Why do we develop Care Robotic Devices and Services?

Current status and prospect of care robotics devices and services in Korea

Won-Kyung Song, PhD

Department of Rehabilitative and Assistive Technology,
National Rehabilitation Center, Seoul, Korea

National Rehabilitation Center, Korea = Rehabilitation Hospital + Research Institute

- **Location: Seoul, Korea**
- **Rehabilitation Hospital**
  - One of the biggest rehab hospitals in Korea.
  - Around 300 beds.
  - Major Patients: Spinal Cord Injury and Stroke.
- **Translational Research Program for Rehab Robots**
  - 2013~. **Making bridge from technological R&D to clinical applications**
  - **Experience on the enhancing tech, supporting device testing, and KFDA (MFDS) clearance/approval as a medical device**
- **Pilot Provision Program for Rehab Robots**
  - 2012~. MoTIE and MoHW.
  - **Pilot Provision of Rehabilitation Robots** to **Rehabilitation Hospitals**
- **Translational Research Program for Care Robots**
  - 2019~. MoTIE and MoHW
  - **Care Robot Device + Service Model**

Service Robots

- Quarantine robots

AI Quarantine robot, KT

Hey-bot, Hills Engineering

- Care robots

Care robots for Transfer, Position Change, Toileting, Feeding

- Reception robots

LG CLOi GuideBot,
LG

Mobile Manipulator,
KI-RO

- Delivery robots

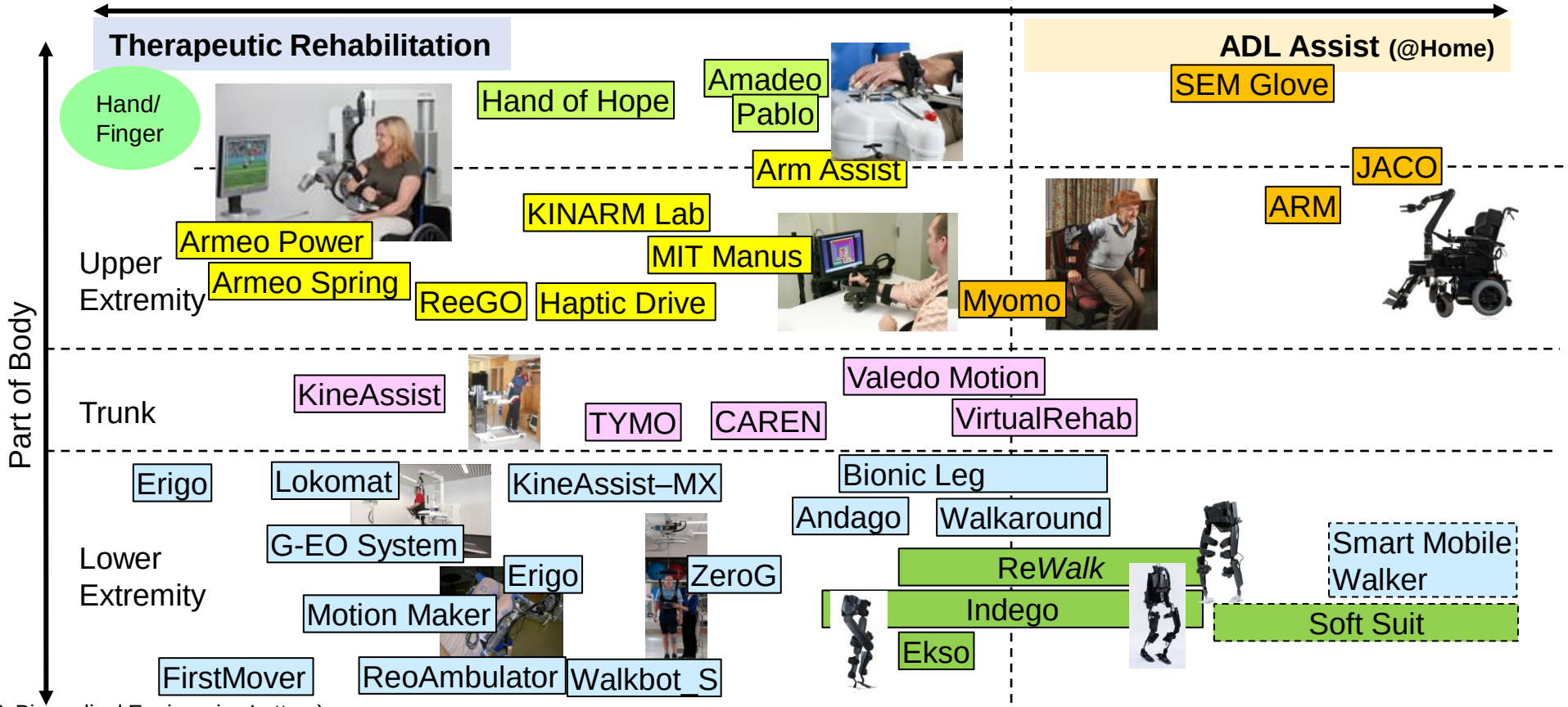
Sirbot, RGT

Indoor delivery robot,
Robotis

Serving robot series
Cogaplex-Woori Robot

Care Robot: A robot device that mainly performs tasks that require a caregiver.

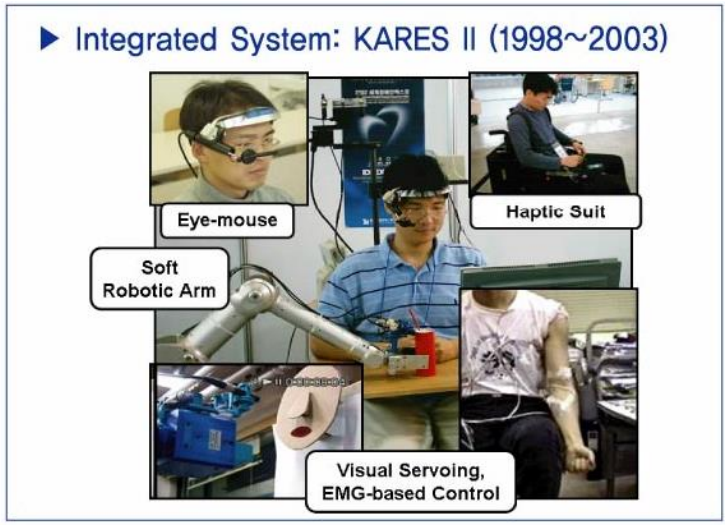
- Therapeutic rehabilitation robots (hospital),
- Assistive robots (home),
- **Care robots (hospital, facility, home)**
  - **Nursing care + Social care**



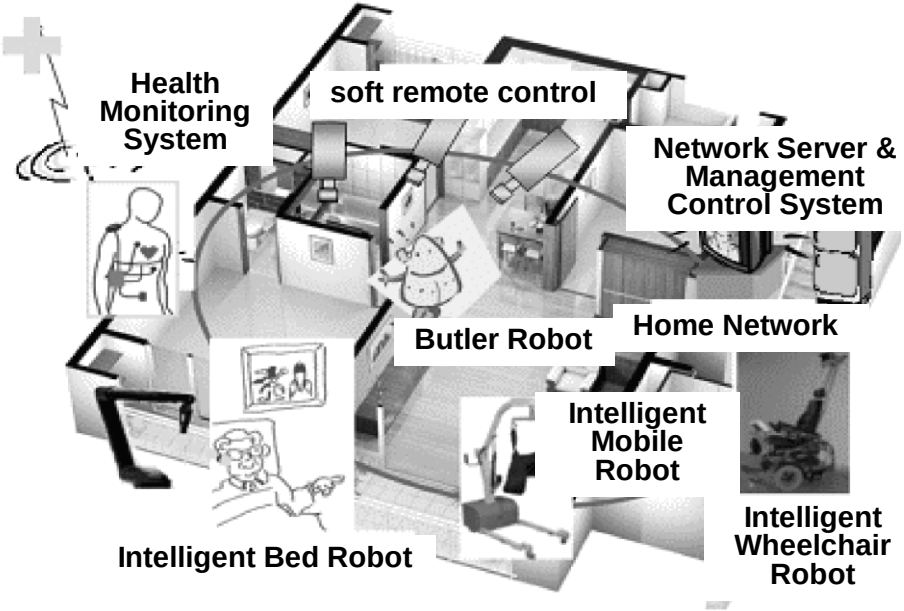
Modified form (Song, 2016, Biomedical Engineering Letters)

History of Welfare Robots

KARES I (1996. 5.~1998. 4.)



KARES II (1998. 12.~2003. 8.)

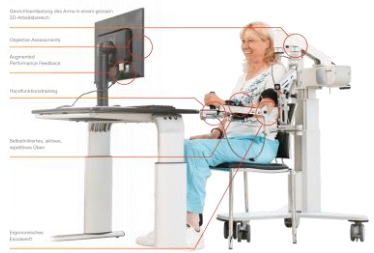


Intelligent Sweet Home for the elderly/disabled
(1999. 7.~ 2007. 6.)

Rancho Los Amigos Orthosis
7 DOF, 1960s

MANUS ARM, iARM:
A successful “commercial” robotic arm.
(Exact Dynamics, NL, 1990)

Wilmington Robotic Exoskeleton
Tariq Rahman, PhD, Whitney Sample, 1995~

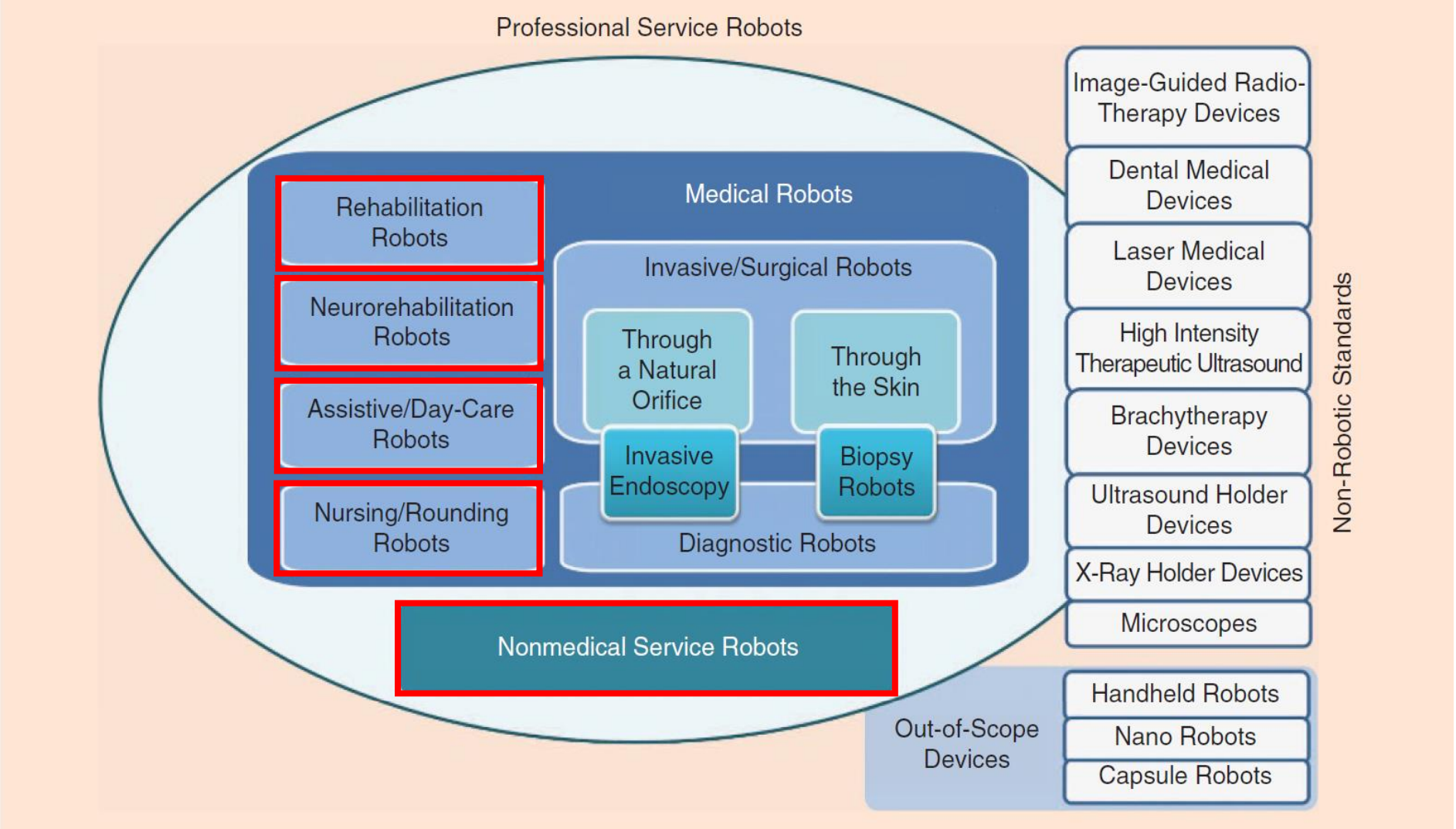


Armeo Spring

Armeo Power

Lokomat (2001~)

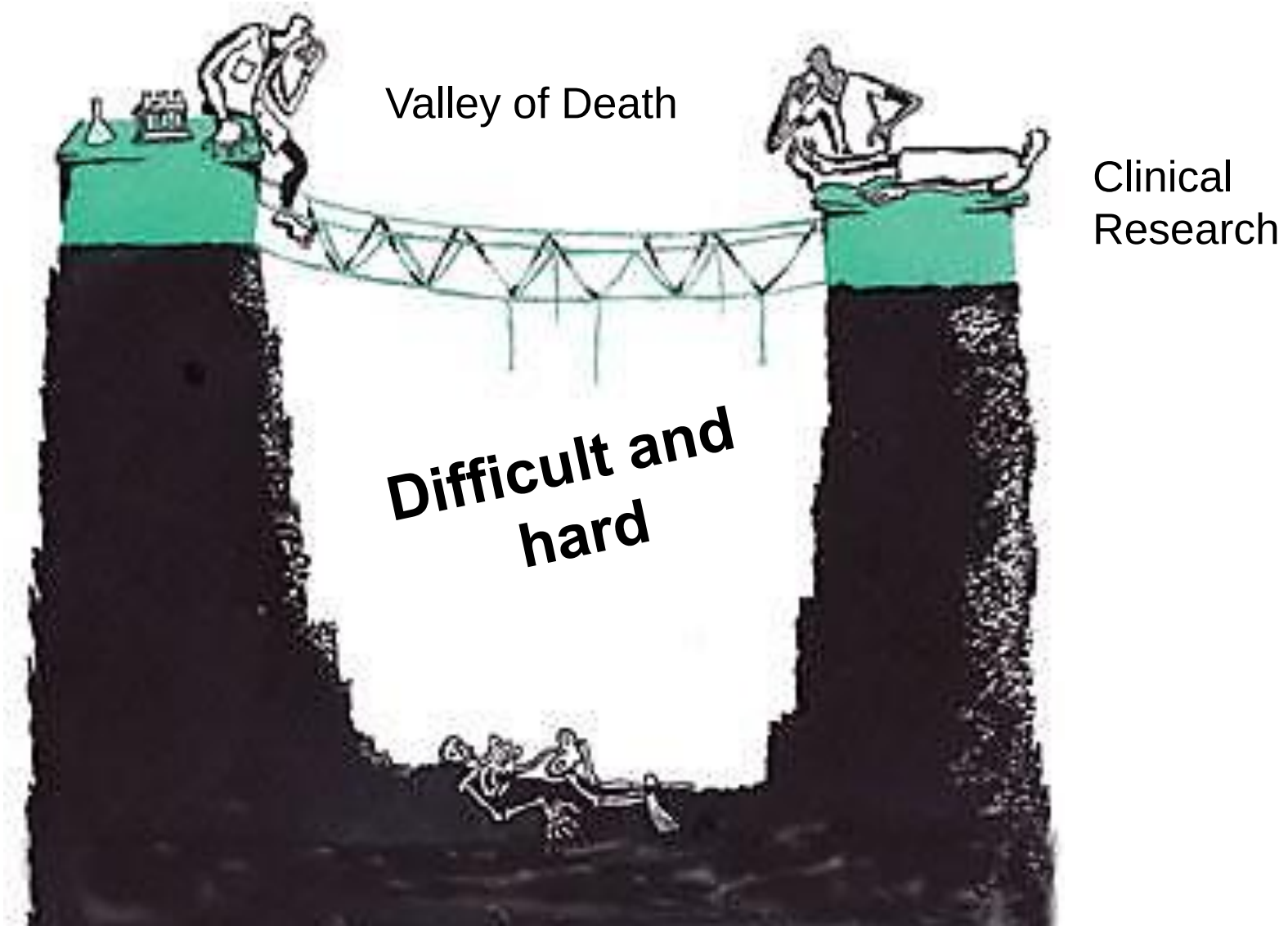
Professional Service Robots, Rehabilitation Robots



Jacobs, T., Veneman, J., Virk, G. S., & Haidegger, T. (2018). The Flourishing Landscape of Robot Standardization [Industrial Activities]. IEEE Robotics & Automation Magazine, 25(1), 8-15.

Translational Research for Rehabilitation Robots

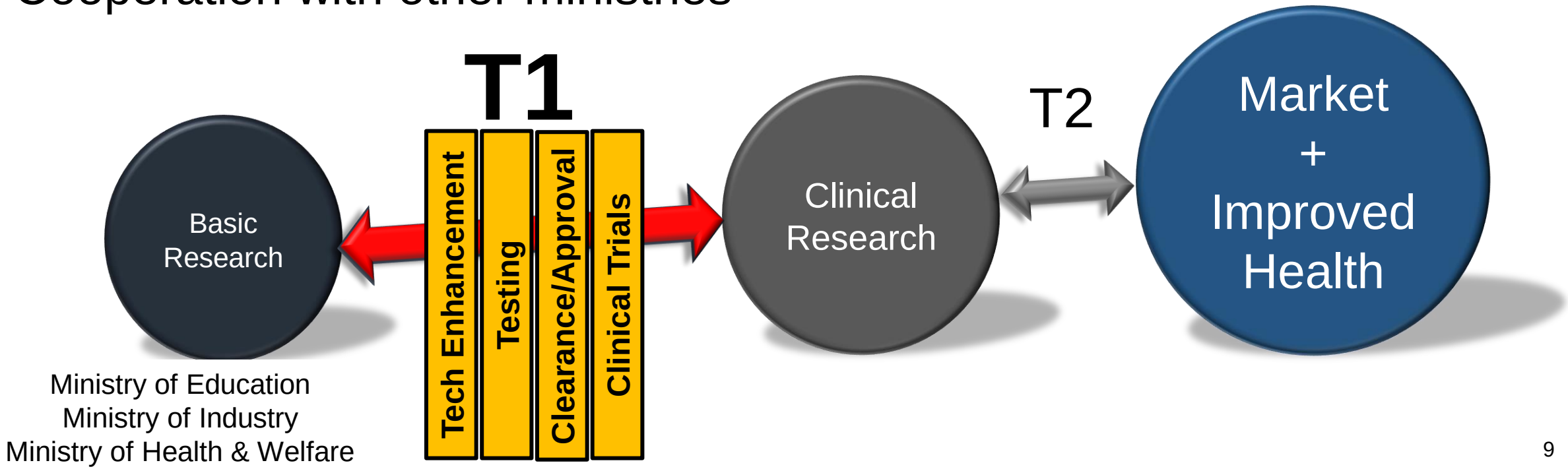
Translational research: Crossing the valley of death



Nature **453**, 840-842 (2008)

Translational Research for Rehabilitation Robots

- (1) Technology Enhancement, (2) Test,
  (3) Clearance/Approval (Certification), (4) Clinical Trials
- Specialized in rehabilitation robots, starting in 2013
- Accelerate clinical entry of rehabilitation robots
- Cooperation with other ministries

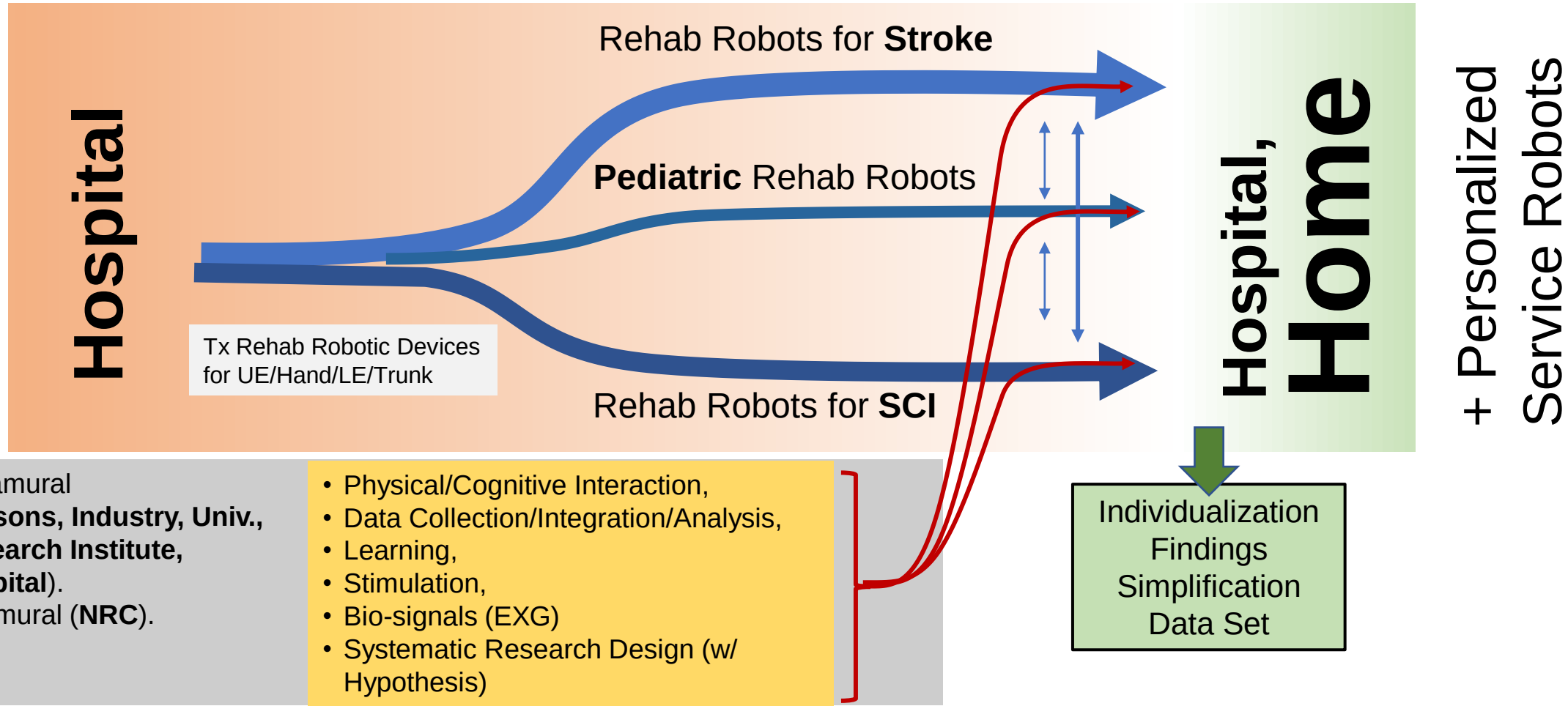


Exowalk

뇌병변 장애인 대상 보행훈련재활로봇

Next Direction: TRP for Rehab Robots

- **1) Tech enhancement → 2) Testing → 3) Approval / Clearance → 4) Clinical Trials / Usability Test** → Pilot Supply → Market



Issues of rehabilitation robots for Activation

- **Product and item classification** in **gray zone**
- Assistive technology **as a service (for MD, therapists)**
- Translational research **for new ideas**
- **Experience accumulation** for **pilot provision**
- Suitable level of **medical fee**
- Expand **technology into home**
- **Data** accumulation, integration, and utilization
- **Clinical trials** through IDE (Investigational Device Exemption) exempt
- **Insurance** such as vehicle insurance

Pilot Provision for Rehab Robots

Pilot Supplied Rehabilitation Robots Making references on Markets, QoL

2012
(2012.4.1.~2016.3.30.)

Gait Rehabilitation Robot (Walkbot_S)

- Number of institutions deployed: 4
- Sales record after this program
  → Gait Rehabilitation Robot 21 EA

2013
(2013.5.1.~2017.4.30.)

Feeding Assistive Robot (CareMeal)

Transfer Robot (Robin-T)

Upper-Limb Rehabilitation Robot (Neuro-X)

- Number of institutions deployed: 4
- Sales record after this program
  → Transfer robot 2 EA, Upper-limb rehabilitation Robot 8 EA

2014
(2014.5.1.~2018.4.30.)

Trunk Stability Rehabilitation Robot (3DBT-33)

Hand Rehabilitation Robot (RAPAEL Smart Glove)

- Number of institutions deployed: 4
- Sales record after this program
  → Hand robot 250 EA
  → Trunk stability robot 4 EA

2015
(2015.5.1.~2019.4.30.)

End-effector Type Gait Rehabilitation Robot (MORNING WALK)

Robotic Electronic Magnifier (E-bot PRO)

- Number of institutions deployed: 6
- Sales record after this program
  → End-effector type gait robot 3 EA
  → Robot electronic magnifier 431 EA

2016
(2016.8.2.~2020.7.31.)

Wearable Walking Assistance Robot (ANGELEGS)

Care bidet Robot (CURA1020)

- Number of institutions deployed: 4
- Sales record after this program
  → Wearable walking robot 1 EA
  → Care bidet 92 EA

Pilot Supplied Rehabilitation Robots

2017
(2017.5.1.~2021.3.31.)

Exoskeleton Type Walk-Assist Robot (EXOWALK)

Upper-Limb Rehabilitation Robot (3DBT-61)

- Number of institutions deployed: 3

2018
(2018.5.1.~2021.12.31.)

Exoskeleton Type Gait Rehabilitation Robot (SUBAR)

- Number of institutions deployed: 3

2019
(2019.5.1.~2022.12.31.)

End-effector Type Gait Rehabilitation Robot (Morning Walk)

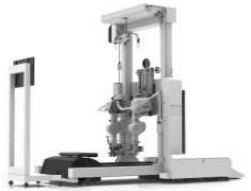
The continuum of gait rehabilitation

Exoskeleton Type Gait Rehabilitation Robot (EXOWALK PRO)

- Number of institutions deploying: 3

2020
(2020.1.1.~2023.12.31.)




- Number of institutions deploying: 6

2021-22
(2020.1.1.~2023.12.31.)

- **Clinical demonstration of lower-limb wearable robot (Angelegs M20)**
- Target: 90 of **cerebral palsy (children and adolescents)**

- Number of institutions deploying: 5

Walkbot_S: Exoskeleton-based Gait Rehabilitation Robot

Morning Walk: End-effector-based Gait Rehabilitation Robot

Rapael Smartglove: Hand Rehabilitation Robot

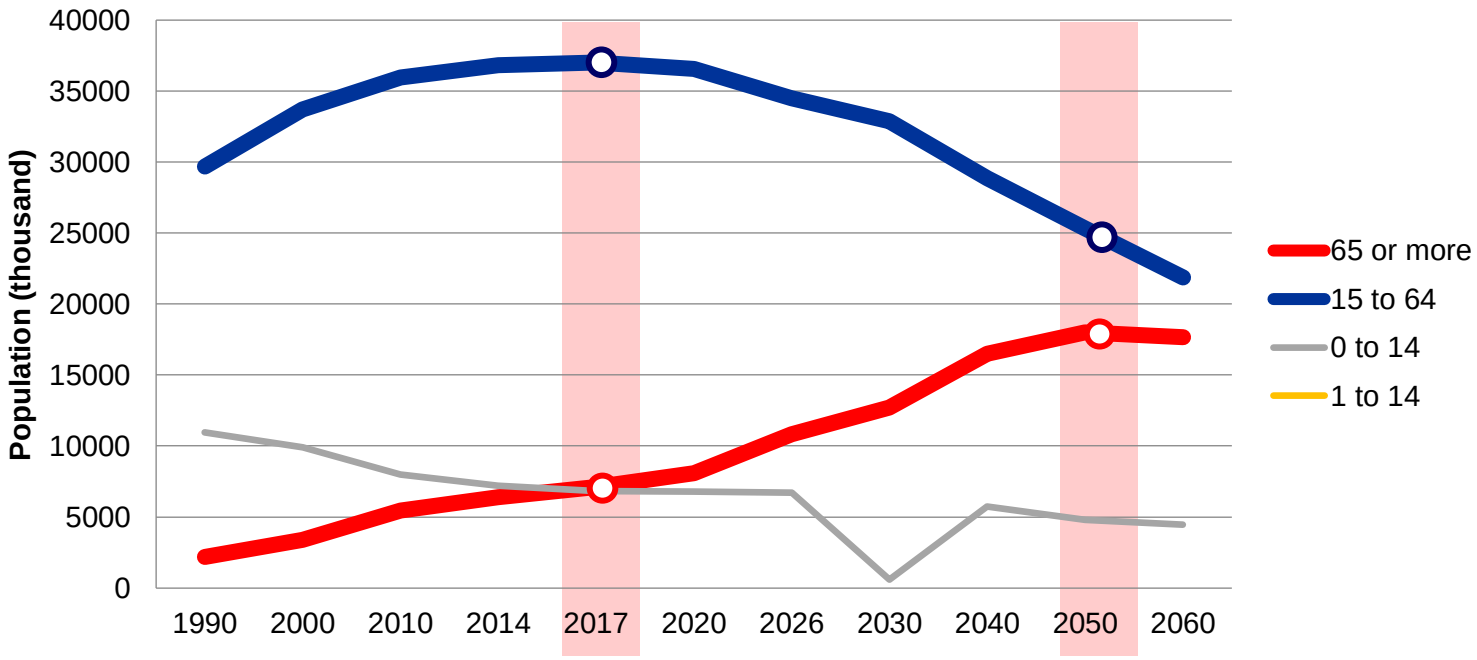
Experience of Pilot Provision of Rehabilitation Robots

- **Pilot cooperation** project of **Ministry of Industry** and **Ministry of Health and Welfare**
  - Looking for a good robot from 2010
- **Difficulty selling** even with **medical device approval** and **demonstration in various hospitals**
- Documentation of robotic device manual is needed.
- **Good hospital selection** - **Good reference**
- **Many feedback** after the hospitals of rehabilitation robots
- **Leadership and contribution** for each party.
- Sustainable sales of robots require **continuous improvement** and **long time**.

R&D for Care Robots

Korea faces rapidly aging population

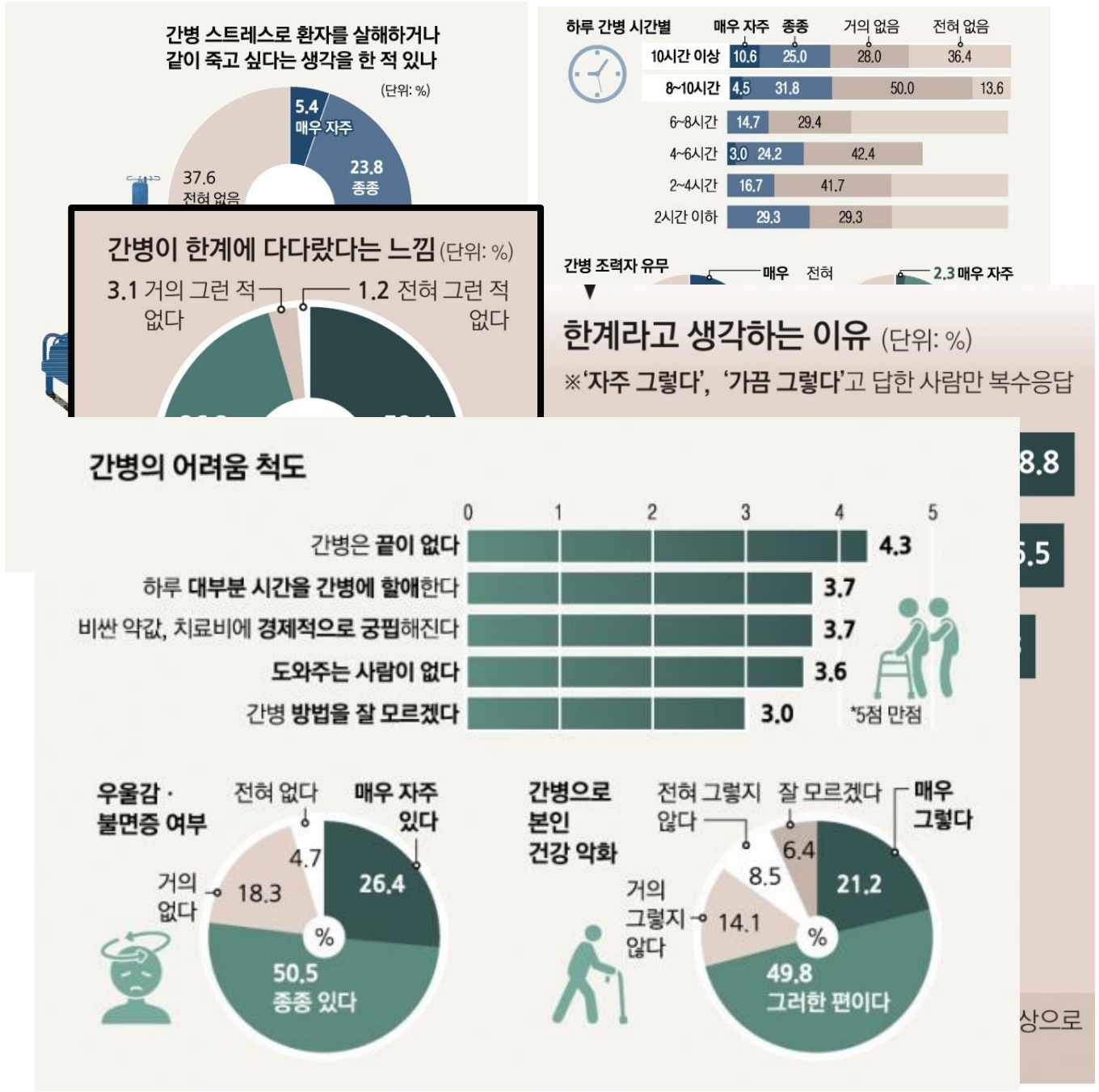
- Being expected to surge in demand for Care Robots
  - People with significant disabilities and senior citizens.
  - Productive (15 to 64): Elderly (65 or more)
    = 5.2:1 (2017, Korea) → 1.4:1 (2050, Korea)



Statistics Korea, Population Projections (2011)

Difficulty of Caregiving

- Care is endless.
- Most of the day is devoted to care.
- They become economically poor due to expensive drugs and treatment costs.
- There is no one to help
- I don't know how to care.



서울신문, https://www.seoul.co.kr/news/newsView.php?id=20180904007002

서울신문, https://www.seoul.co.kr/news/newsView.php?id=20180904007002

Systematic Thinking (2017~2018): Setup strategies & Priorities for Care Robots Projects

- Shadowing in the real world
- Survey

- Care Robots Working Group with Various Stakeholders

- Focus Group Interview
- In-depth Interview
- Advisory Meeting

- Overseas Visits (Japan, Sweden, U.K., Finland, Denmark)




- MoHW - MoTIE Smart Care Robot Council

- Care Robot Network Forum (n=49) with Various Stakeholders

- Care Robots Symposium



Target Users = Care Receivers + Caregivers

Mid-aged with Cerebral Palsy

(People with Significant Disabilities)

- People with Significant Disabilities
- Need help 24 hours a day
- Want to show my independence from my parents
- Want to reduce discomfort or anxiety when I am self-reliant

73 year old Male

(Old Adults with Severely Limited Mobility)

- Do not want to be burden on my wife and children
- My wife, who takes care of me, grows older and becomes weak
- Worried about who can take care of my old wife

Caregiver in her mid-50th

(Caregiver for old adults and PwD)

- Waist and wrist discomfort with chronic pain
- Want to take care of a mild person who could cause little physical and mental burdens
- Hard to adapt to new people every time

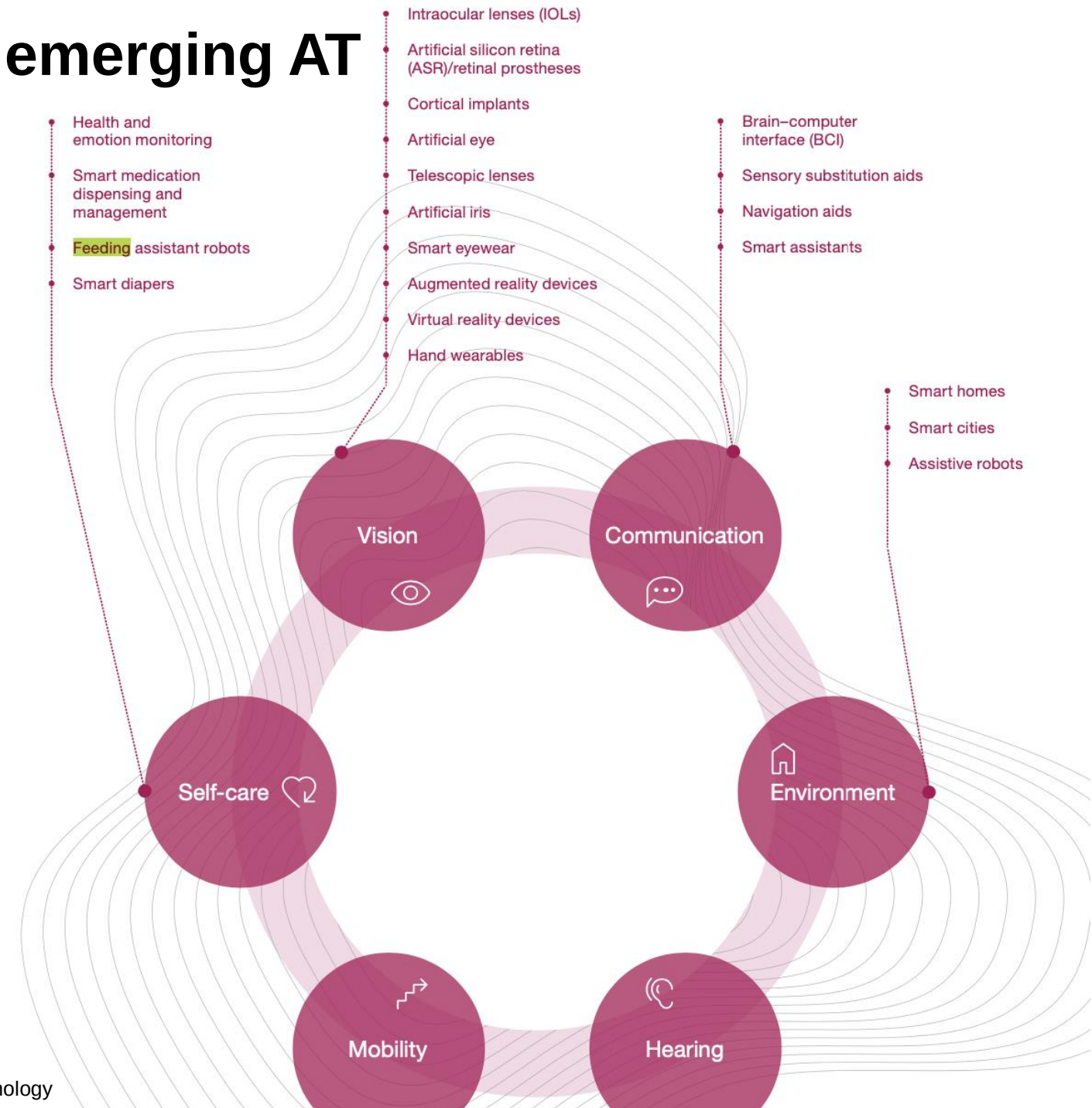
How many people can reduce the burden of care?

- Care Receivers =
  540,000 (1% of Korean)
  - People with Significant Disabilities.
  - Old Adult with Severely Limited Mobility.

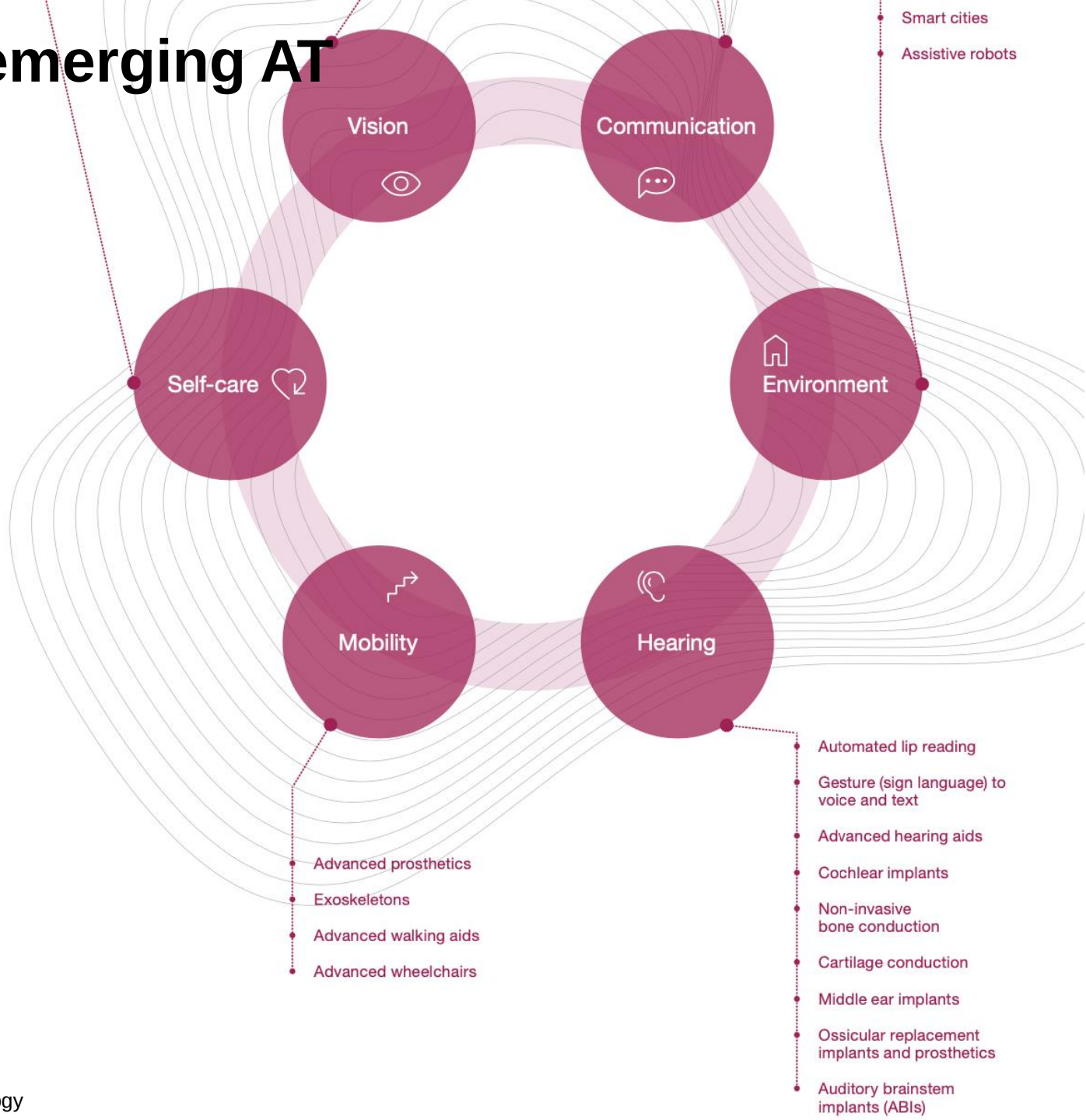
- Formal Caregivers =
  360,000 (0.6% of Korean)

- Formal + Informal caregivers =
  3,600,000 (6% of Korean)
  Including informal caregiver, i.e., family member, and paid workers

Taxonomy of emerging AT

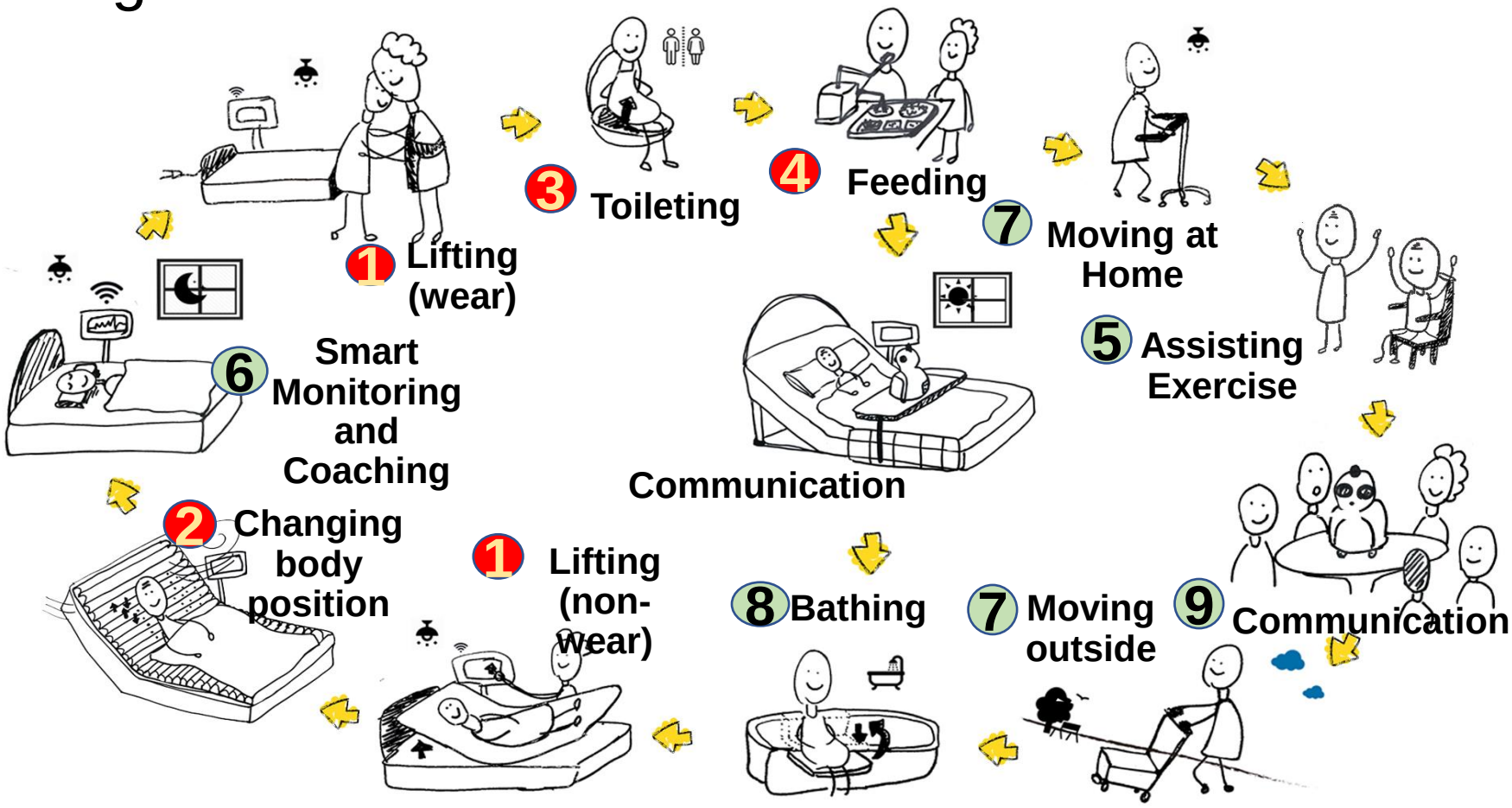


Taxonomy of emerging AT



9 Categories of Care Robots

- High Priority: 1) Lifting, 2) Changing body position, 3) Toileting, 4) Feeding



Lim, M. J., Song, W. K., Kweon, H., & Ro, E. R. (2022). Care robot research and development plan for disability and aged care in Korea: A mixed-methods user participation study. *Assistive Technology*, 1-10.

Convergence and connection of various services

Support for healthy living

Alarm service for taking medicine and meals

Indoor Information

Telling indoor spaces

Social connectivity

Video calling service

Support emergency

Recognition of emergency and support

Personalization

Individual service based on personality

Cognitive training

Apps for cognitive training

https://roaigen.com/en/html/product/product03.php

Smart Care Robot Ecology Balance: Product and Service

Product

① Planning & Tech Development

Planning

- Co-design
- User Forum
- Co-creation
- Rapid Prototyping

Tech Development

- Design
- Vision
- HCI
- Evaluation
- Hand Control
- Force Control
- Soft Robotic

Data Technology R&D

② Translational Research

Translational R&D

- Smart Monitoring
- Lifting
- Moving
- Changing Body Position
- Toileting
- Feeding
- Bathing
- Handling, Walking
- Communication

Advisory Group

- Focus Group
- User Consulting
- Industrial Design, Service Design

Data Technology Verification

Service

③ Living Lab

Social Service Model

- Design Smart Care Space
- User Testing
- User Experience
- User Monitoring
- Cost-Beneficial Study

Safety Requirement

- Risk Assessment
- Evaluation / Standard
- Safety Guideline

Date Technology Testing

④ Public Supply

Smart Care Space

- Experience Shop
- Technology and Service Consulting
- Public Awareness
- Date Technology Dissemination

Expert Consulting

- Education
- Support Technology

Social Service

- Public Benefic
- Pilot Service
- Local Government Funding

(R&D)
Ministry of Trade, Industry and Energy

(R&D) NRC,
Ministry of health and Welfare

(Non-R&D) NRC
Ministry of health and Welfare

Care Robot under Development

Ministry of Industry
Common product technology for care robots

Transfer support
(Lift type,
smart sling)

Bedsore/posture change support
(AI-based)

Excreted support
(feces treatment)

Meal support
(Fully automatic, food sorting)

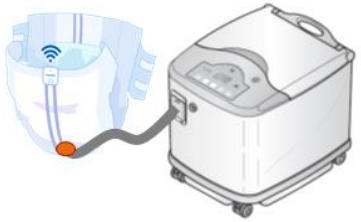
Creating a data-based sustainable development and demonstration environment

Ministry of Health & Welfare
Translational research for care robots

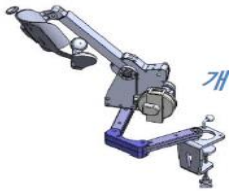
Transfer support
(2 pillars + mobile robot)

Bedsore/posture change support
(sensor based)

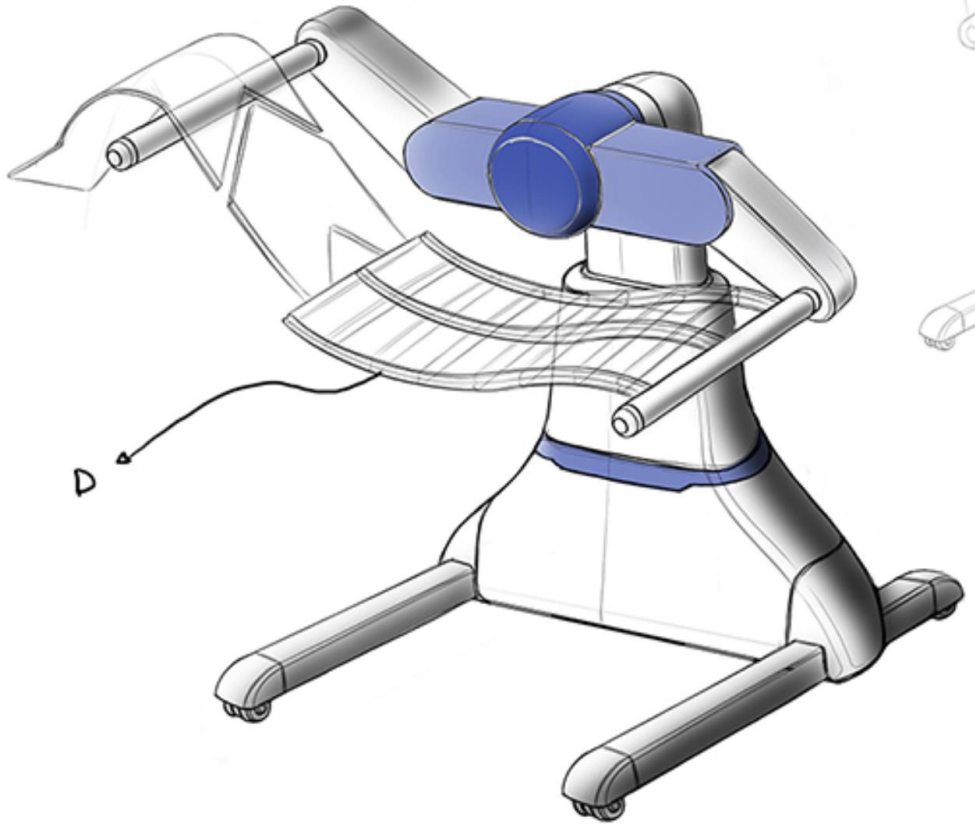
Excreted support
(Urine only, monitoring)

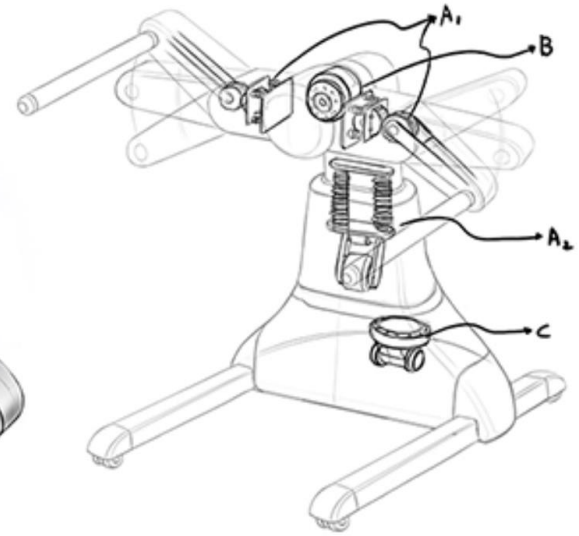


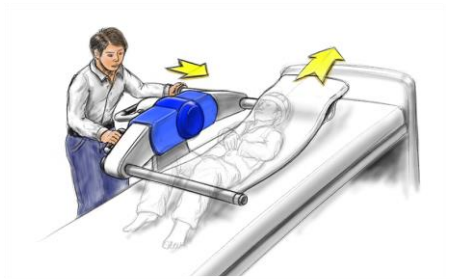
Meal support
(Strength support, using one's own arm)

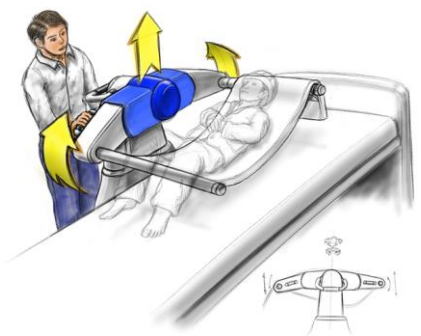


Transfer Robot with Smart Sling (Man & Tel, KIST, …)







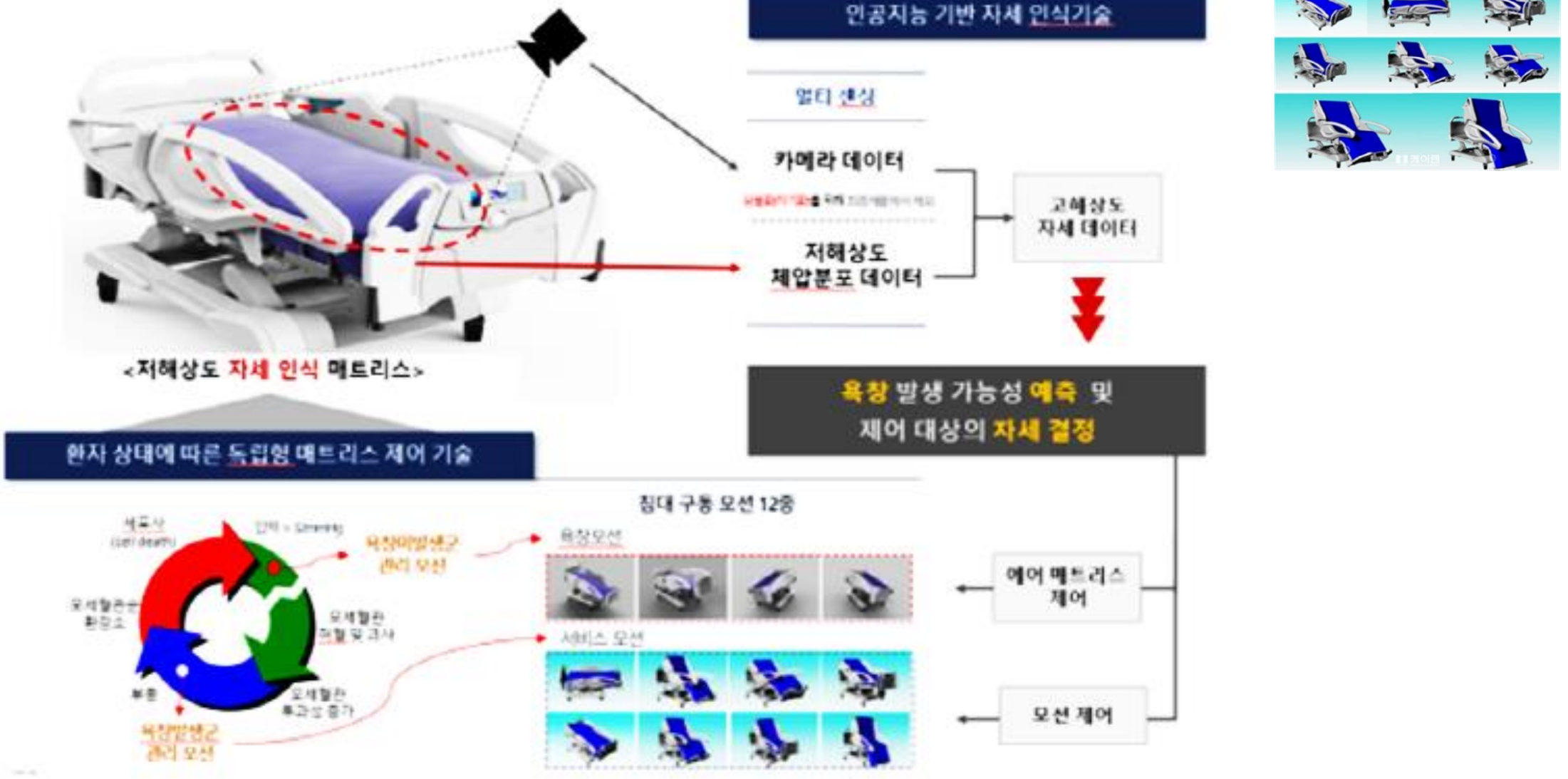


A1: 중력보상 장치(기어타입)
A2: 중력보상 장치(링크타입)
B: 메인 액츄에이터
C: 주행 의도 추종 주행 기구부
D: 공압 방식의 스마트 슬링

Development of Human Centered Smart Assist Robot with Dual Arms for Patient Transfer
2019.04 ~ 2021.12

https://www.medibot.kist.re.kr/post/development-of-human-centered-smart-assist-robot-with-dual-arms-for-patient-transfer

Posture Changing Robot (Alpha robotics, …)



http://www.irobotnews.com/news/articleView.html?idxno=17407

Toileting Robot (Curaco, …)

- Acquired product approval from the Ministry of Food and Drug Safety for excretory care products(Nov. 2021)
- A change in the nursing paradigm to systematize the work that was done manually by nursing personnel in the medical field

로봇신문

뉴스 | 기획·테크 | 오피니언 | 로봇컬처 | 이벤트 | 로봇신문특집

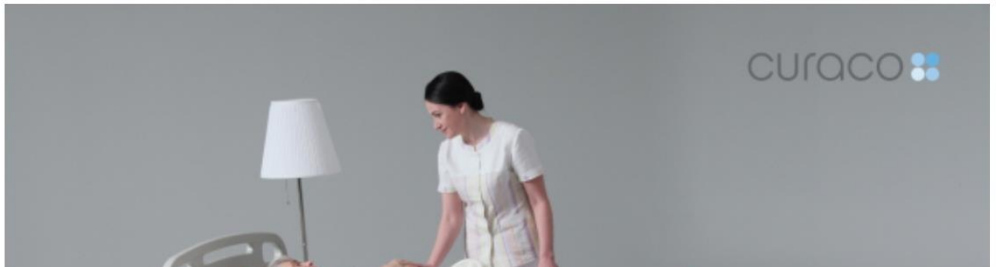
종합 | 정책 | 개인서비스 로봇 | 전문서비스 로봇 | 산업용 로봇 | 로봇 부품·소프트웨어 | 인공지능 | 드론 | 로봇카 | 3D 프린팅

홈 > 뉴스 > 전문서비스 로봇

큐라코, 배설케어 제품 식약처 품목허가 획득

배설케어로봇 전문기업으로서는 전세계 최초로 의료기기 품목허가 획득

승인 2021.11.04 17:40:00



- Reusable urine flow/volume measuring device, Curacare M1
- Example of urine volume measurement = Waste bin (feces collection tank) Collected amount – Washing water usage
- Actual daily urine volume = 3,000cc – 2,000cc = 1,000cc/day
- Average urine volume per 1 time = 1,000cc / 10 times = 100cc / 1 time

MEDI:GATE NEWS

배설케어로봇 전문기업 큐라코, 식약처 품목허가 획득

간병 패러다임의 변화에 대한 단초 제공

이 기사를 많이 읽은 의사 통계를 위한 데이터 축적이 충분치 않습니다.

MEDI:GATE

큐라코는 지난 2일 식품의약품안전처(KFDA)로부터 재사용가능소변유량·용적측정장치, Curacare M1(큐라케어M1)에 대한 의료기기 품목허가를 받았다고 밝혔다.

큐파코는 자동으로 대소변을 처리해 주는 배설케어로봇(Excretion Care Robot) 전문기업이다다.

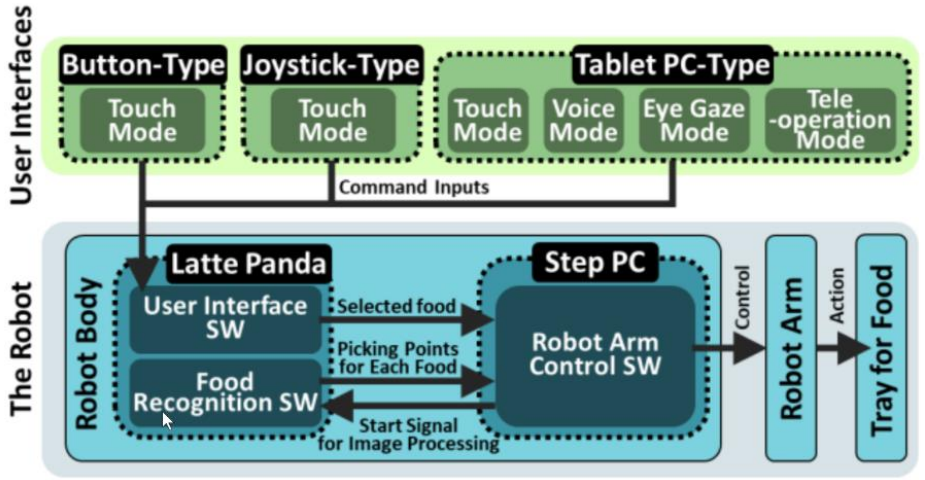
큐라코에서 생산해 판매하고 있는 배설케어로봇 '케어비데'는 와상환자(고령자, 중증환자, 장애인 등)들의 대소변 시 종이기저귀를 사용하지 않고 자동으로 처리해 주는 '자동 대소변 처리장치'다.

환자의 대소변이 감지되면 즉시 처리하고 비데로 청결하게 세정시킨 후 온풍건조까지 모든 과정을 자동으로 실행된다.

http://www.irobotnews.com/news/articleView.html?idxno=26844

http://medigatenews.com/news/2151493298

Feeding Robot (KITECH, GIST, …)



System Overview

- The Robot
  - 6 DoF robot arm
  - Robot arm controller
  - Interface/Recognition SW
- User Interfaces
  - Button-Type
  - Joystick-Type
  - Tablet PC-Type

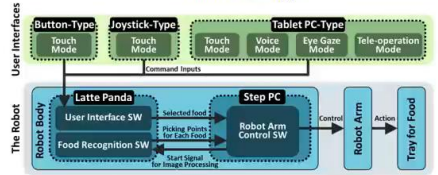


Fig 1. (b) the whole system structure

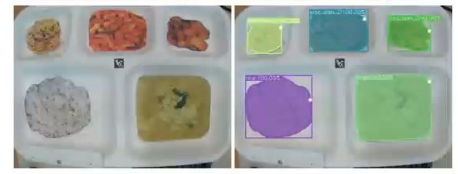


Fig 2. (a) original image. (b) segmentation result

Ubiquitous Robots 2021

KITECH 한국생산기술연구원

Transfer robot (Dong-A Metal, PNU, YUH, KUH, …)

- Development of a safe transfer system with shake control technology applied and a modular patient transfer assistance system applicable to various use environments

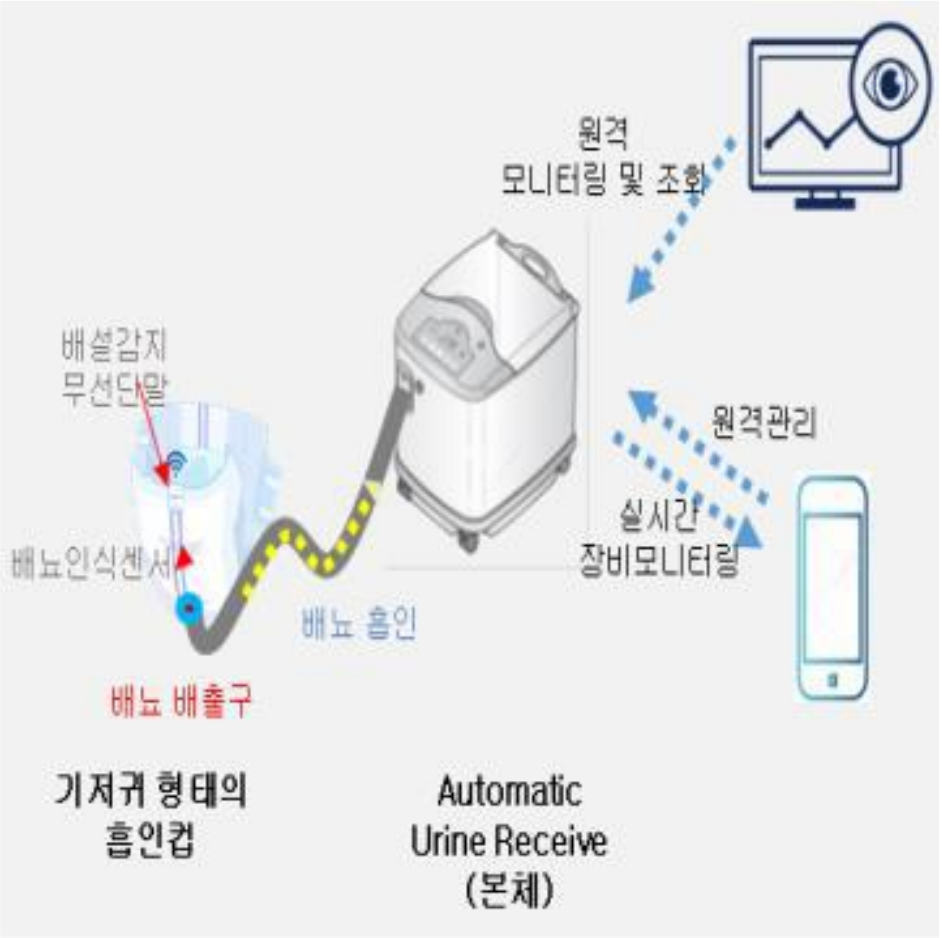
- Integrated lift-off robot with a maximum load of 130 kg or more
- Move on two drive wheels that can change direction

Posture change robot (Goodpol, Able Engineering, KUH)

- Development of multi-axis driven responsive care robot including pressure ulcer prevention monitoring devices
- Posture control bed + mattress + pressure sensor array
- Lateral Tilting included

Toileting robot for urine (Creidus, …)

- Automatic urination suction device with Urine Receptacle function in smart diaper
- Development of an easy-to-carry automatic excretion assisting robot in the form of a diaper applied with automatic urination suction robot technology
- Reduced diaper change quantity through urine suction function in diaper

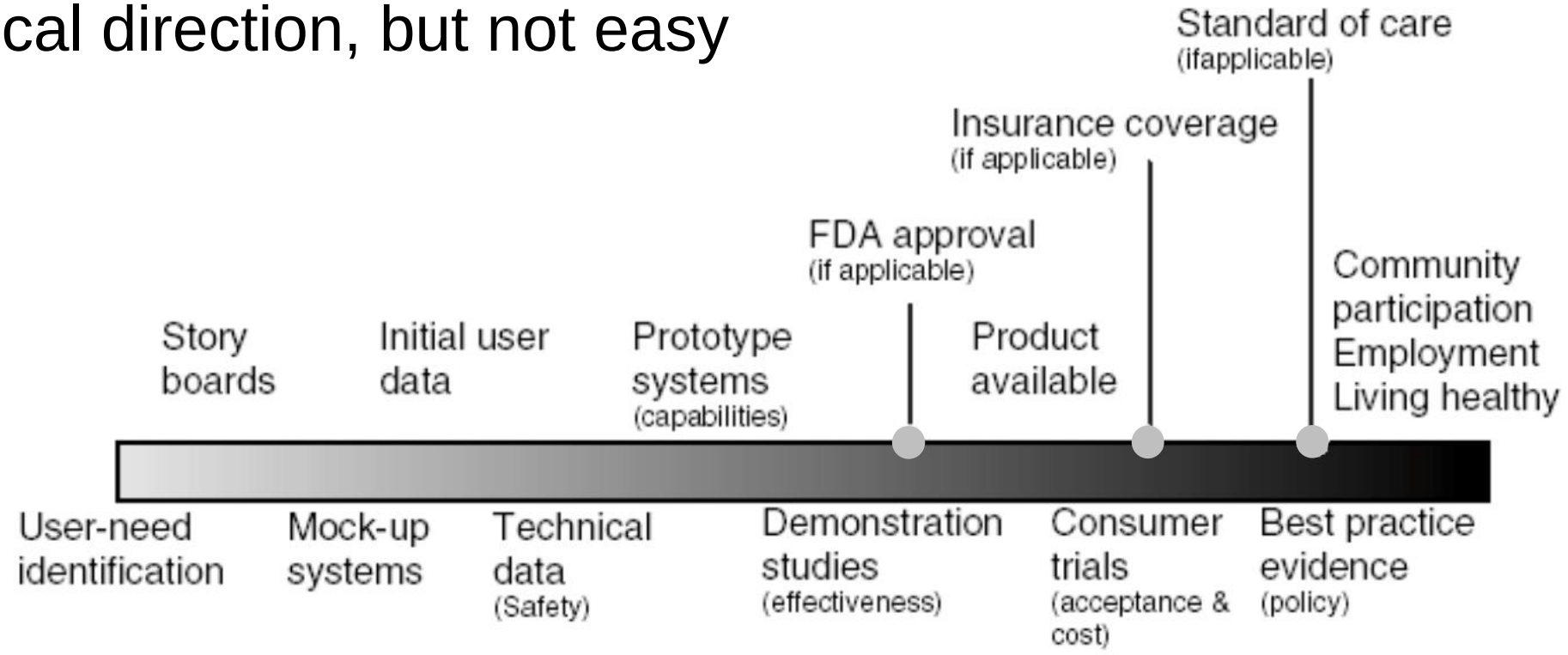


Feeding robot (NT Robot, SKKU, YU)

- Development of care robot with active assistance type structure for the severely disabled and the elderly with mobility difficulties
- Use one's arm
- Different assistive forces can be applied when raising and lowering the arm.

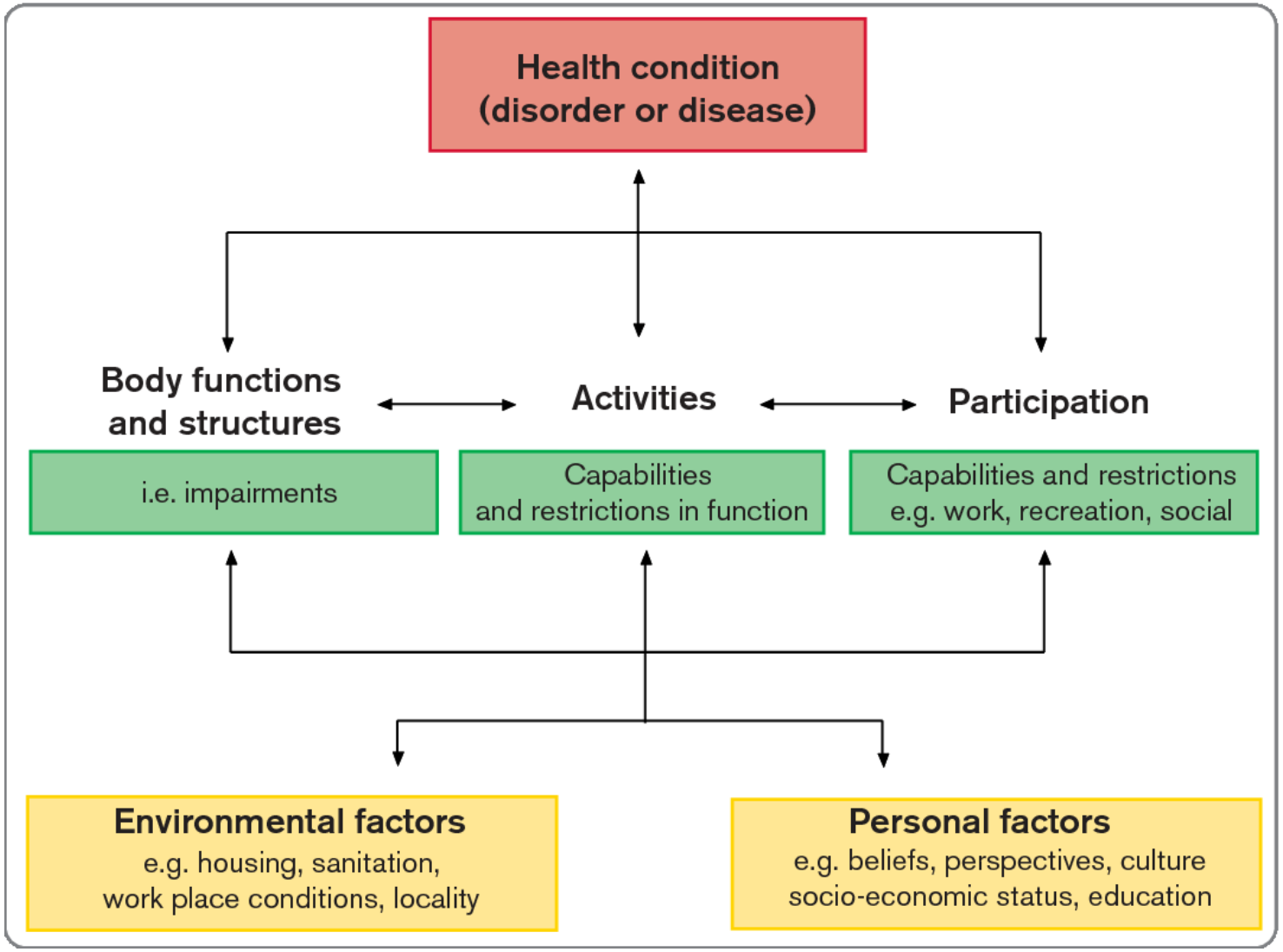
Participatory Action Research

- Participation of consumers and stakeholders throughout the entire cycle
- Practical direction, but not easy



Ding 2007

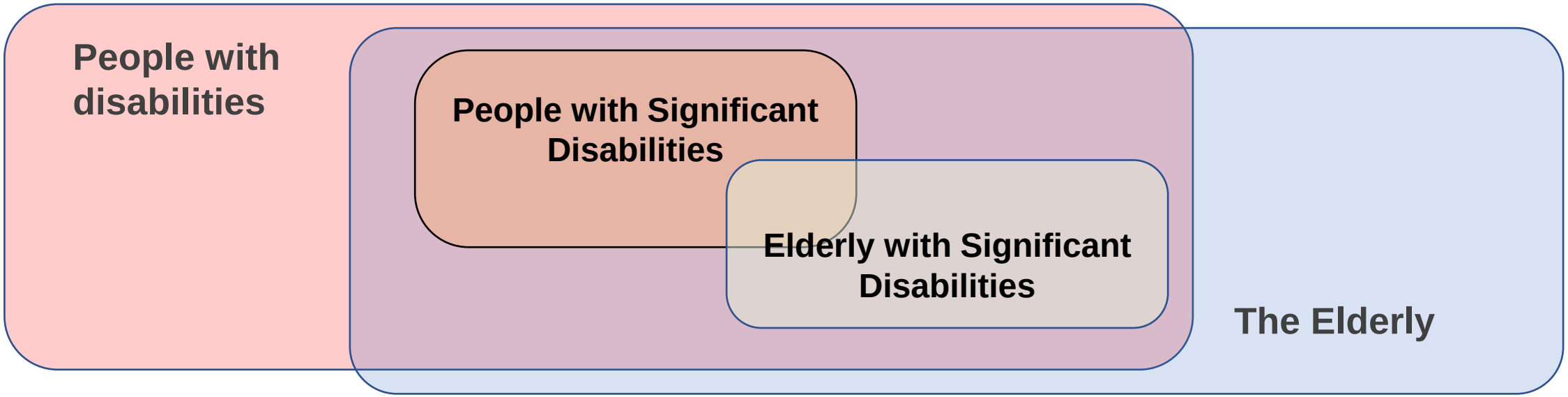
ICF (International Classification of Functioning, Disability and Health) 국제기능장애건강분류



World Health Organization · 2001
http://www.welfareissue.com/news/articleView.html?idxno=2307

Smart Care Space

- Custom-made space: New/Existing care robots + Environment + ICT



1st Smart Care Space

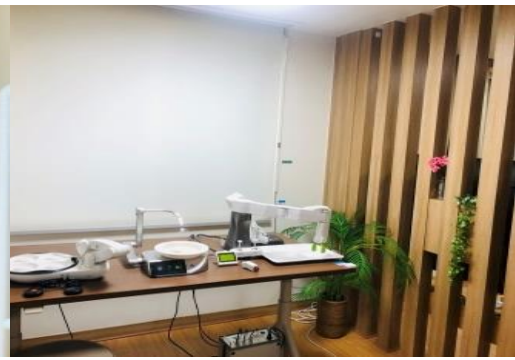
Entrance

Kitchen

Bedroom

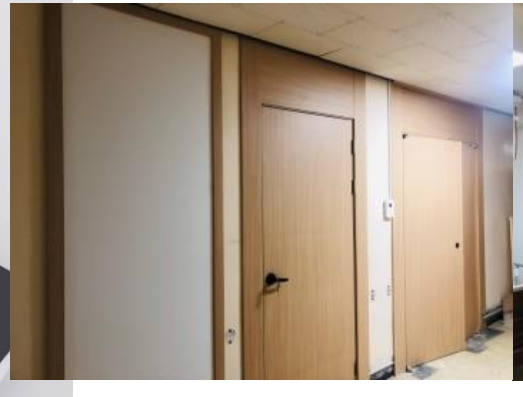
Bathroom

Living room



Dining room

2nd Smart Care Space



Entrance

Kitchen

Bedroom

Bathroom

Caregiver’s room

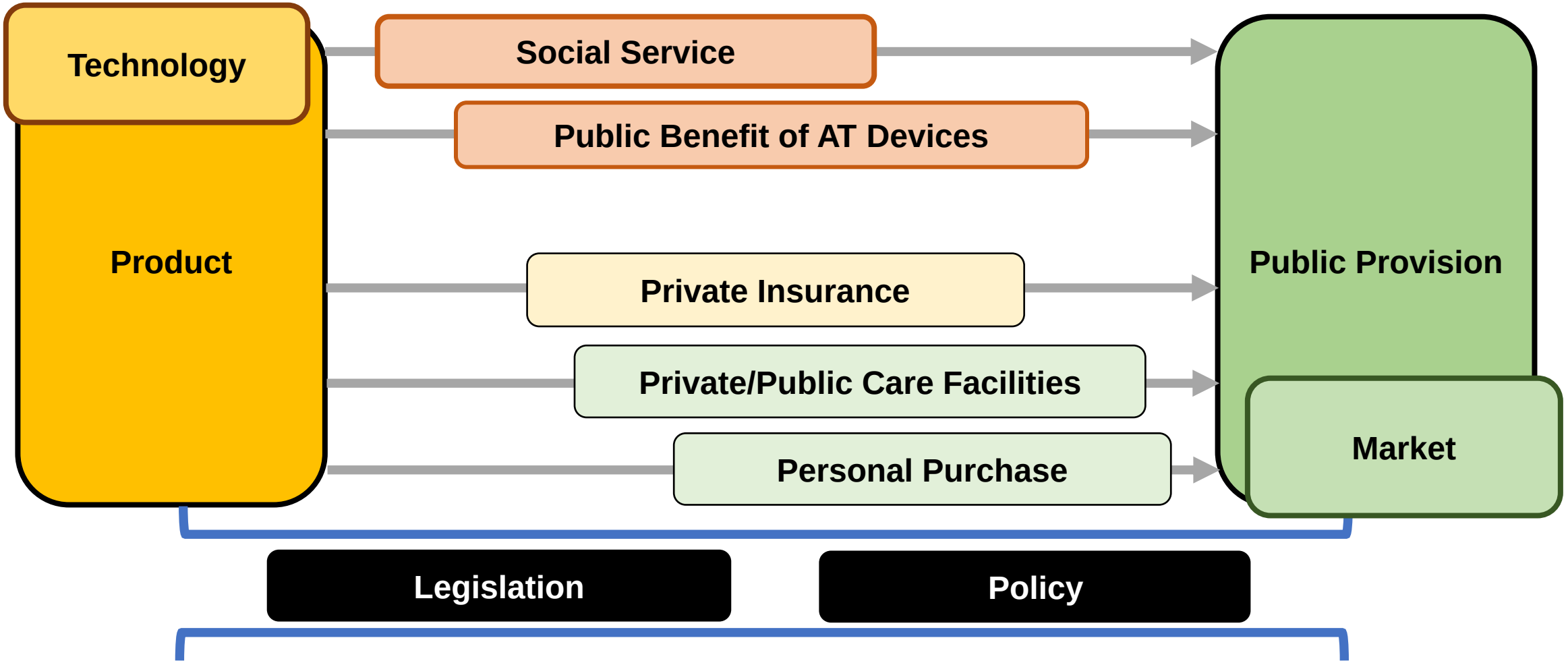
Pantry

Smart Care Space

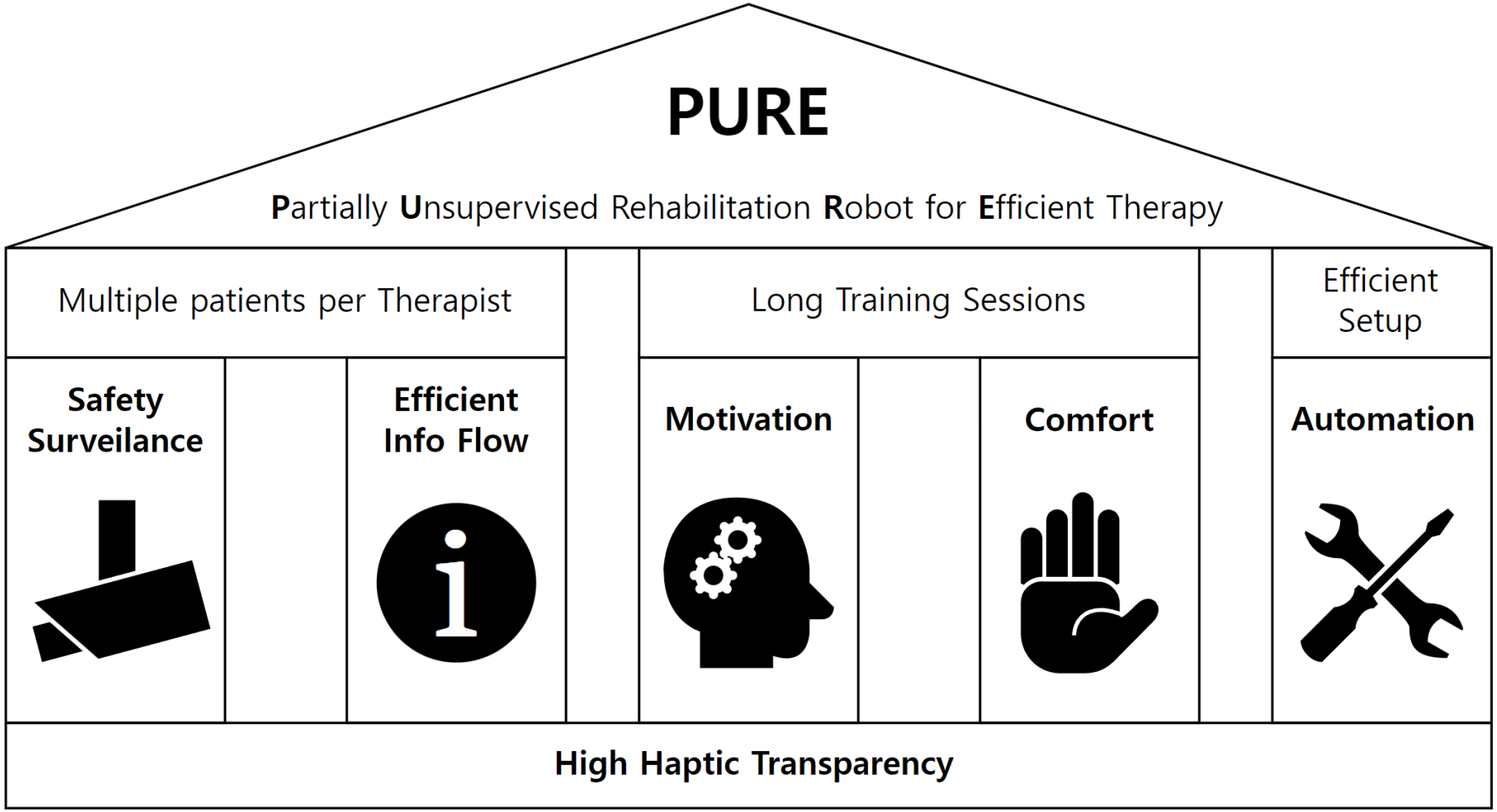
	1st Smart Care Space	2nd Smart Care Space	3rd Smart Care Space
Space	60 m^2	40 m^2 (similar with 1 person living space in facilities or medical safety houses)	20 m^2 (similar with 1 person living space in facilities or medical safety houses)
Hoist	Ceiling hoist with extensive program of ceiling and wall mounted tracks	Ceiling hoist with single track	Floor lift
IoT devices	Installed including AI speaker	Installed including AI speaker and touch-typed input devices	Will be installed
Caregiver's rest space	-	Available	-
Device storage space	Available	Available (relatively wide)	N/A (shared warehouse)

Service + Business Model to Public Provision + Private Market

- Not only technology, but also regulation and policy



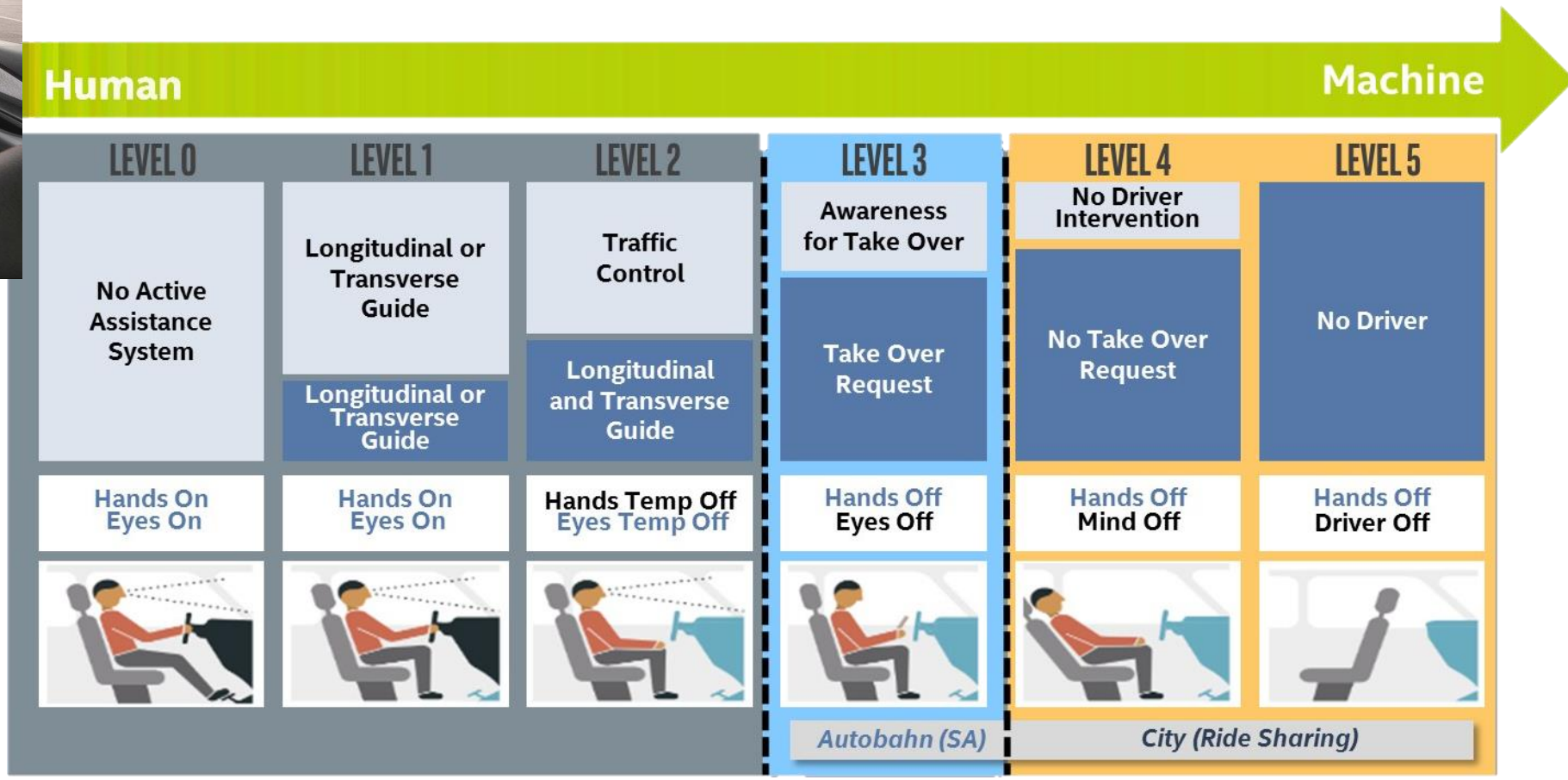
PURE – A Partially Unsupervised Rehabilitation Robot for Efficient Therapy
→ Partially Unsupervised Care Robot for Efficient Caregiving ?



https://sms.hest.ethz.ch/research/current-research-projects/armin-robot.html

6 Levels of Vehicle Autonomy

The Society of Automotive Engineers (SAE) defines 6 levels of driving automation ranging from 0 (fully manual) to 5 (fully autonomous).



https://www.kakaobrain.com/blog/59
https://post.naver.com/viewer/postView.nhn?volumeNo=27140933&memberNo=32025603

Take Home Messages

- Moving from **technology that helps caregivers** to **smarter care**
- Based on R&D experience on **Therapeutic Rehabilitation Robots**, it is expanding into **Care Robots**.
  - Making tangible results through various R&D and pilot provision for over 12 years.
- **Innovative technology** and **practical technology** must be balanced.
  - R&D should be conducted in a sustainable way.
  - The depth and scope of R&D should be expanded.
- **Application and demonstration** according to various **situations** and **cultural perspectives**
  - **Good testbed, older adults,**
  - **Hospitals, facilities, and home in diverse environments**
- With the development of the **non-face-to-face industry** due to COVID-19, the utilization of **Data-Network-AI-Robot** will increase.