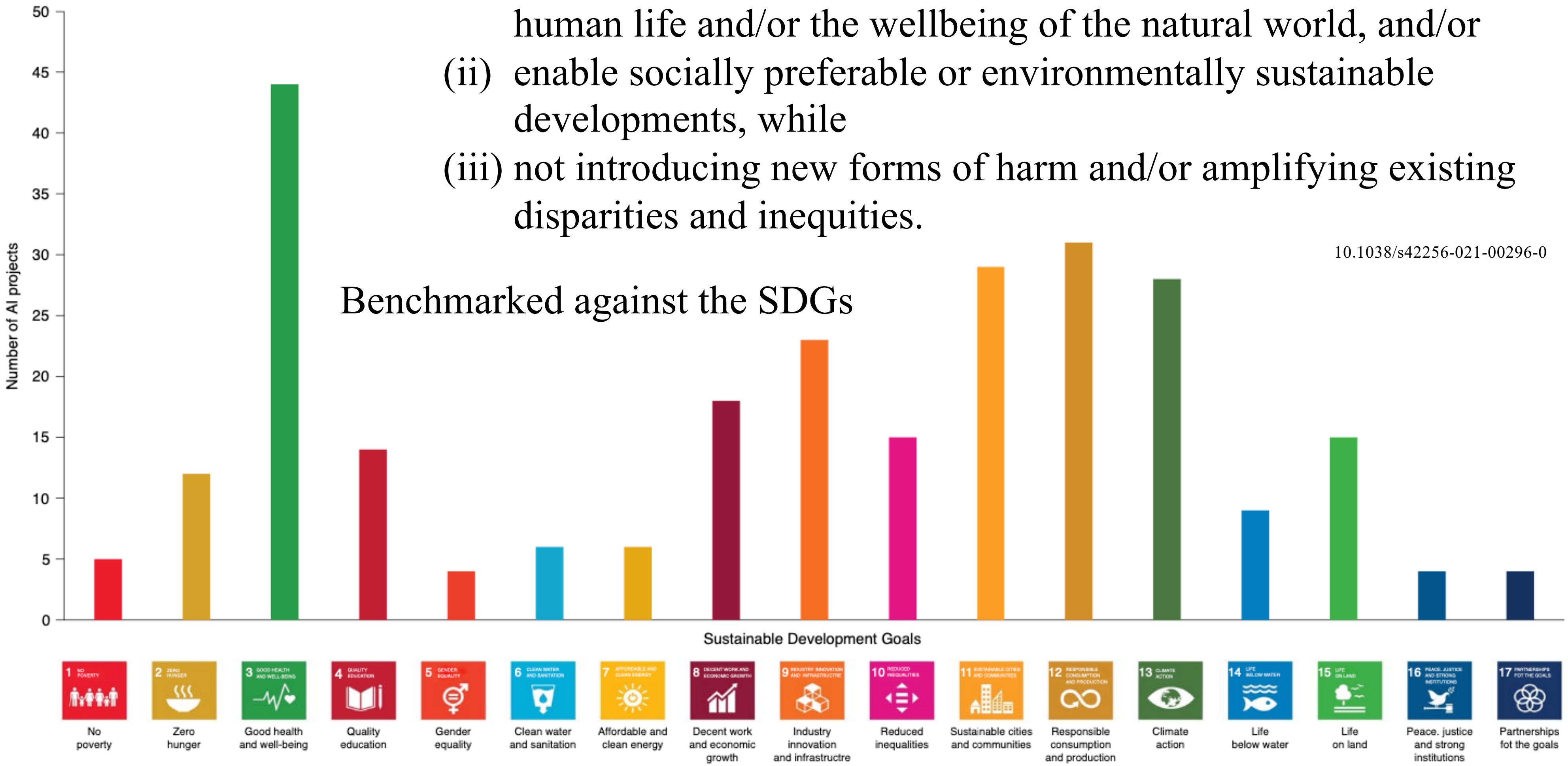
nature machine intelligence

AI4SG is formally defined as the design, development and deployment of AI systems in ways that help to

(i) prevent, mitigate and/or resolve problems adversely affecting human life and/or the wellbeing of the natural world, and/or
(ii) enable socially preferable or environmentally sustainable developments, while
(iii) not introducing new forms of harm and/or amplifying existing disparities and inequities.

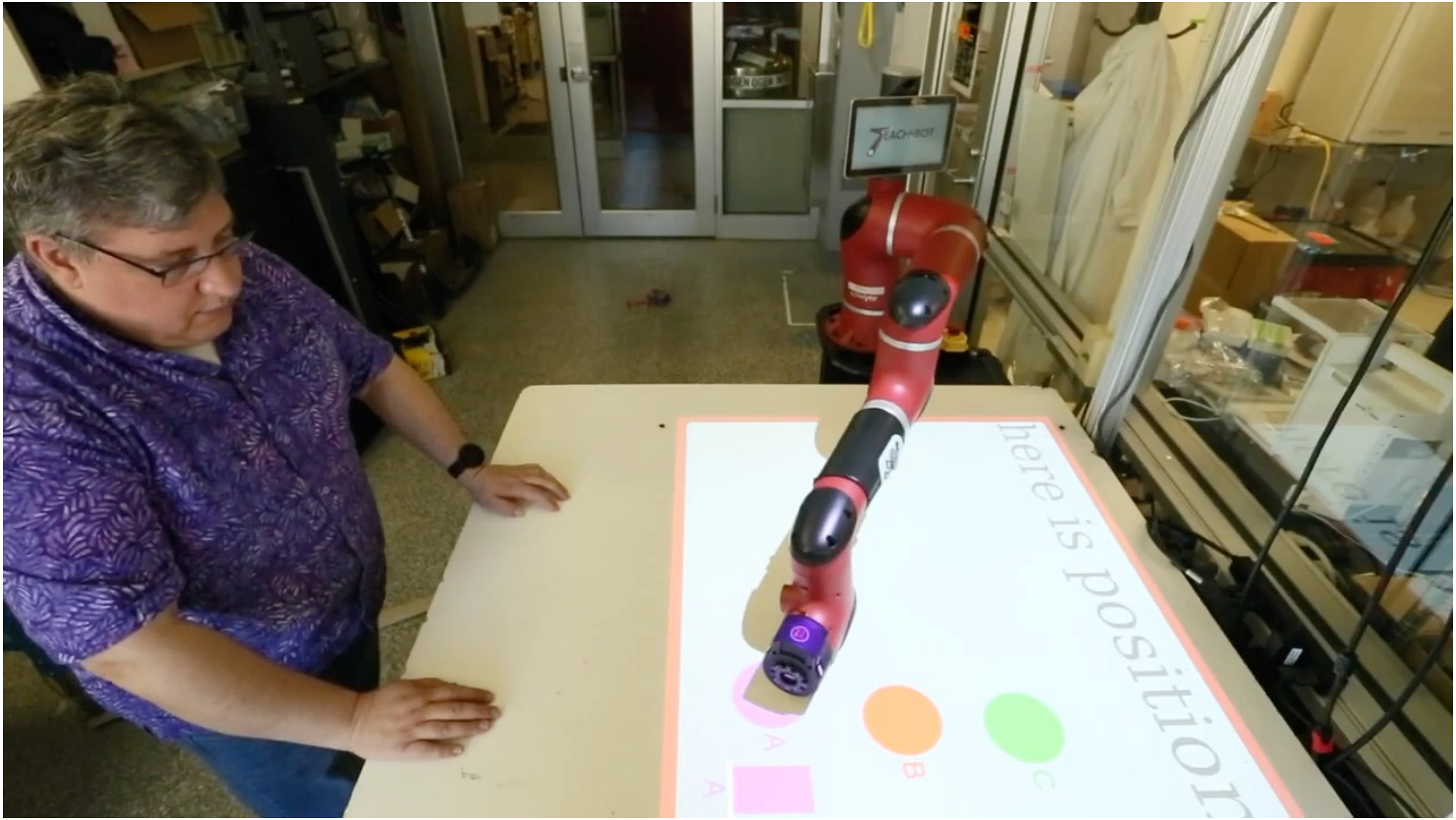
10.1038/s42256-021-00296-0

Benchmarked against the SDGs



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

TeachBot

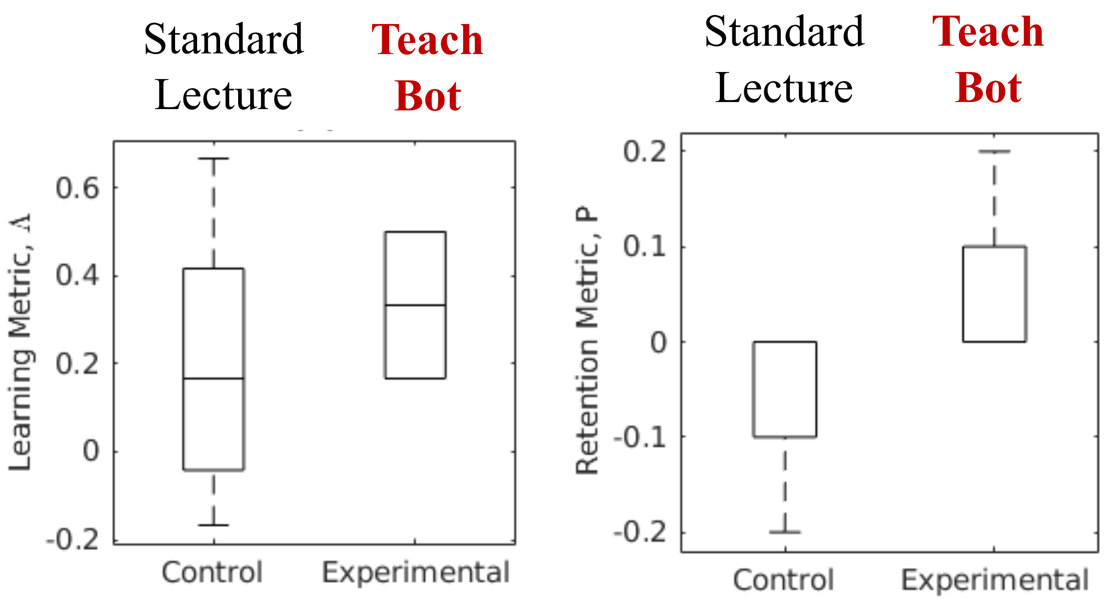


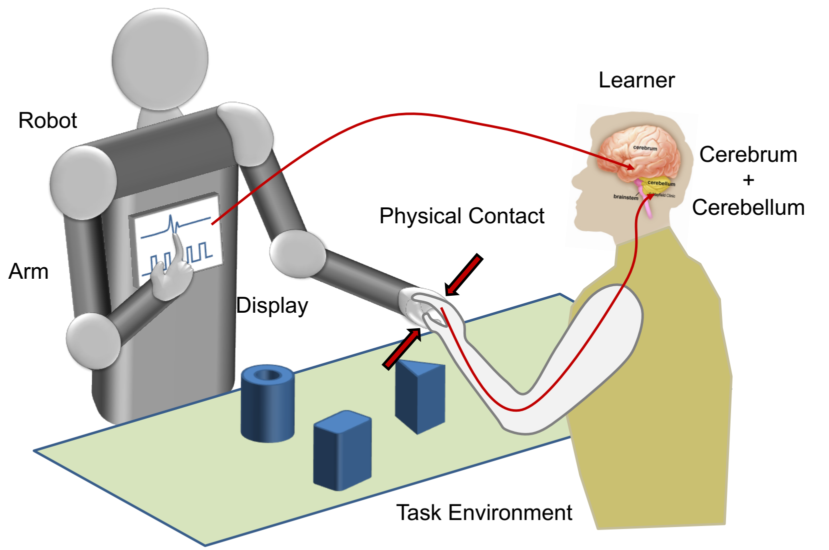
Experimental Results

- A learner can improve learning effectiveness, when a high-level perception through eyes and a low-level stimulus through hand motion take place at the same time.

D. Satterthwait, "Why are 'hands-on' science activities so effective for student learning?", Teaching Science, Volume 56, Number 2, June 2010

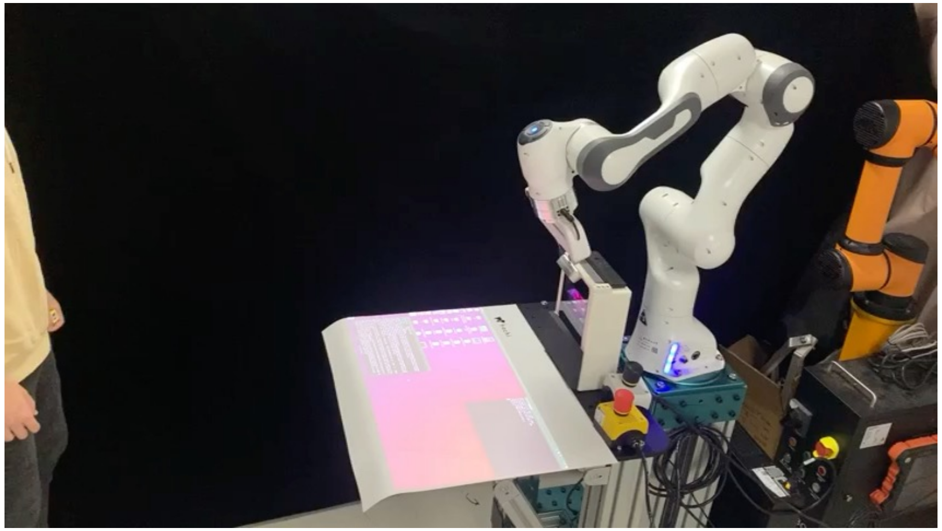
  - The TeachBot group outperformed the regular lecture group on both metrics

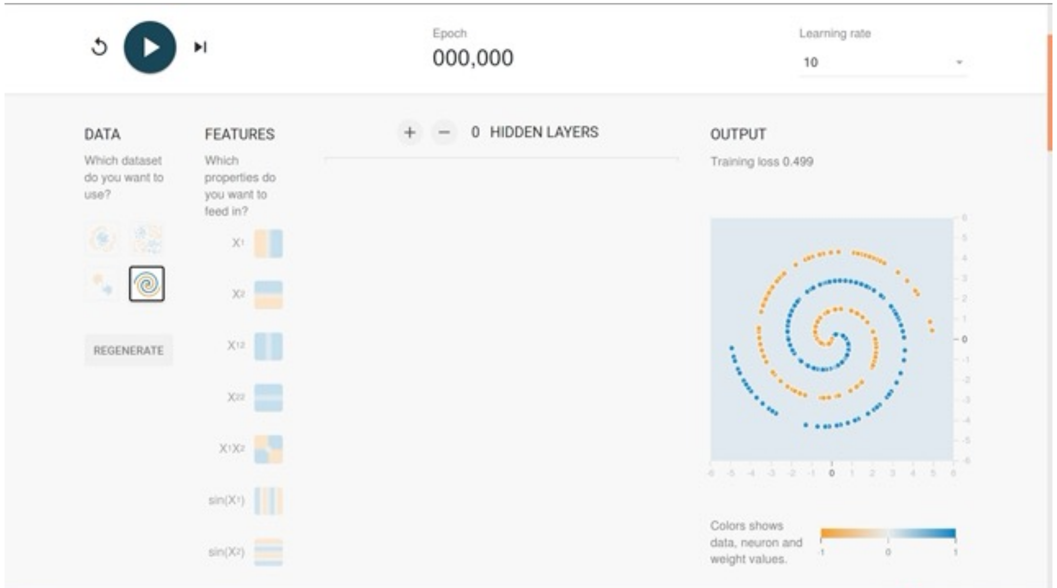


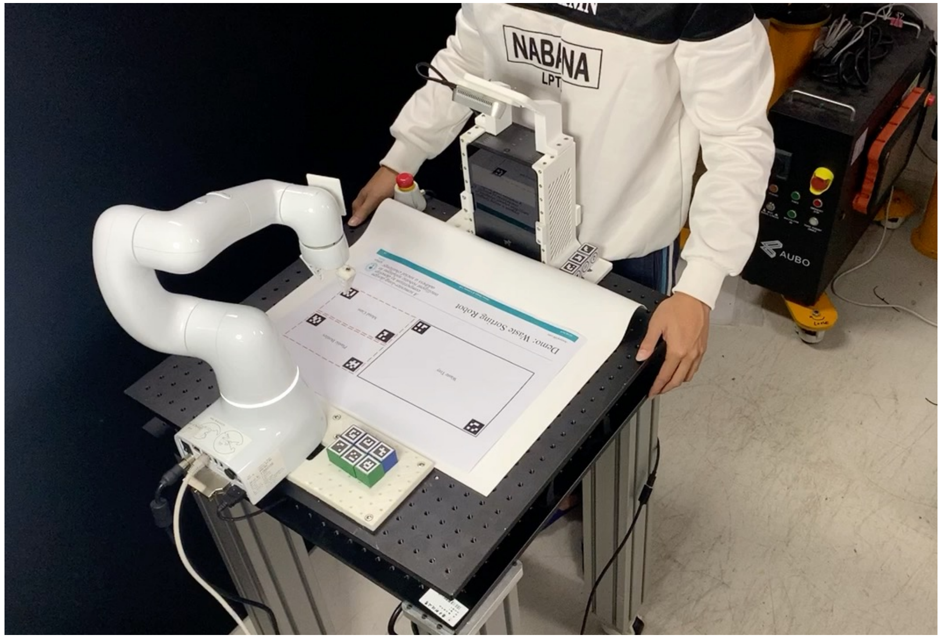


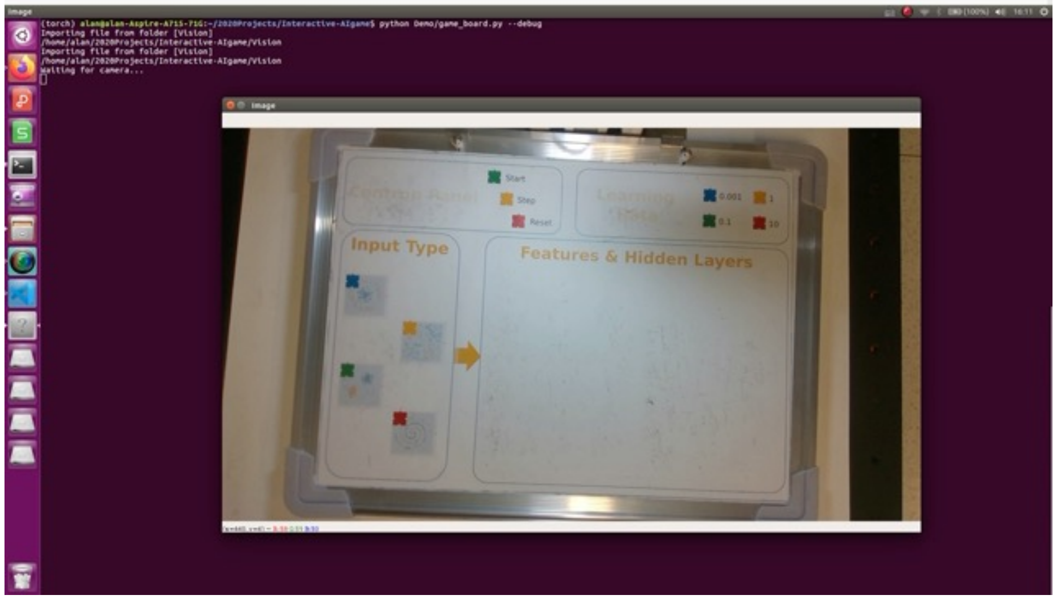
Asked the same questions a week later;
How much did they memorize?

DeepClaw

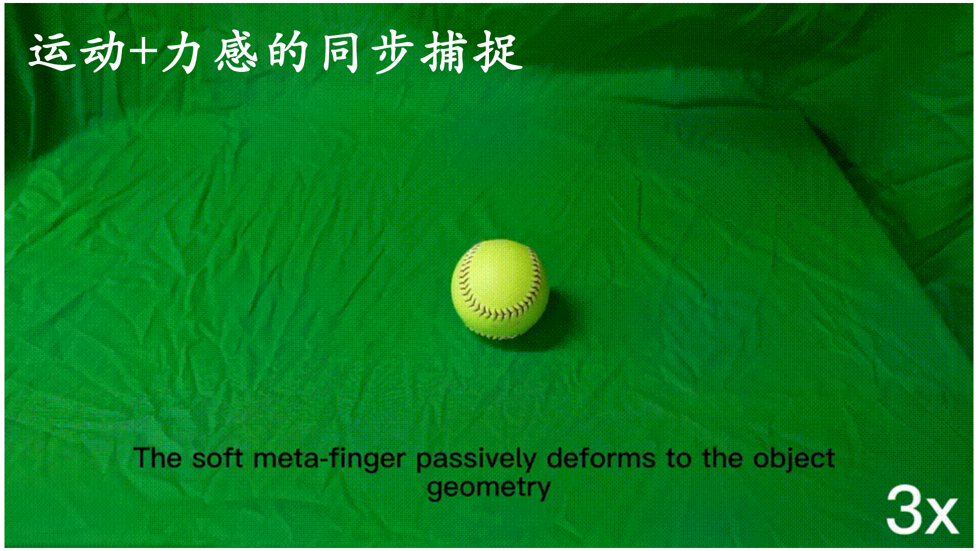



Epoch
000,000
Learning rate
10
DATA
Which dataset do you want to use?
REGENERATE
FEATURES
Which properties do you want to feed in?
0 HIDDEN LAYERS
OUTPUT
Training loss 0.499
Colors shows data, neuron and weight values.

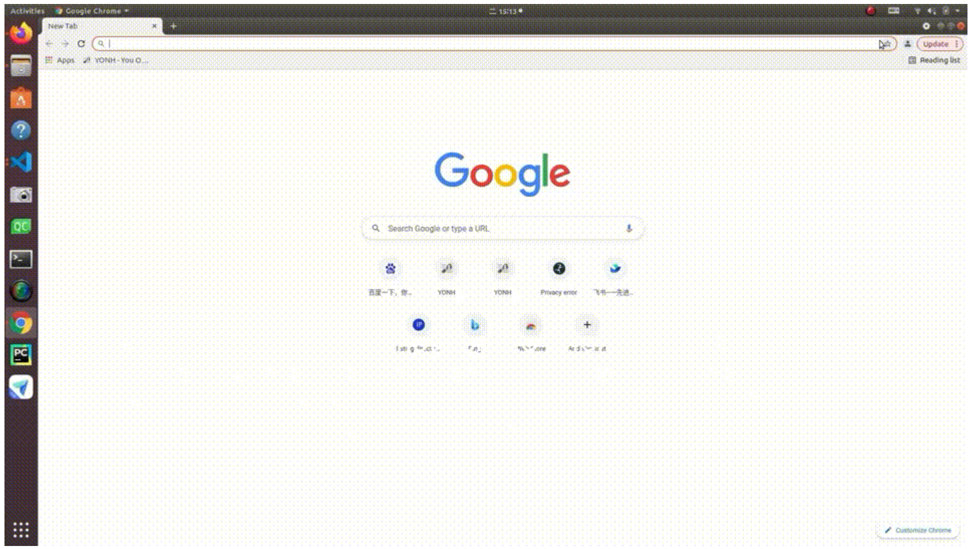

NABANA
AUBO


Input Type
Features & Hidden Layers

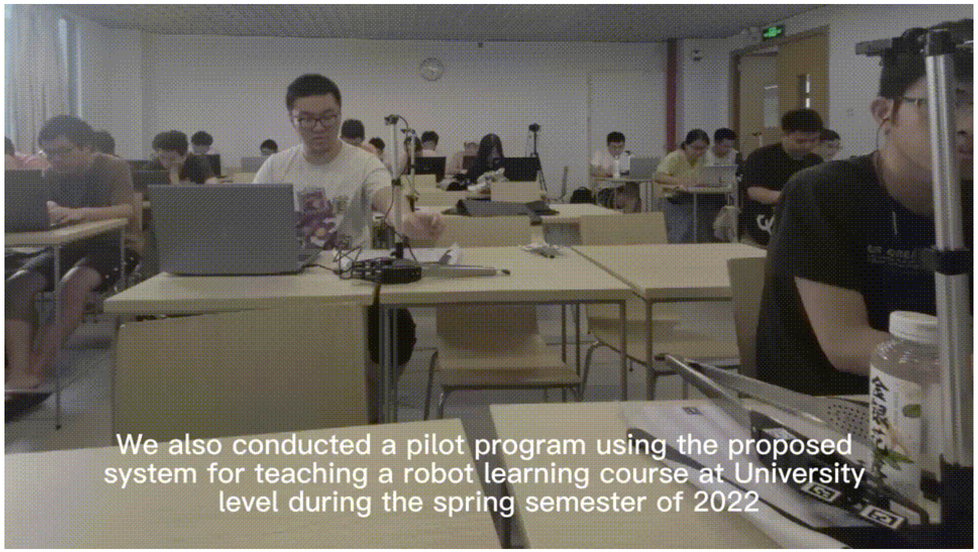
「运动+力感」的低成本同步捕捉与交互



浏览器端人机交互界面



教学创新场景应用



Universal Manipulation Interface

SuperCane

A Soft Robot System of Supernumerary Robotic Limbs for Elderly Sit-to-Stand Assistance at Home

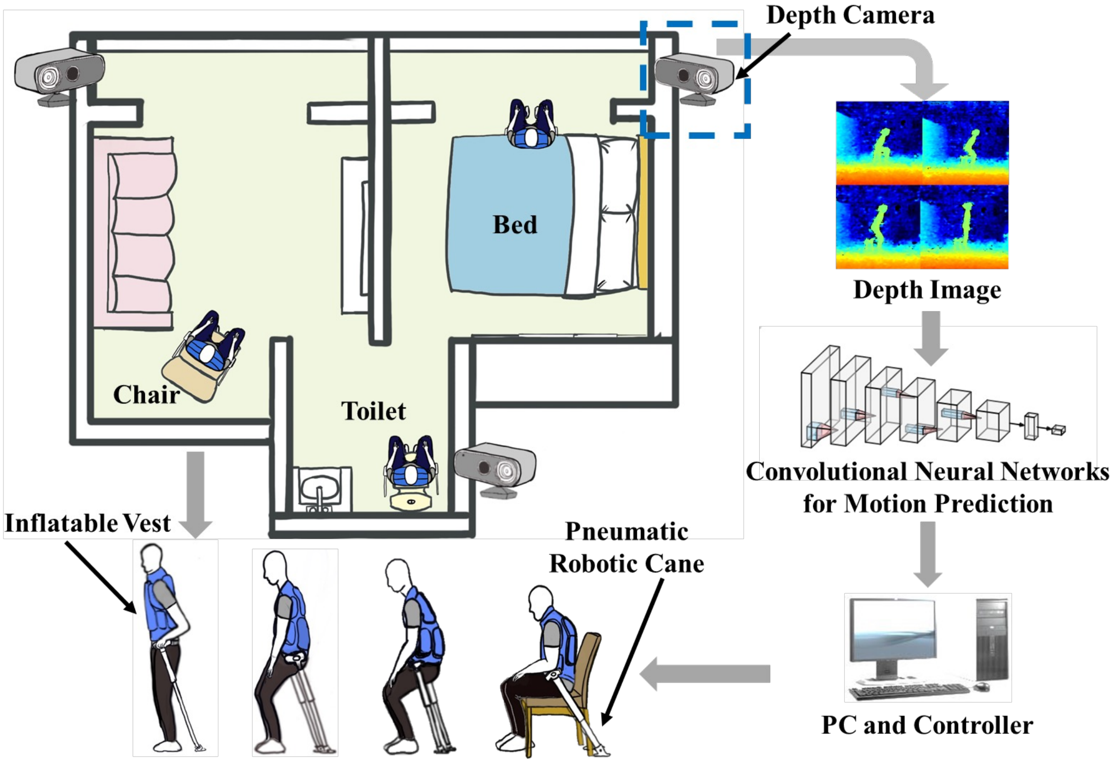
Xia Wu[1], Haiyuan Liu[1], Ziqi Liu[1], Mingdong Chen[1], Fang Wan[2], Chenglong Fu[1], Harry Asada[2], Zheng Wang[1], and Chaoyang Song[1*]

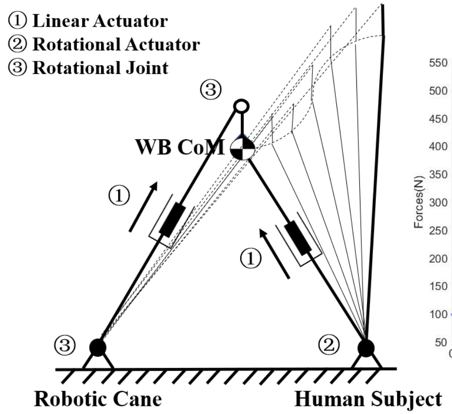
[1]Department of Mechanical and Energy Engineering, Southern University of Science and Technology, China

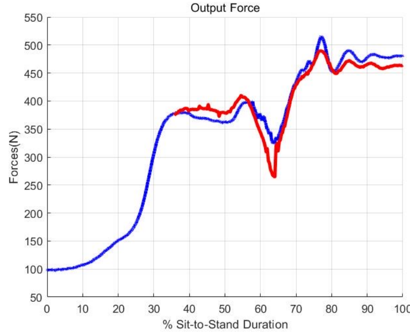
[2]SUSTech Institute of Robotics, Southern University of Science,China

[3]Department of Mechanical Engineering, Massachusetts Institute of Technology, USA

RoboCane: A Soft SuperLimb with Ambient Intelligence for Elderly Sit-to-Stand Assistance





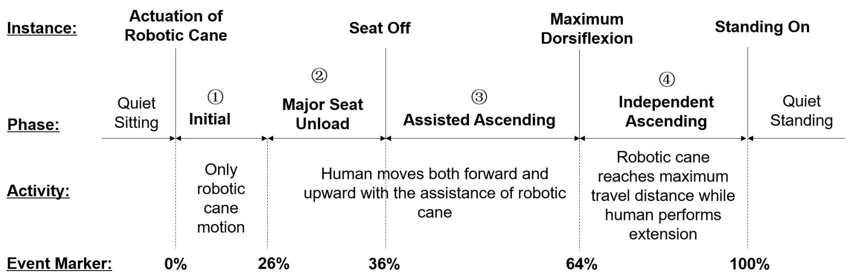


Modified telescopic inverted-pendulum model:

- Less demanding in inputs:
  - Trajectory of CoM, robotic cane input.
- Better accuracy.

Consist of 4 components:

- **Robotic cane** for lower limb support.
- **Inflatable vest** for force redistribution without hard push.
- **Depth camera** for privacy-safe intention detection.
- **Biomechanical Model** for assisted sit-to-stand motion.



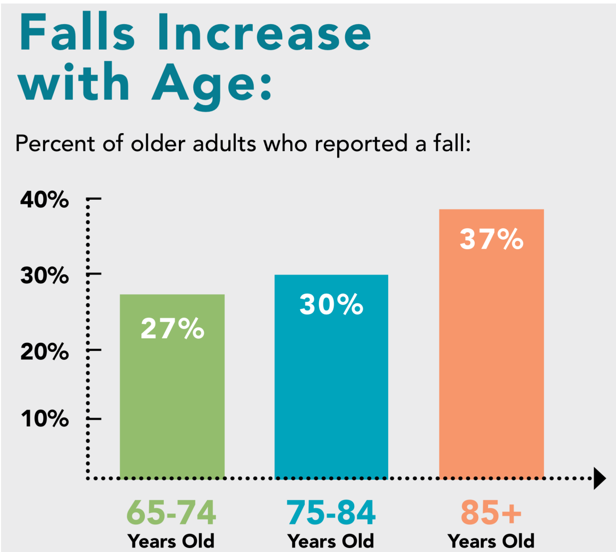
Relevant 4 phases of assisted sit-to-stand motion

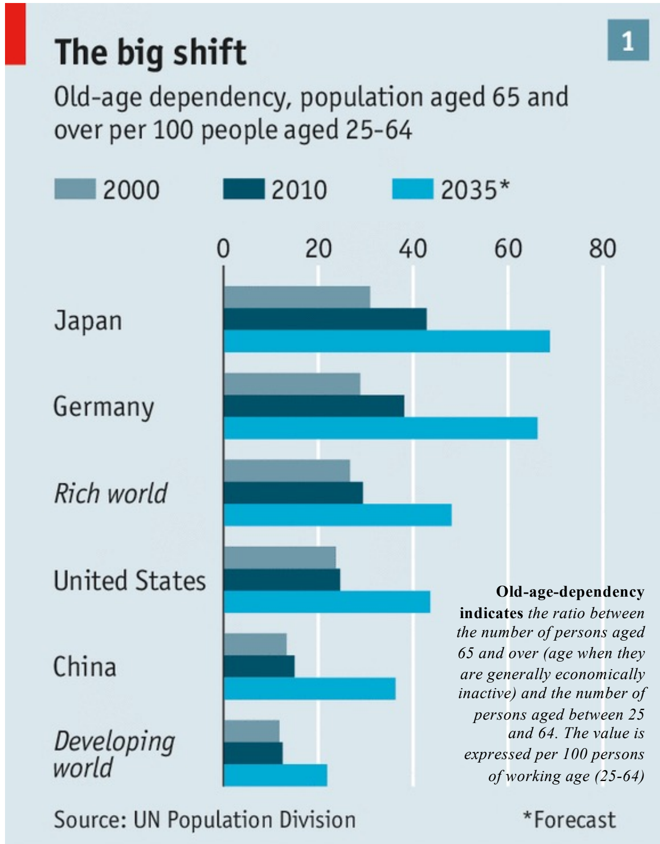
Stand & Fall

A Challenge for Everyone, Especially the Elderly

"Challenge to balance or strength > Ability to stay upright"

Source: USA CDC





1/5 falls causes a serious injury

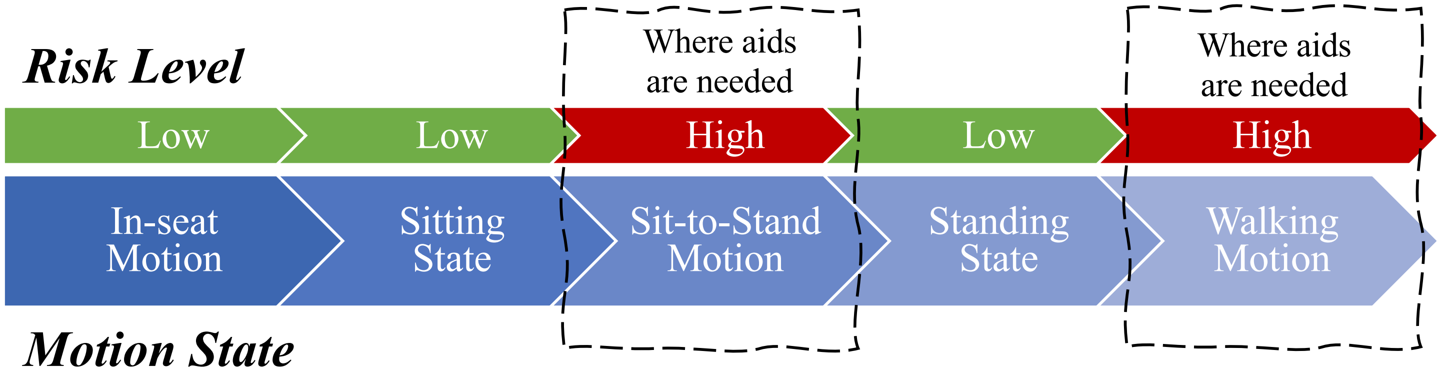
- a broken bone or head injury

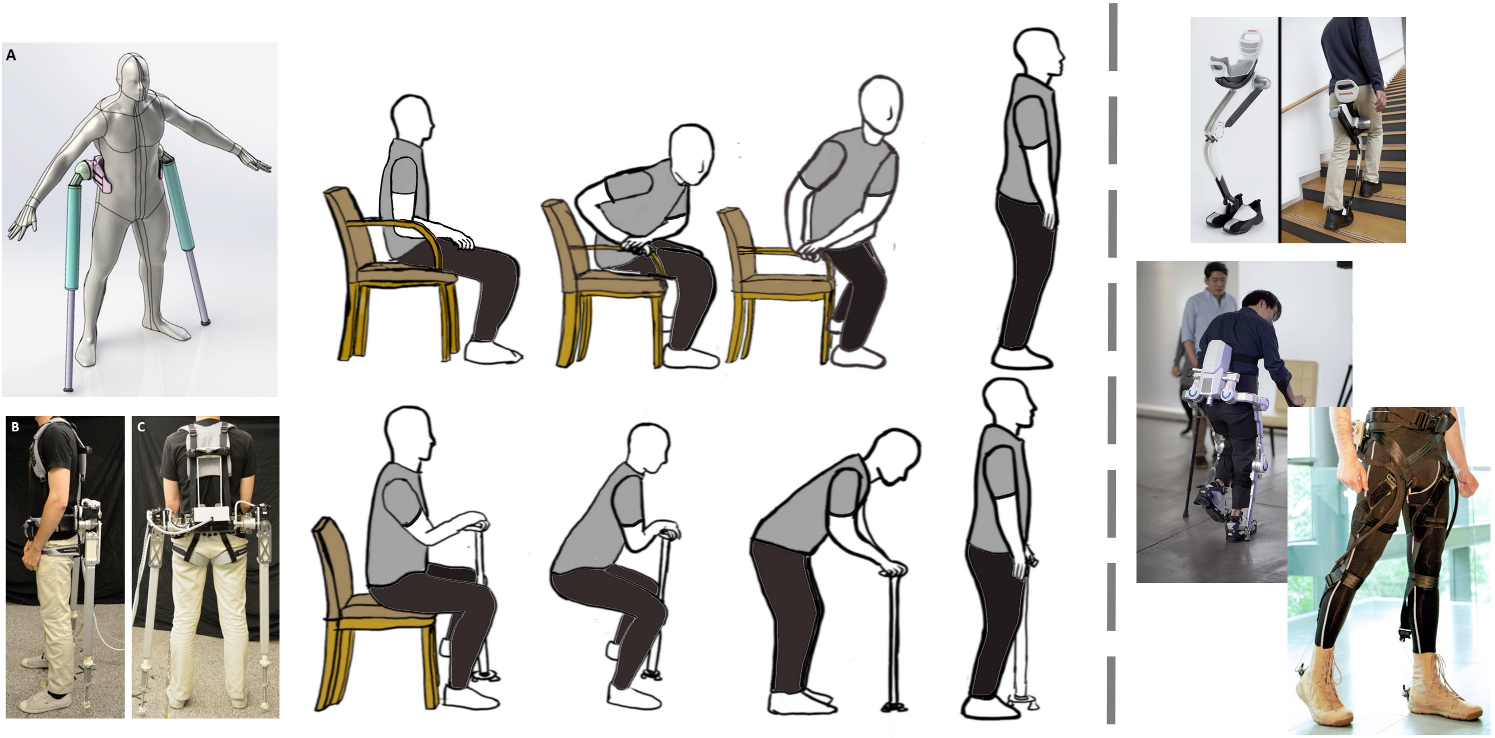
Fear of falling

- seriously affect an aging adult's quality of life
- keep a person from being active and thriving

Falls Happen During Motion Transition

Sit-to-Stand is among the high-risk levels of motion states





Health-based risks

This includes things like balance problems, weakness, chronic illnesses, vision problems, and medication side-effects. They are specific to an individual person.

Environmental risks

These are things like home hazards (e.g. loose throw rugs), outside hazards (e.g. icy sidewalks), or risky footwear (e.g. high heels). This category can also include improper use of a walker, cane, or other assistive device.

Triggers

These are the sudden or occasional events that cause a challenge to balance or strength. They can be things like a strong dog pulling on a leash, or even health-related events like a moment of low blood sugar (hypoglycemia) in a person with diabetes.

Assistive Tools for Sit-to-Stand

For motion transition from Sitting on Chair, Bed & Toilet to Walking

Bradley, Sara M., and Cameron R. Hernandez. "Geriatric assistive devices." American family physician 84.4 (2011).

Medline Bed Assist bar

Able Life Universal Stand Assist

Carex Upeasy Seat Assist Plus

Medline Toilet Safety Rails

Can we Design Intelligence for Geriatric Assistive Device?

Or how can we better assist the brain and muscle of the elderly during sit-to-stand?

Bradley, Sara M., and Cameron R. Hernandez. "Geriatric assistive devices." American family physician 84.4 (2011).

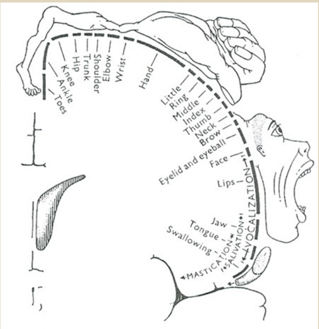
Table 1. Comparison of Assistive Devices

Assistive device	*Pros*	*Cons*	*Examples of conditions indicated for use*
Canes			
Standard/straight cane	Improves balance; adjustable	Should not be used for weight bearing; umbrella handle may cause carpal tunnel syndrome	Mild ataxia (sensory, vestibular, or visual); mild arthritis
Offset cane	Appropriate for intermittent weight bearing; shotgun handle puts less pressure on palm	Commonly used incorrectly (backward)	Moderate arthritis
Quadripod (four-legged) cane	Increased base of support; can bear larger amount of weight; stands freely on its own	Slightly heavier than straight cane; awkward to use correctly with all four points on ground simultaneously	Hemiparesis
Crutches			
Axillary crutches	Able to completely redistribute weight off of lower extremities; permits 80 to 100 percent weight-bearing support; inexpensive	Difficult to learn to use; requires substantial energy expenditure and strength; risk of nerve or artery compression; unable to use hands	Lower extremity fracture
Forearm (Lofstrand) crutches	Frees hands without having to drop crutch; less cumbersome to use, particularly on stairs	Permits only occasional weight bearing	Paraparesis
Platform crutches	Forearm is used to bear weight rather than hand	Difficult to learn to use	Rheumatoid arthritis
Walkers			
Standard walker	Most stable walker; folds easily	Needs to be lifted up with each step; slower, less natural gait	Severe myopathy; severe neuropathy; cerebellar ataxia
Front-wheeled (two-wheeled) walker	Maintains normal gait pattern; does not need to be lifted up with each step	Large turning arc; less stable than standard walker	Severe myopathy; severe neuropathy; paraparesis; parkinsonism
Four-wheeled walker (rollator)	Easy to propel; highly maneuverable, with small turning arc; typically has seat and basket	Not for weight bearing; less stable than front-wheeled walker; does not fold easily	Moderate arthritis; claudication; lung disease; congestive heart failure

Can we Design Intelligence for Geriatric Assistive Device?

Or how can we better assist the brain and muscle of the elderly during sit-to-stand?

Geriatric Assistive Device Selection



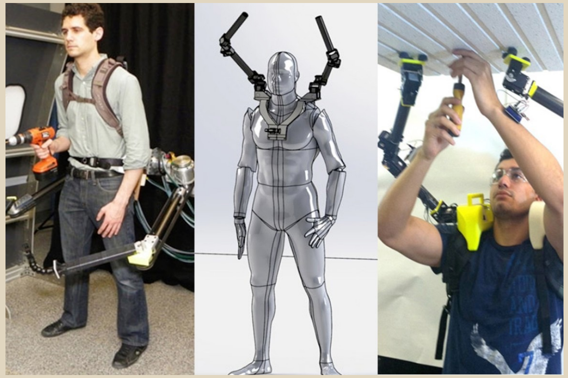
Does the patient need one or both upper extremities for weight bearing or balance?

One → What frequency of weight bearing is needed?

- Minimal → Standard cane
- Intermittent → Offset cane
- Often → Quadripod cane

Both → What frequency of weight bearing is needed?

- Minimal → Four-wheeled walker (rollator)*
- Intermittent → Front-wheeled walker or forearm crutches
- Often → Front-wheeled† or standard walker
- Constant → Standard‡ or front-wheeled walker



SRL as a potential solution?

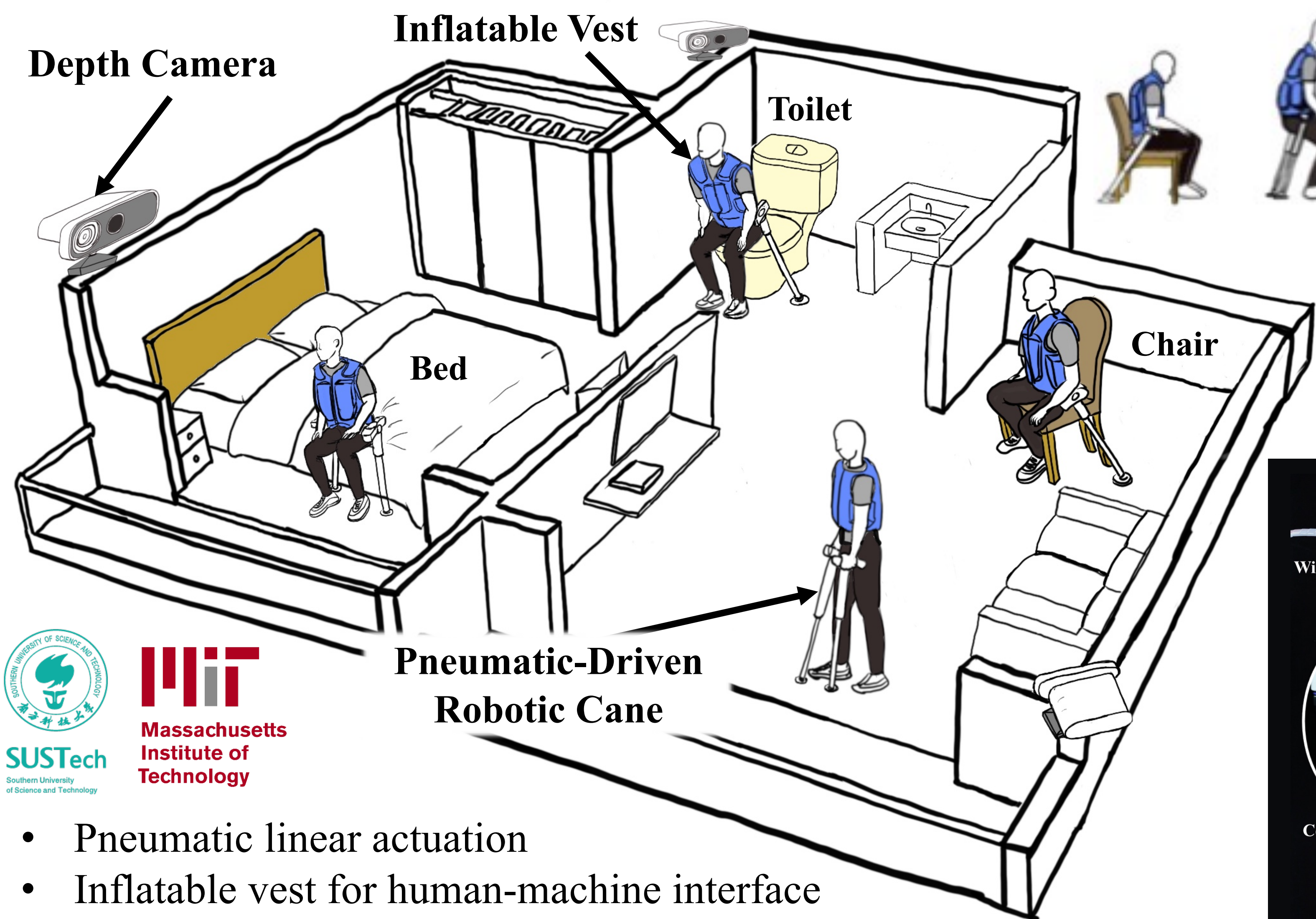
*—Use with caution; this type of walker is appropriate if balance or cognitive impairment is mild and the patient could benefit from having a seat.

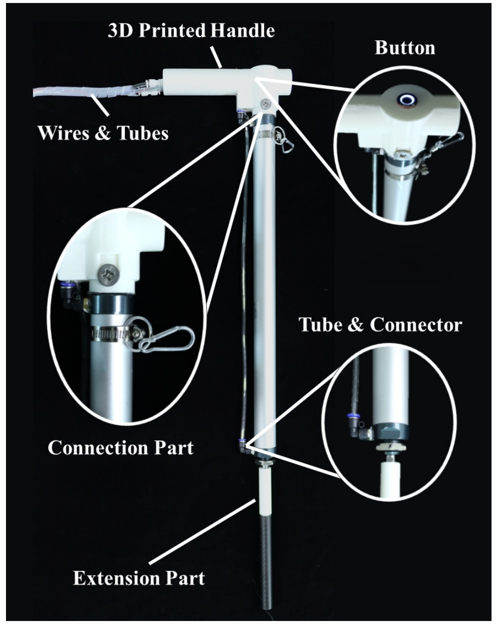
†—If the patient requires weight-bearing assistance, but not constantly, a front-wheeled walker may suffice.

‡—If the patient requires weight bearing all of the time, a standard walker may be preferred because it is more stable.

Bradley, Sara M., and Cameron R. Hernandez. "Geriatric assistive devices." American family physician 84.4 (2011).

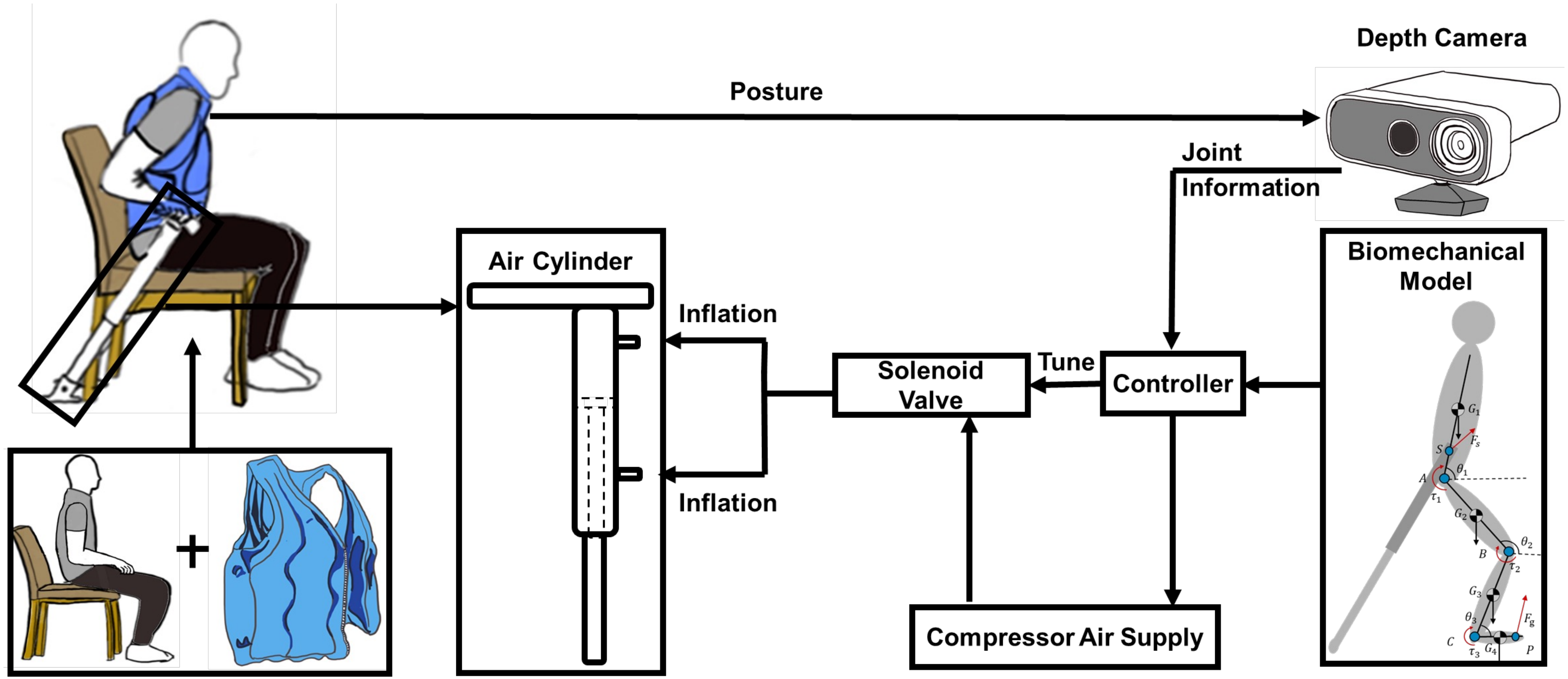
A Super-limb for the Elderly

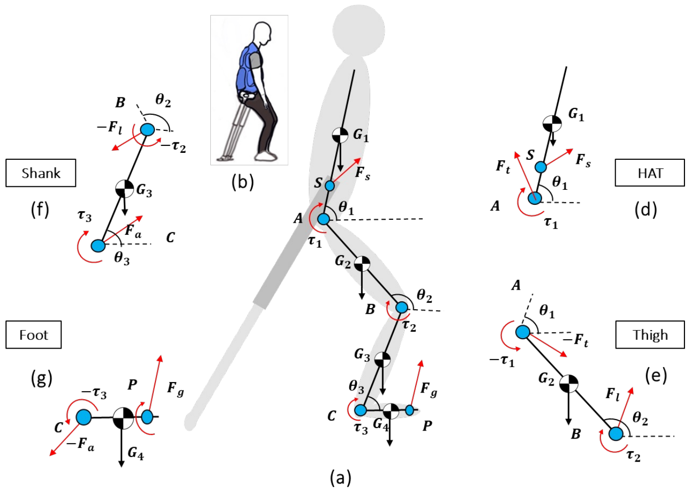




- Pneumatic linear actuation
- Inflatable vest for human-machine interface
- Privacy-safe recognition & prediction

Robots for Social Good

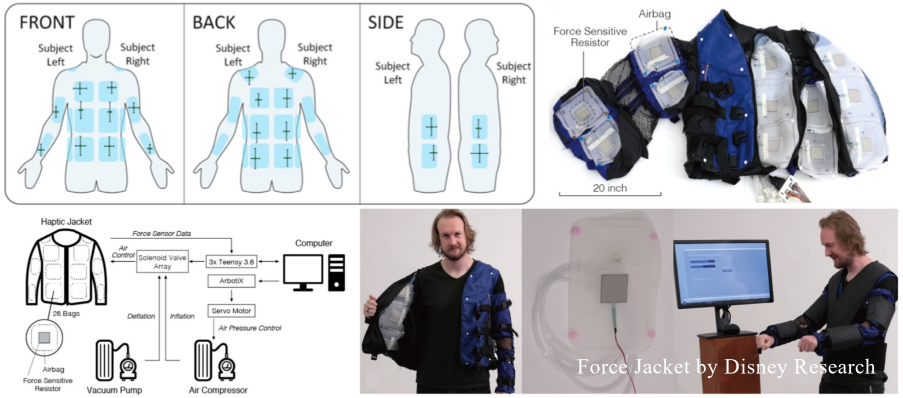




- Assistive Sit-to-Stand can be much more complicated than the current design
- Current progress establishes *the first steps* towards an autonomous assistive device

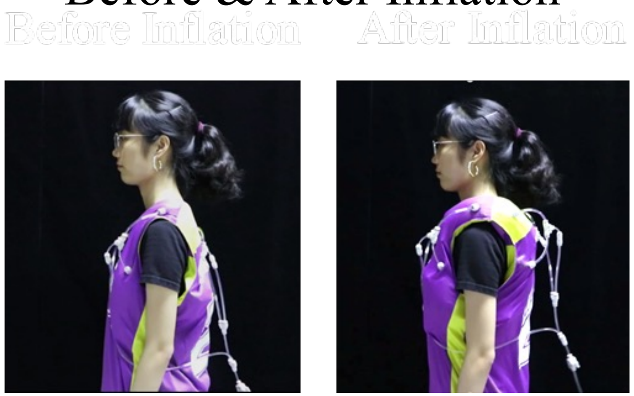
Inflatable Vest

An inflatable swimming suit sewed inside a jacket with cane hooks under the arms



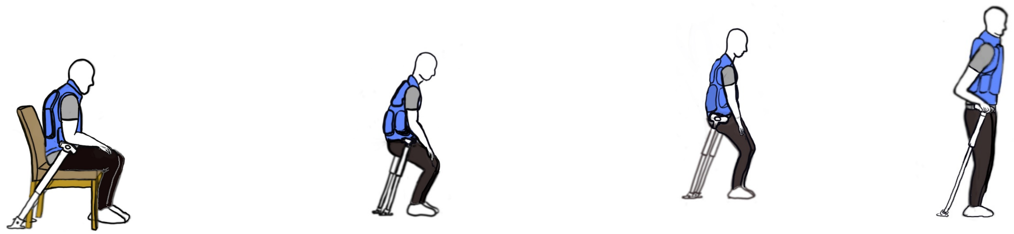
- Design issues with active assistance for the elderly as a wearable device
- Yet to be solved with a better design

Before & After Inflation



Gradually Reduced Peak Force Exerted by Human Leg

Reduced Ground Reaction Force with a Robotic Cane



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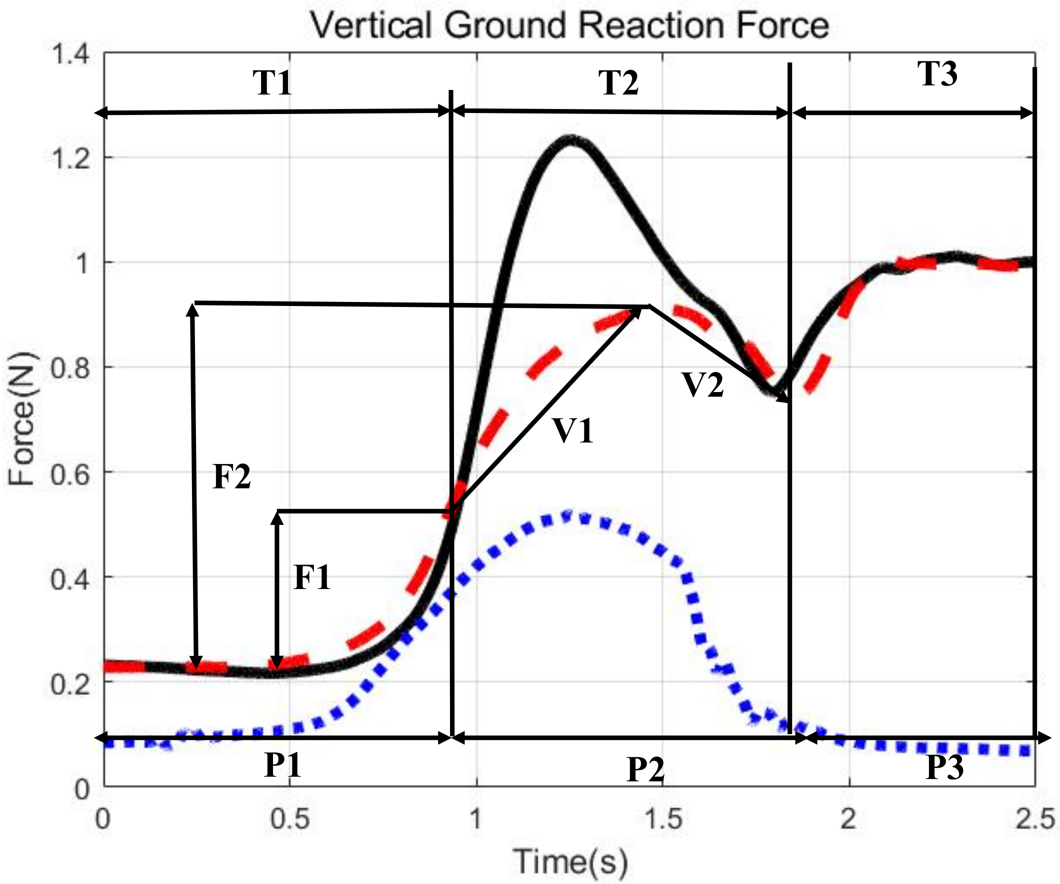
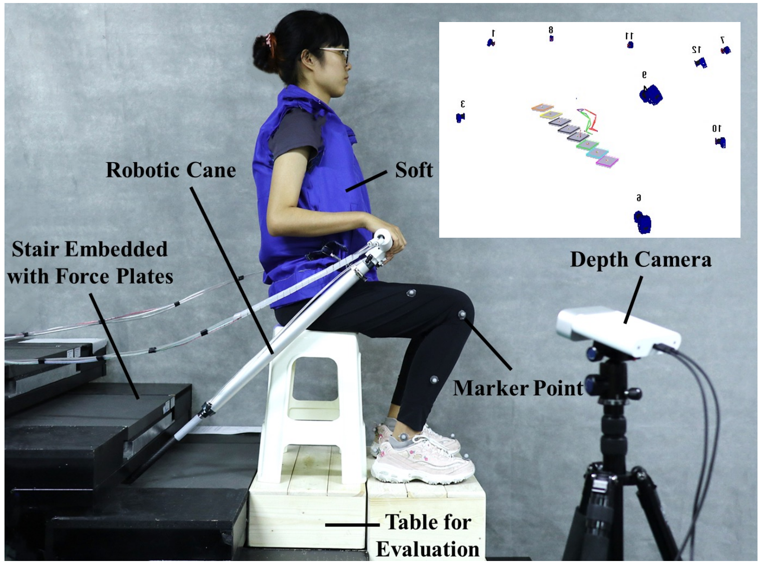
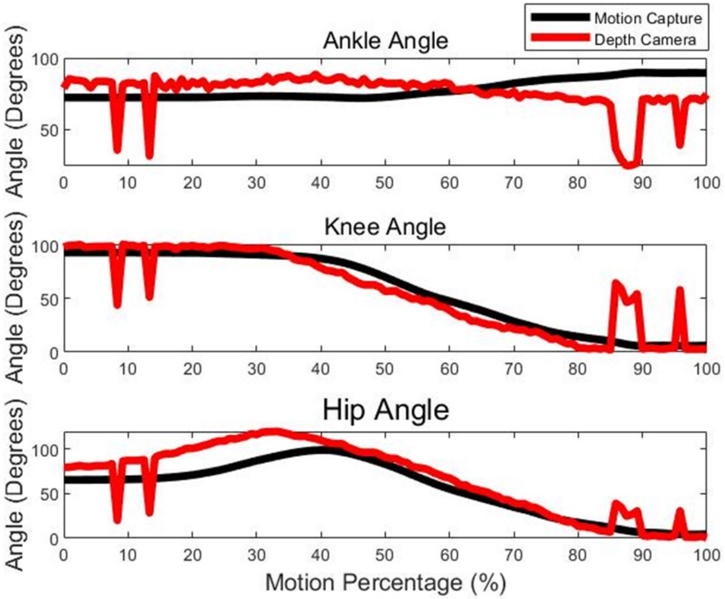
- Current progress establishes *the first steps* towards an autonomous assistive device

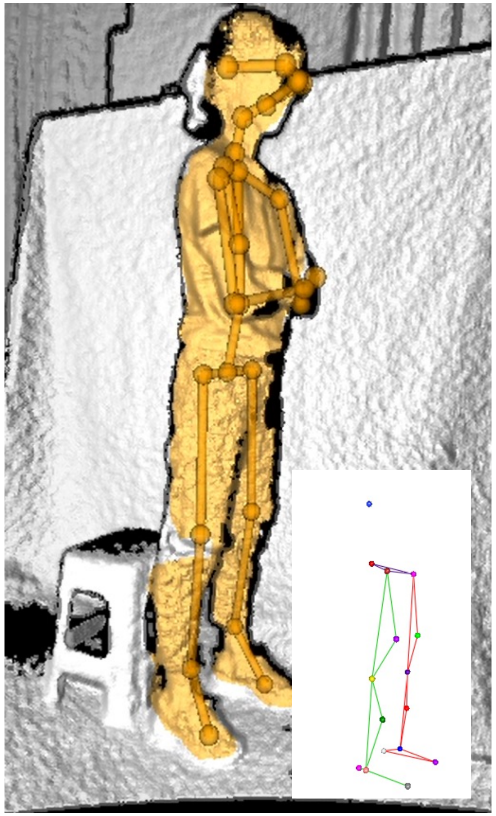


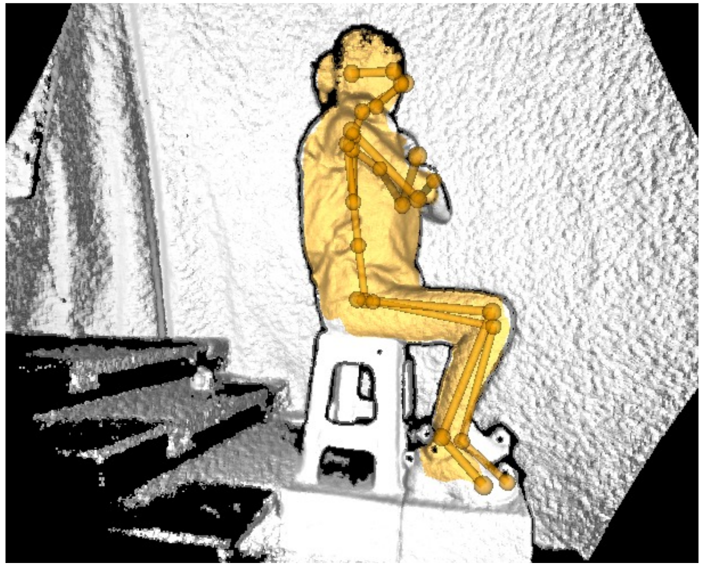
Depth Sensing for Ambient Intelligence

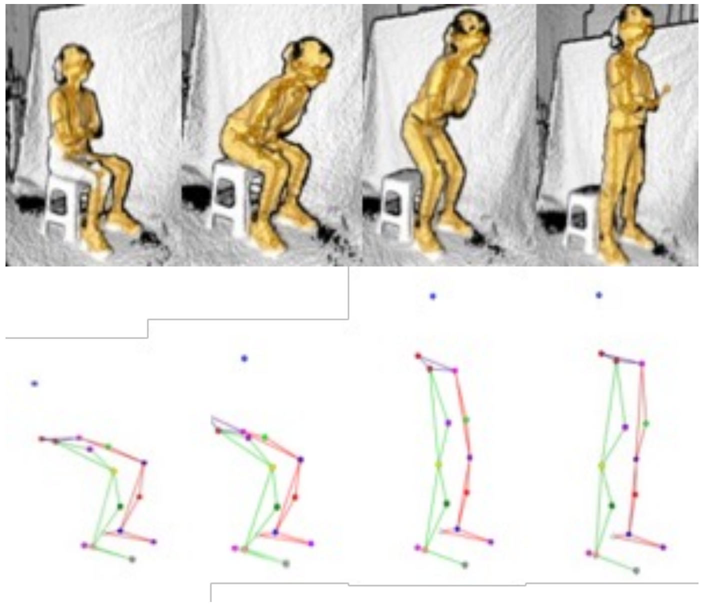
Towards an environment that satisfies our needs mostly without our having to think about it









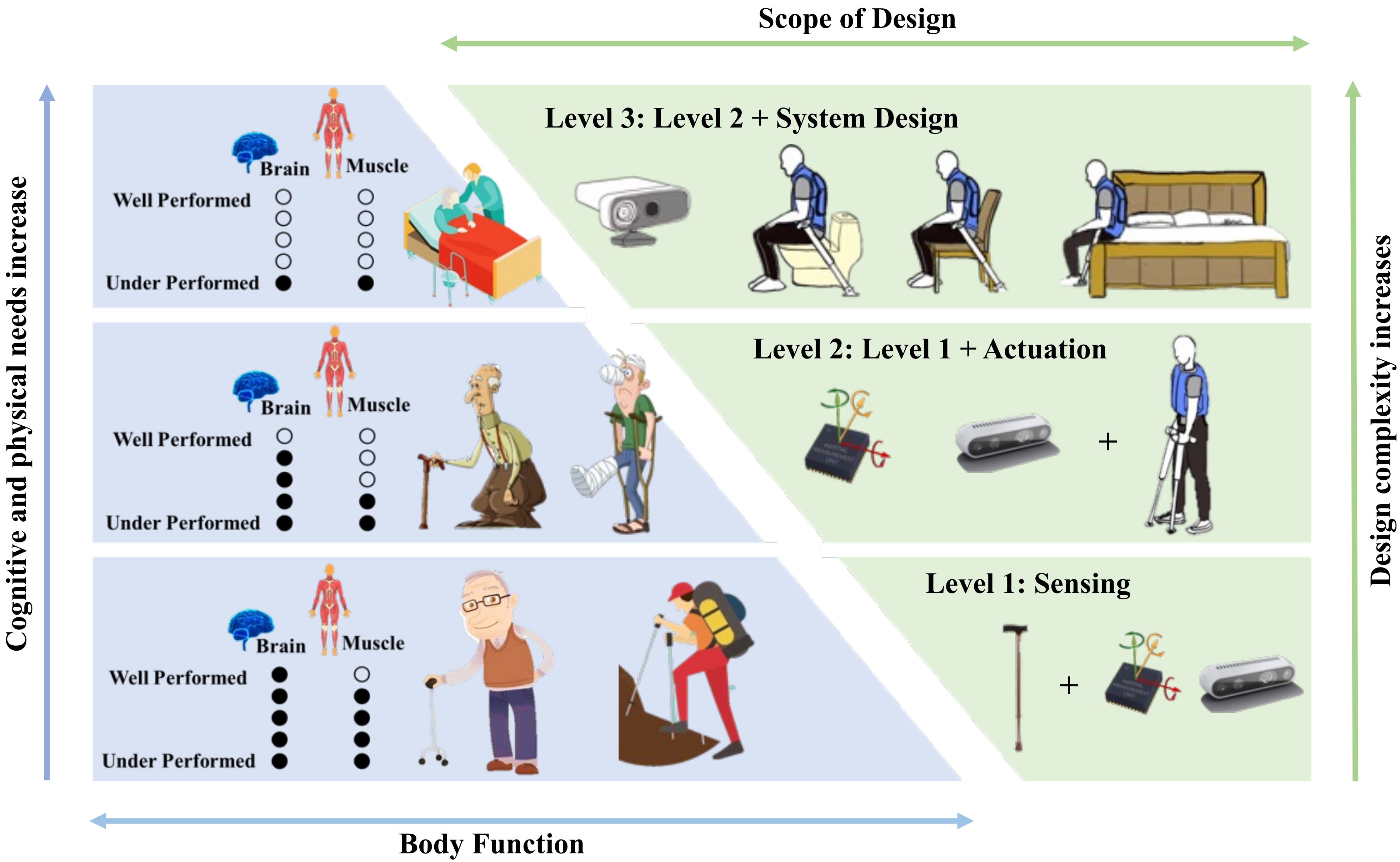


- Ambient control of assistive robot for the elderly requires rich motion data
- Consumer-grade depth sensing vs. Industrial-grade motion capture
- Future research on ambient control of super-limb robots for the elderly?

Experiment Setup

- Depth sensing for ambient motion recognition and intention detection

SRL Design for the Elderly



12 RESPONSIBLE CONSUMPTION AND PRODUCTION

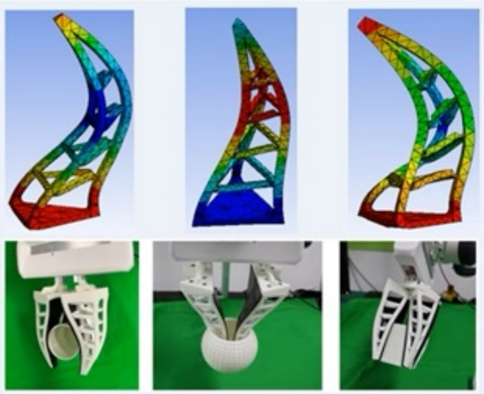
Soft Robot Learning

DeepClaw Robot Learning System

A Shareable & Reproducible Robot System for Learning and Benchmarking

非结构环境视触抓取与识别机理

面向生活垃圾
抓取与识别的
视触感知软体机器人



- 全方向自适应软体机器人
- 低成本、高可靠柔性驱动
- 柔性触觉传感器集成阵列

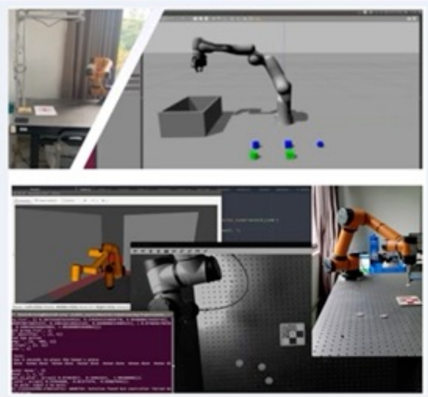
生活垃圾的视触特征的数据化表征

建立非金属、中小尺寸
生活垃圾视触信息的
基准数据集

- 垃圾视触特征的系统表征
- 垃圾视触分类基准数据集
- 无监督学习数据采集标定

智能软体机器人垃圾分拣系统集成

采用视触融合软体机器
人技术的垃圾分拣与
效率检测平台



- 机器人垃圾分拣系统示范
- 垃圾分拣的量化分析模型
- 经济效益集环境影响测试

Rigid-Soft Interactive Learning

Rigid-Soft Transferrability

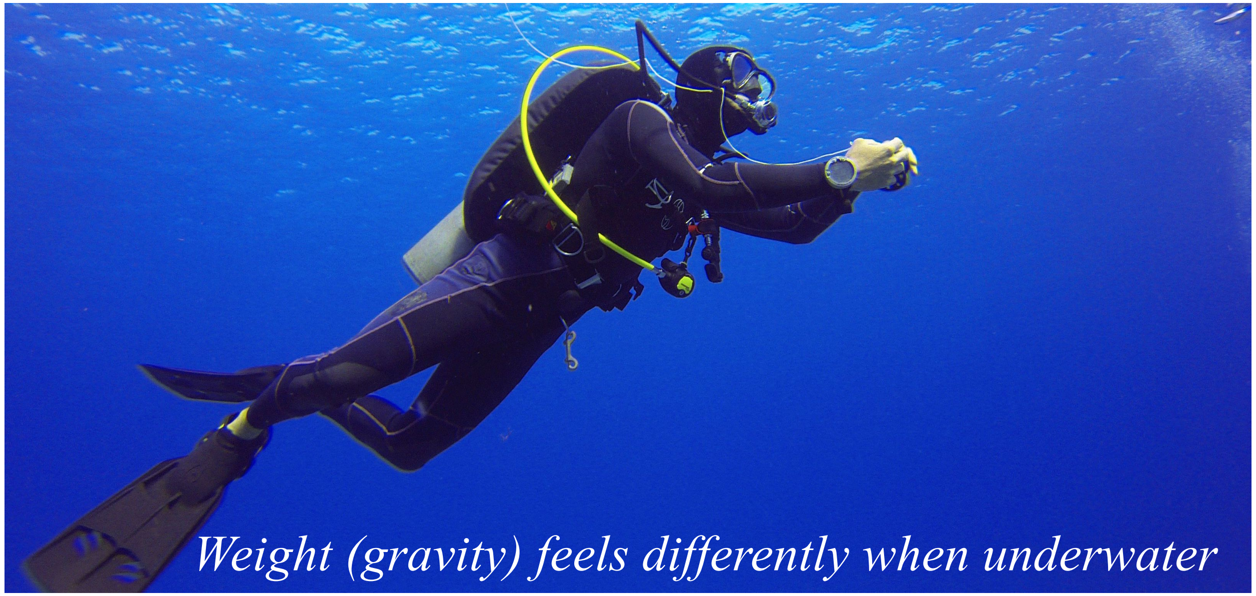
Wasteless Themed Design Projects

Review of Challenges for Human Activities Underwater

Review of Challenges for Human Activities Underwater

The human musculoskeletal biology is **not** designed for activities underwater

- **Life** assistance: air, vision, body temperature, …
- **Motion** assistance: fins, gloves, …
- **Safety** assistance: dive suit, …
- **Cognitive** assistance: communication, …




Marine Biology


Underwater archeology

- Human body is not designed for underwater work
- Many underwater work cannot be replaced by robots since many work requires humans dexterity.
- Underwater work is difficult, exhausted and dangerous.

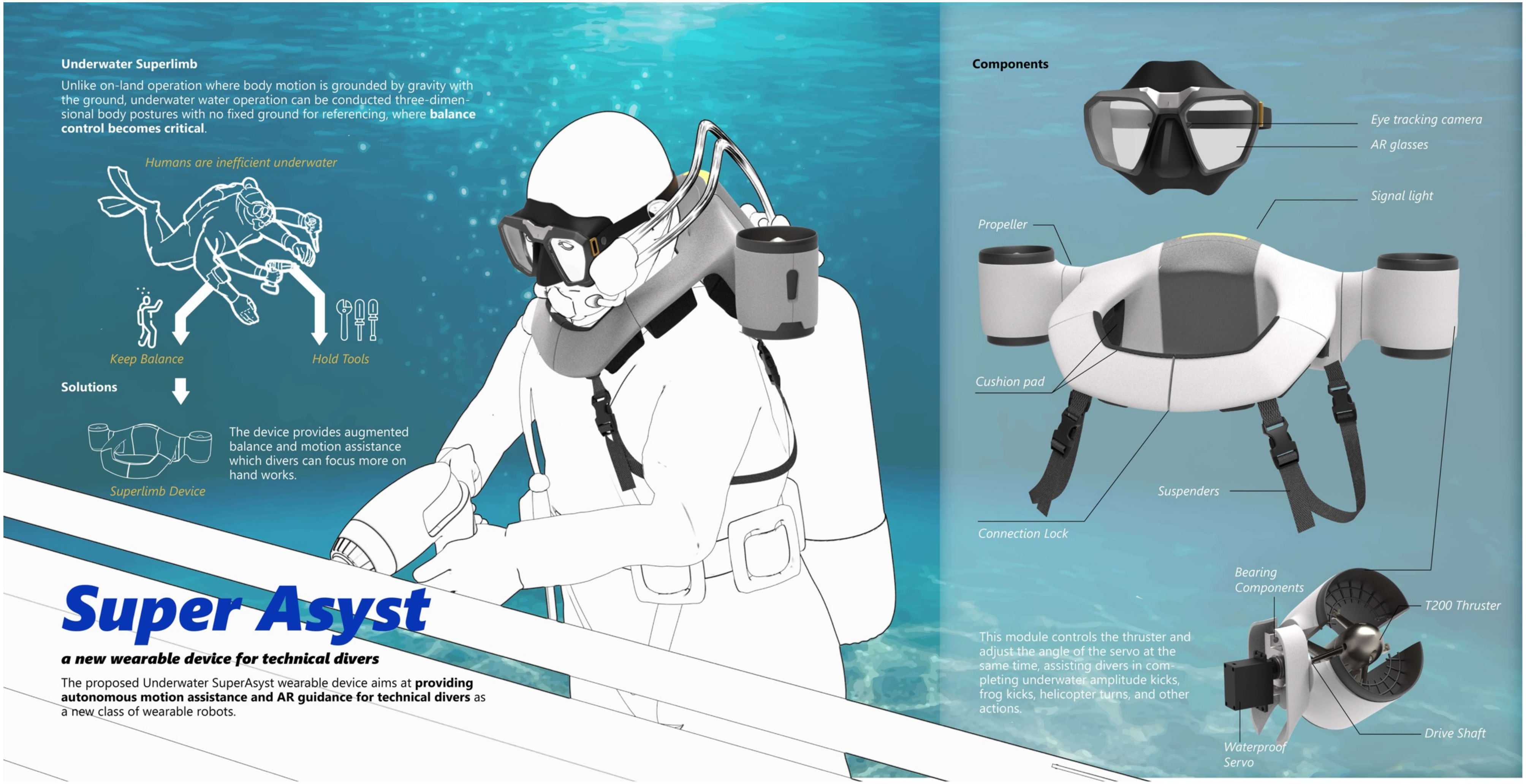
Helping divers to keep balance and support their motion to save their metabolic energy consumption. Making underwater work safer and easier.

Design a super-limb for underwater work


Paleontology

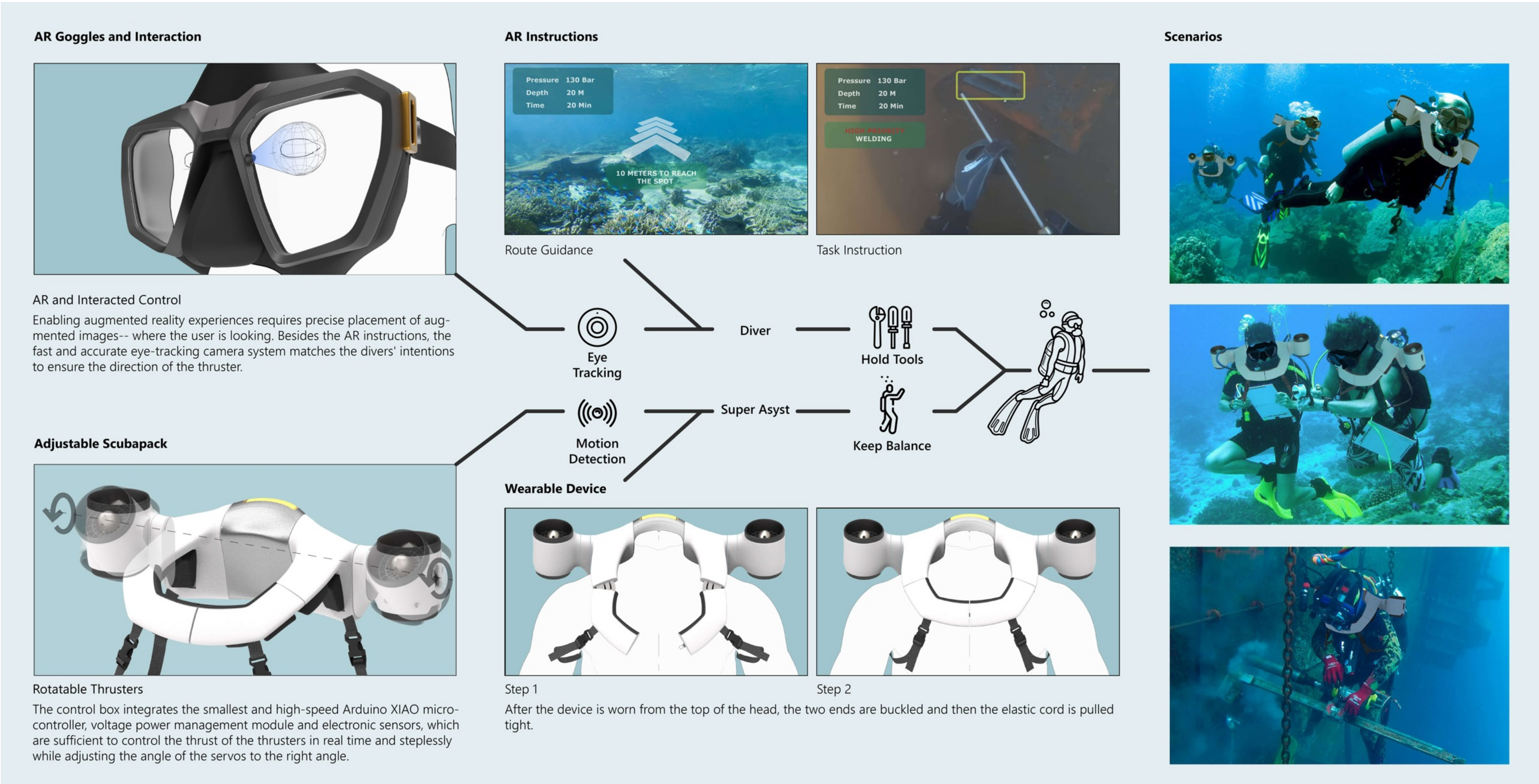

Underwater Welding

Super Asyst Concept Design



Designed by Chen Mingdong, Supervised by Wan Fang & Song Chaoyang

Super Asyst Concept Design



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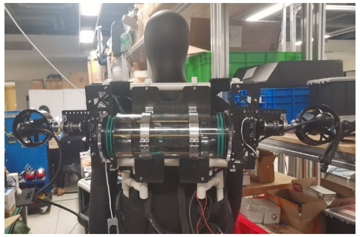
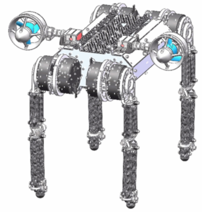


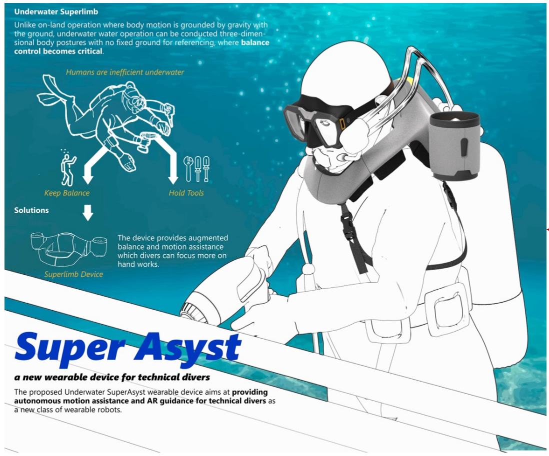
Underwater Superlimb for Safe Diving Assistance

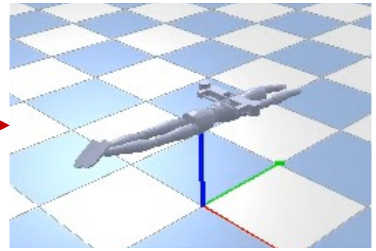


Human Divers ← *As a wearable robot* | *As a test platform* → **Robotic Diver**

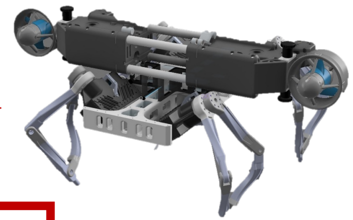
Intention Recognition for Autonomously Safe Body Pose Control with Underwater Superlimb

Industrial design
- Mingdong Chen (RA)
- Yuanning Han (UG)
- Xian Li (UG)



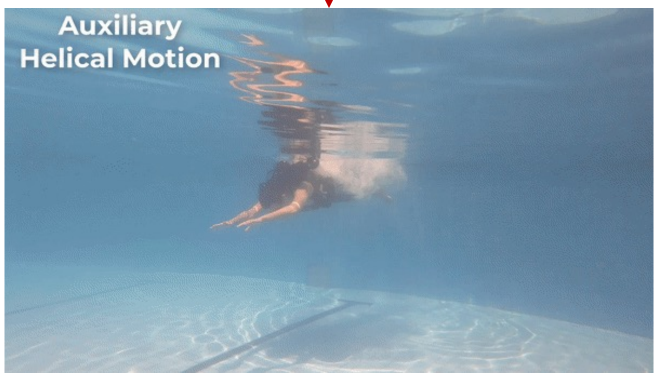


Modeling & simulation
- Jiayu Huo (UG)
- Jingran Wang (UG)



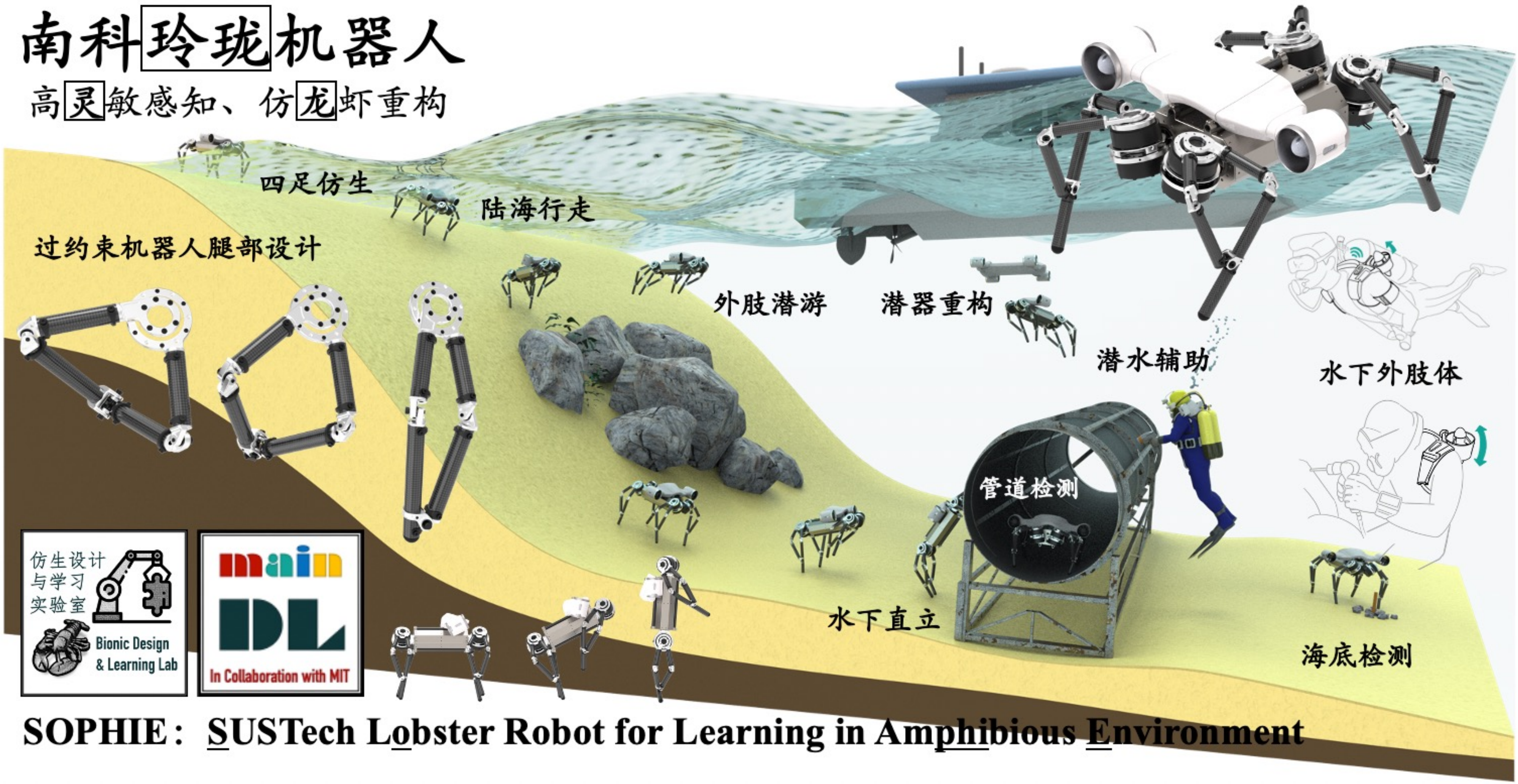
Amphibian system
- Ziqian Wang (Ph.D.)
- Feng Tian (UG)
- Xianhan Li (UG)
- Ruizhou Zhao (UG)

Superlimb prototyping
- Yuqin Guo (Master)
- Wanghongjie Qiu (UG)
- Teng Wang (RA)



Field Testing
- Guo Yuqin (Master)
- Ziqian Wang (Ph.D.)
- Jie Yu (Master)
- Feng Tian (UG)

SOPHIE



SOPHIE： SUSTech Lobster Robot for Learning in Amphibious Environment

Thank you~

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Southern University of Science and Technology