SeAMK
SEINÄJOEN AMMATTIKORKEAKOULU
SEINÄJOKI UNIVERSITY OF APPLIED SCIENCES

CHIBA UNIVERSITY

Sensing Technology for Dementia Care Support

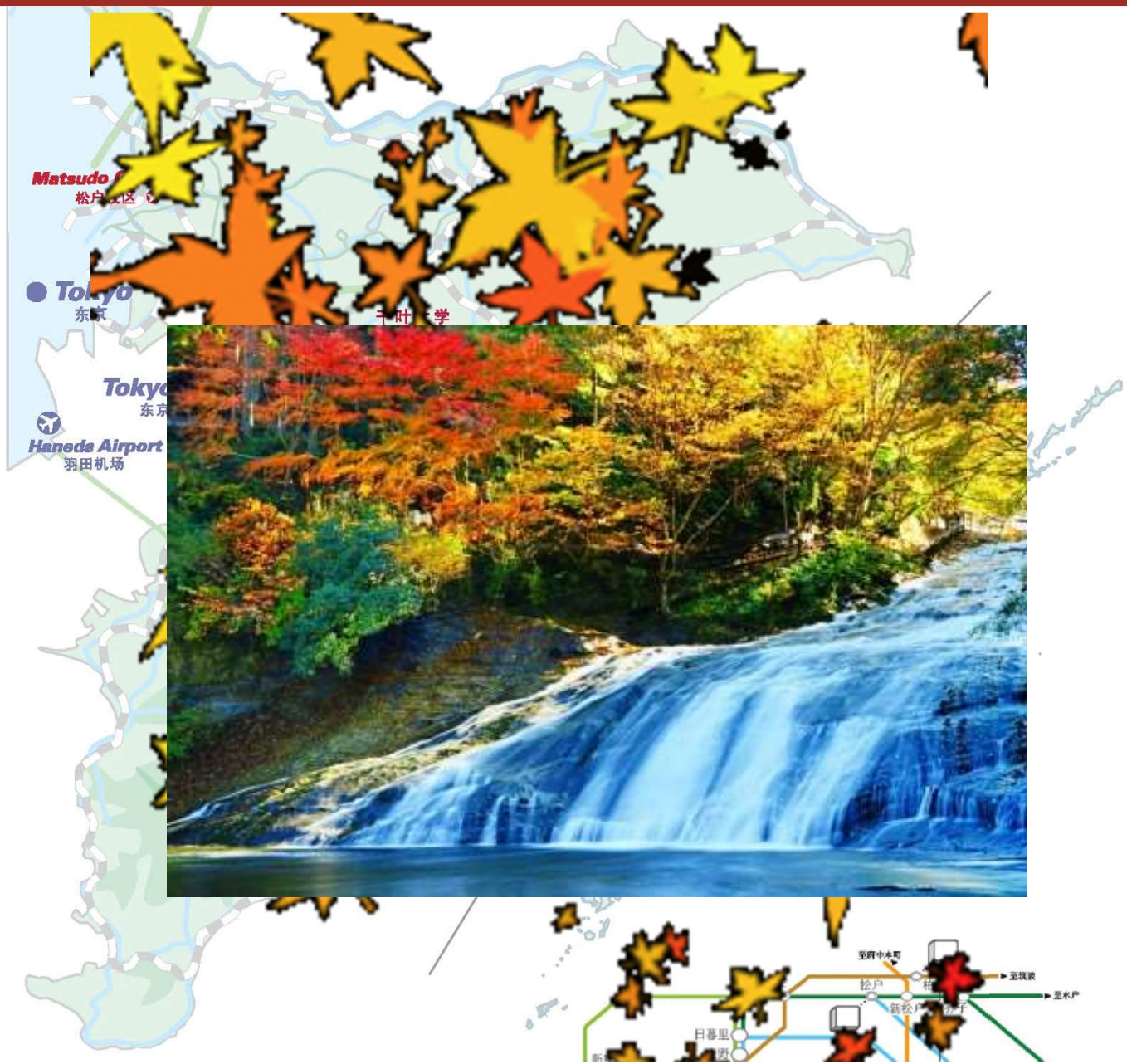
Wenwei YU

Center for Frontier Medical Engineering
Chiba University, Japan

Feb. 17 2021

Virtual International Week at SeAMK

Chiba(千葉): The Sky Gate of Japan



Outline

- Ageing Society in Japan and Finland, dementia in Japan and nation-wide policy, and our motivation
- Current state of dementia care support
- My standpoint
- How sensing technology can help dementia care
  - ✓ Case Studies

Is Finland following the same path as Japan?

Population share of older age cohorts, median age, dependency ratio, life expectancy at different ages

	Finland				Japan			
	1980	*2015*	*2030*	*2050*	*1980*	*2015*	*2030*	*2050*
Population share of elderly people, %								
60+	16.4	27	31.3	33.1	12.8	33.1	37.3	42.5
65+	12	19.7	25.4	27	9	26.3	30.4	36.3
80+	1.8	5.1	8.6	11.1	1.4	7.8	12.7	15.1
Median age	32.8	42.5	44.4	45.1	32.6	46.5	51.5	53.3
Dependency rate, %								
Children	30	25.8	25.8	25.1	35	21.1	21.3	24.3
Eldery people	17.7	31.8	42.8	46.3	13.4	43.3	53.1	70.9
Total	**47.7**	**57.6**	**68.6**	**71.4**	**48.4**	**64.4**	**74.4**	**95.2**

Soures: UN and Bank of Finland.

[Bank of Finland Bulletin]

Japan is faced with an ageing care crisis

- Declining population and super ageing society
- Big pressure to national economy and finance from ageing care – long-term care insurance
- Lack of caregivers for home and community
  - Overworked and overstressed care workers
  - Insufficient care services for care receivers
- Respect for autonomy: one of the common bioethics principles, needs to be taken into account in care service
  - care should be neither too much, nor too little
  - patient centered care for people with dementia

Estimates on Older People with Dementia in Japan

—research team at the Ministry of Health, Labor and Welfare—

- 15% nationwide prevalence rate for dementia (2012)
- Approx. 4.62 million people estimated to have dementia (2012)
- The number of people with dementia is estimated to be 6.75–7.30 million in 2025
  - 1 out of every 5 older people

Motivation

- Prevention and cure haven't been established.
- Persons with dementia are suffering.
- Family carers and professional carers are mentally and physically heavy-loaded.
- All of us have a high risk to get it.
- It turns to be a long-term serious social problem.

Requiring a rally of all power across nations, disciplines

“Dementia Supporters” Training Program

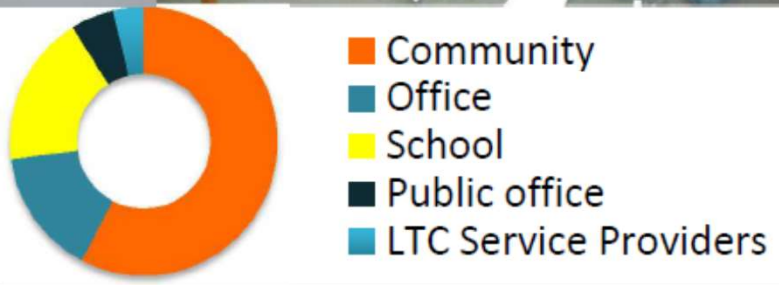
people of every generation, every occupation are becoming “Dementia Supporters”

Over 8 million

supporters have been trained as of September 2016.

Dementia Supporters Program

- ✓ **Voluntarily**
- ✓ **with proper knowledge and understanding**
- ✓ **in communities and work places**



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Current State of Dementia Care

People with Dementia:

- Difficult to express their own intention / will, difficult to know their own state

Care Staff:

- Difficult to notice and understand the state, intention, and decision-making ability of the people with dementia
  - ✓ Lack of experience
  - ✓ In the case that one staff has to care for multiple persons, it is impossible to observe details continuously
- Difficult situations: ADL care, identification of real intention, BPSD

— **ADL:** Activities of Daily Living

— **BPSD:** Behavioral and psychological symptoms of dementia

Current ADL care support technology

SOTA, NTT-Data
Communication

PARO, AIST
Mental Care

PN-L , Panasonic
Bathing Support

PowerSuits, TUS
Lifting Support

Sawayaka, Daiwa House
Excretion

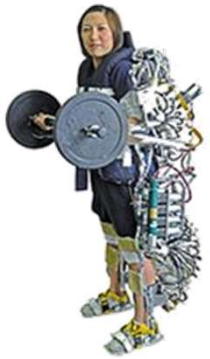
Care Receiver Support Technology

Care giver Support Technology

RIBA, RIKEN
Transferring

SANYO
Bathing

HAL, TSUKUBA
Walking

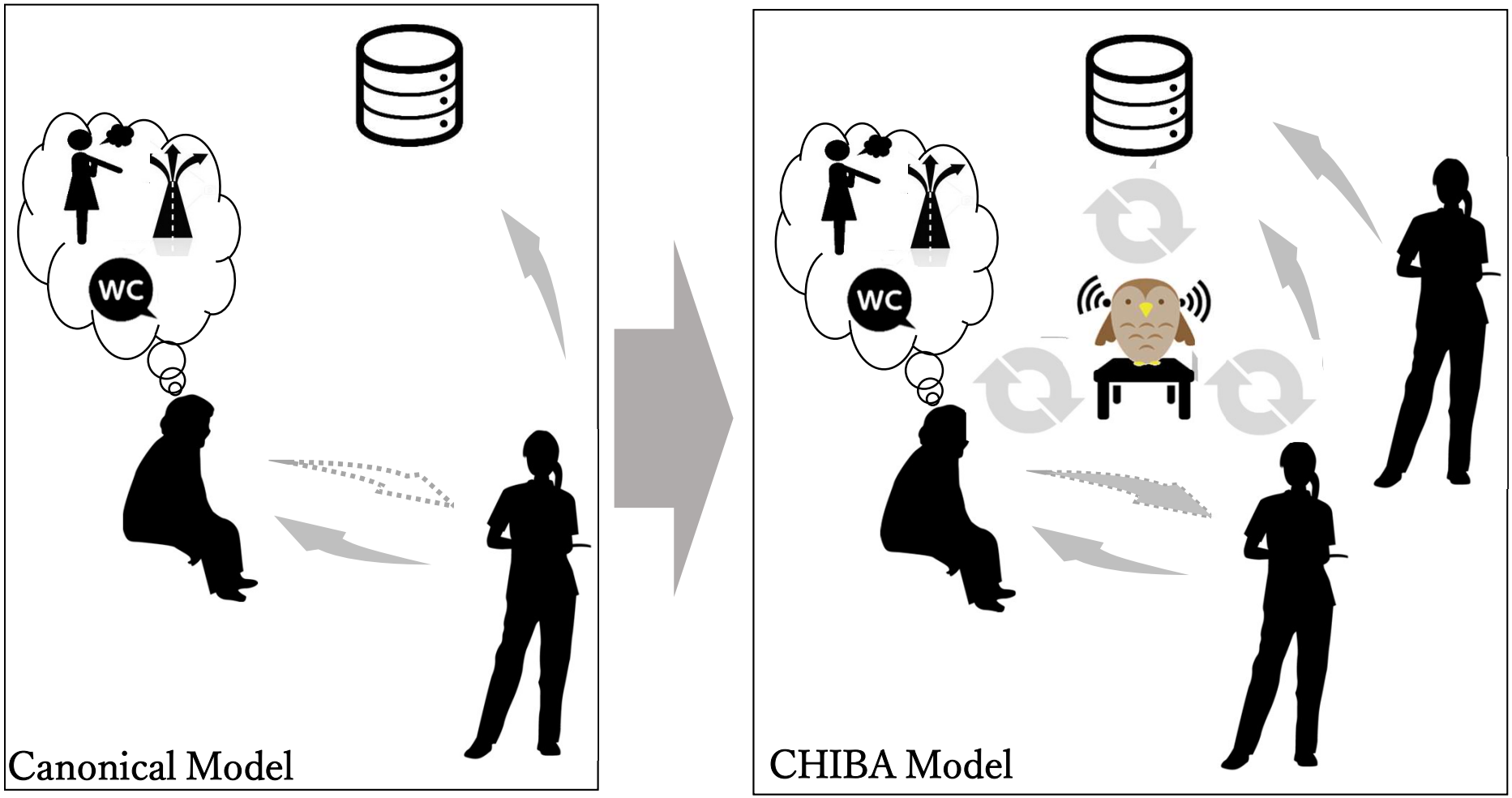


PowerSuits, KIT
Lifting Support

How to realize the patient centered care for people with dementia?

- Supporting the care receivers as needed
- Sensing the state of care receivers during their Activities of Daily Living (ADLs)
  - Need, decision, intention, desire, will
  - Procedure of ADLs

Dementia Care CHIBA Model



WC : ADL

: BPSD

: Decision Making

: Monitoring Info. Integration Platform

Technical Problems

- Non-invasive, non-constrained, long-term measurement is preferable
- Necessary to estimate their states from limited, uncertain information
- Supporting individuals with different living independence and dementia levels

Can the problems be solved in the current Assistive Technology framework?

Outline

- Aging Society in Japan and Finland, Dementia in Japan and Nation-wide Policy
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Fundamental Research & Application

http://www.tms.chiba-u.jp/~yu/English/

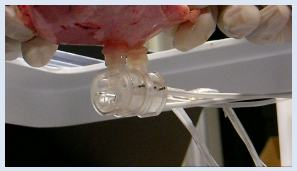
Assistive Technology, Rehabilitation

Assistive Technology

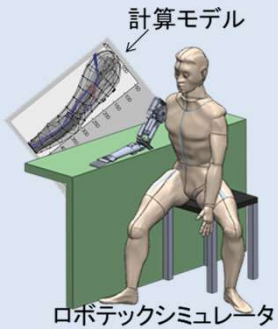
Care Support Robotics

Surgery Support, Medical Training

Soft Pneumatic Forceps



Laparoscopic Surgery Support

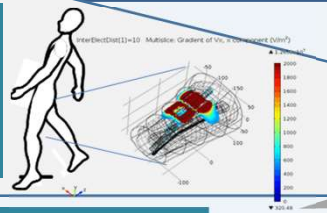


Neurology Simulator

Req

Req

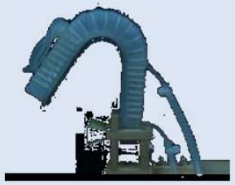
Electrophysiology Simulation



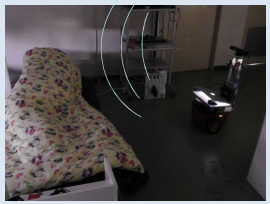
App

App

Robotics Fundamentals

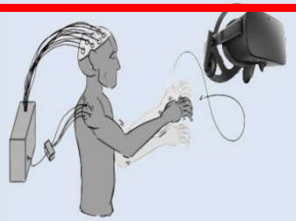


Soft Actuators



Non-contact EM-measurement

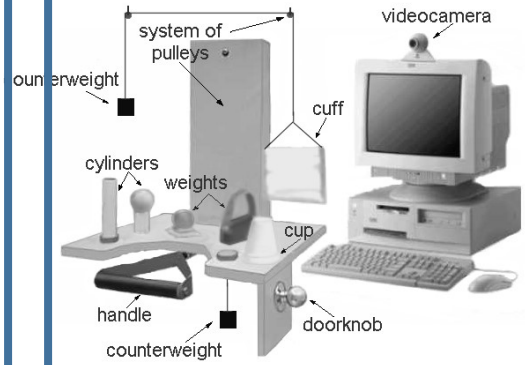
Real Time Visual Tracking



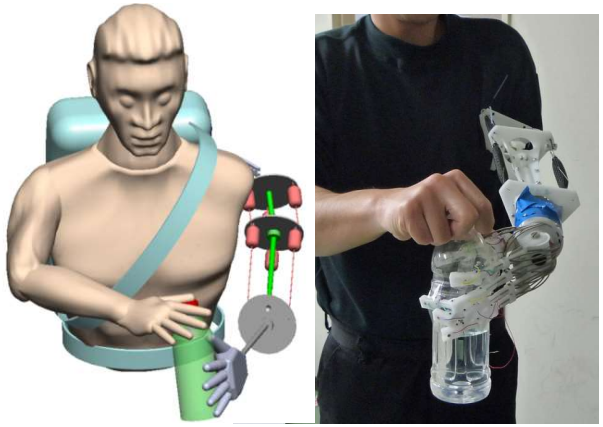
Dynamic Interface

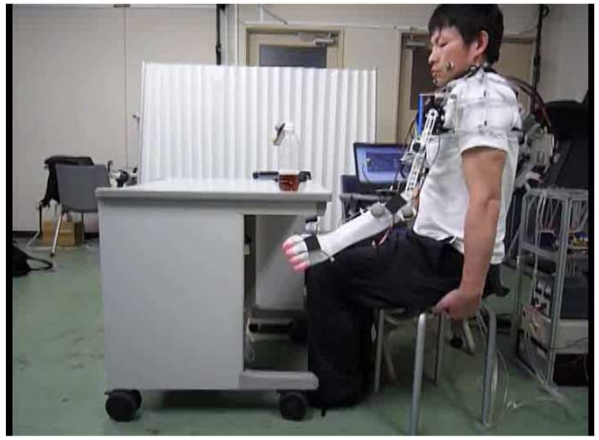
Intention detection for Assistive Technology

Good leg teaches impaired leg



Upper limb home Rehabilitation



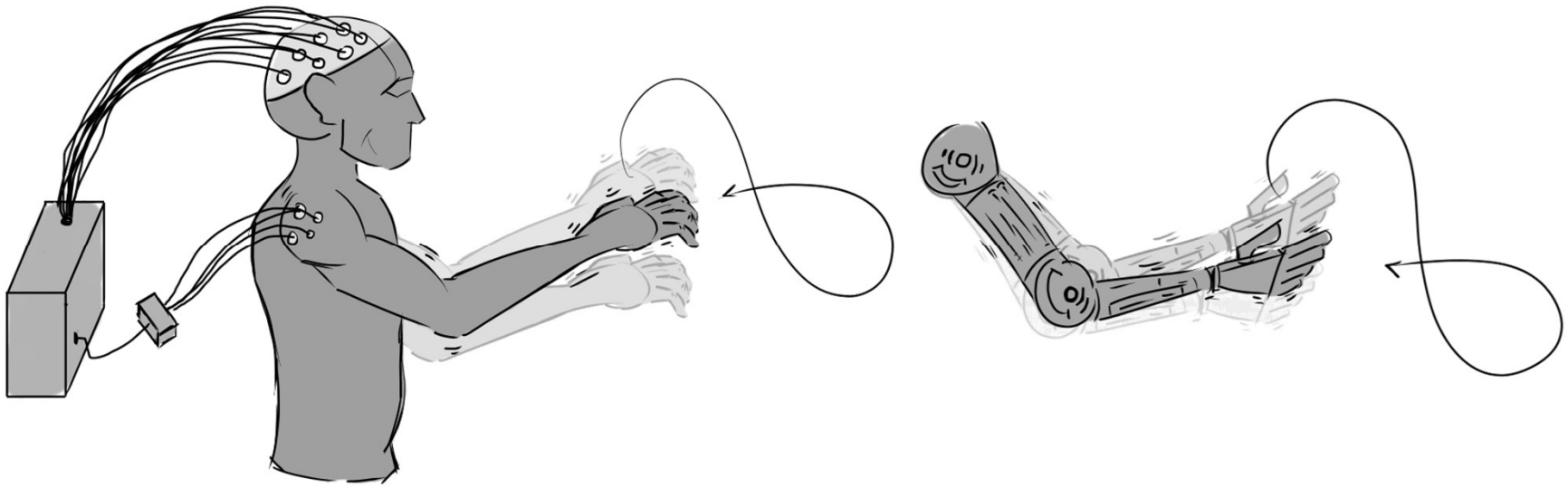


Bimanual coordination for Prosthetic arm users

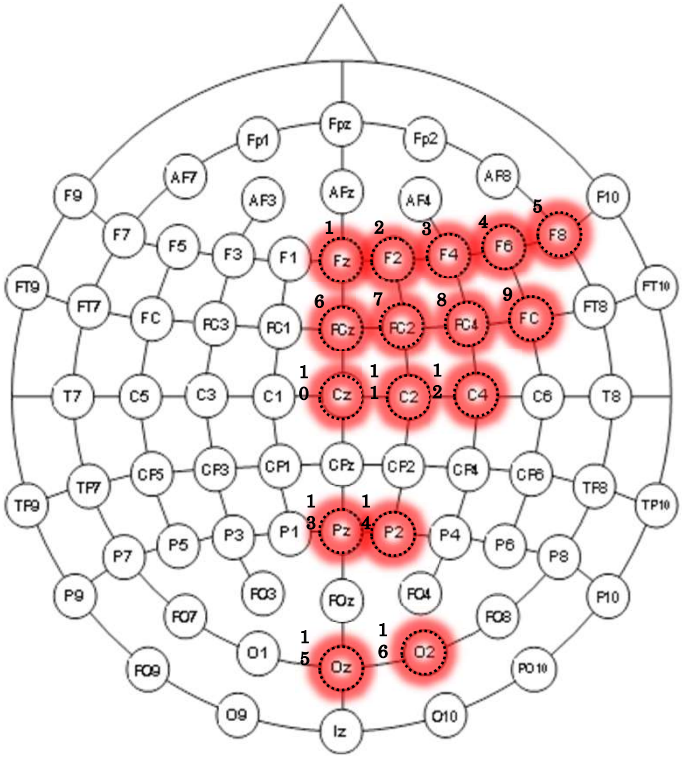
Motion reconstruction for prosthetic arm users

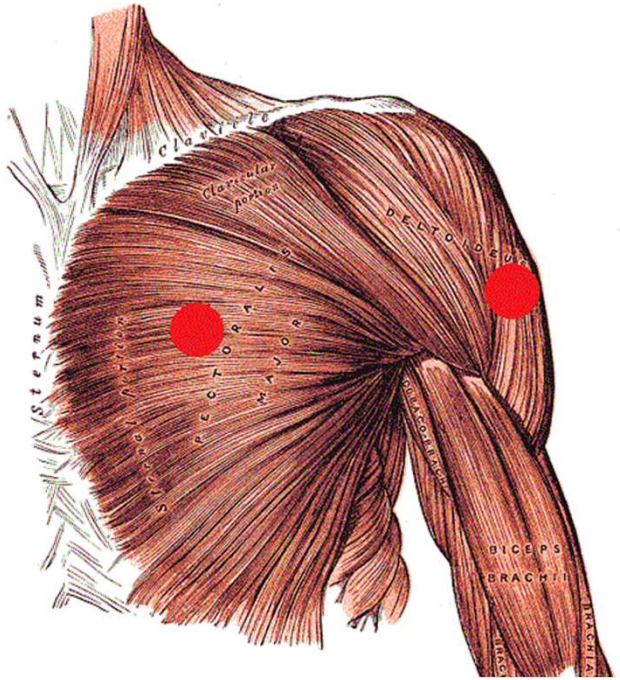
Motion reconstruction: Estimating the position and trajectory of a limb from motion-related bio-signals, without cameras or tracking devices. My focus was the reconstruction of the hand's position.

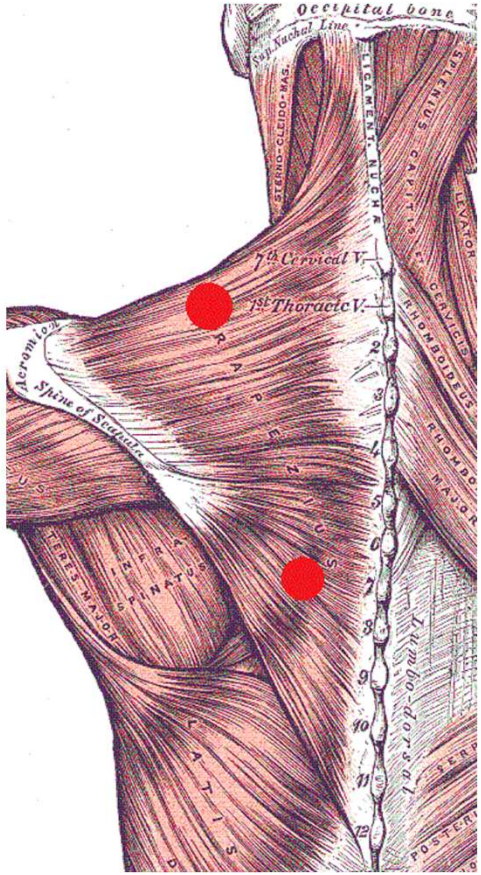
Application: Control of prothesis, video game control, rehabilitation.



Acquisition Method





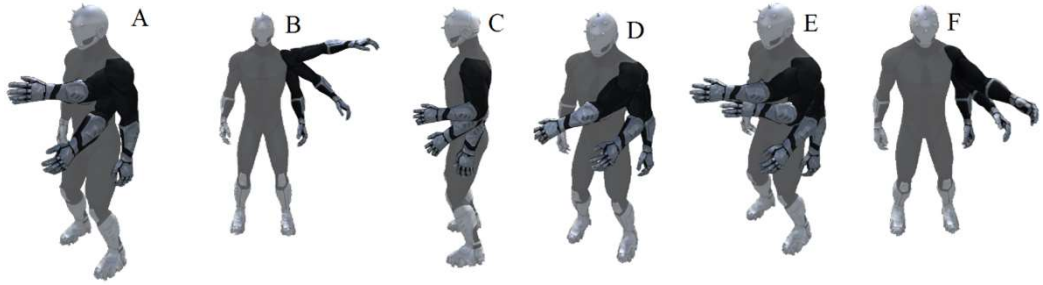


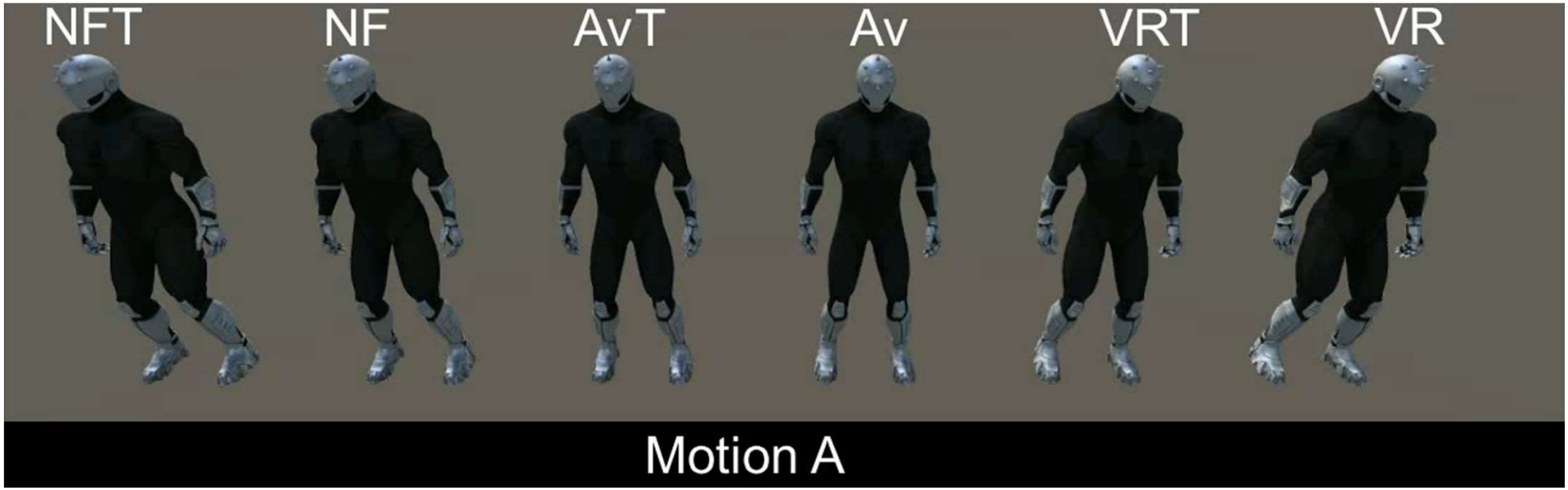
EEG: Electroencephalogram

EMG: Electromyogram

Reconstructed arm motions in VR

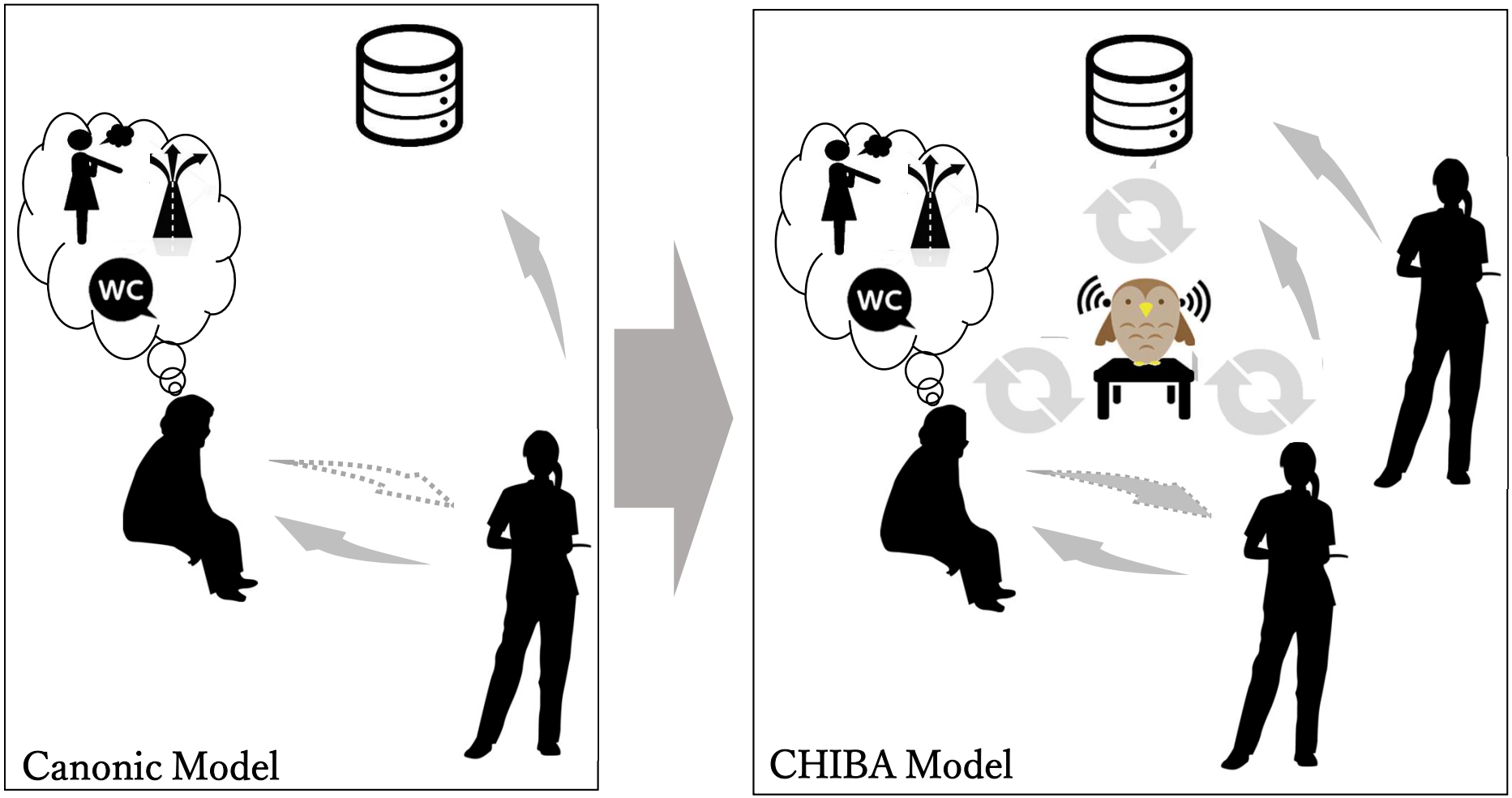
- “T” =Temporal
- Six motions in consecutive order
- Worse result for grasping motions.
- CV=[0.7 0.714 0.779 0.722 0.773 0.774]





Much higher correlation values than those reported in the literature

Dementia Care CHIBA Model



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In the remainder of this talk

- Case studies: Estimation of intention and states of ADLs for the older people
  - ✓ Sensing urinary desire for dementia people
  - ✓ Sensing medication process
  - ✓ Mobile and active sensing for recognizing ADLs in home environment

Urination behavior modeling related R&D

Existing products

urination prediction tool; DFree

○accurate prediction based on sensing bladder activity

△high possibility to cause uneasiness

Kato, 2016

Previous work

Cognitive assistance technology; COACH

○Realization of handwashing assistance form image.

△Urination unexamined（urination signs not analyzed）

Hoey et.al, 2010

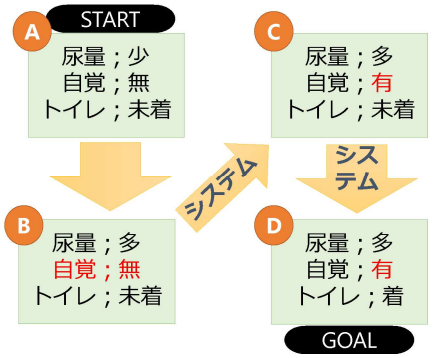
Goal

To estimate urinary desire
from the indicative gestures of the care receivers

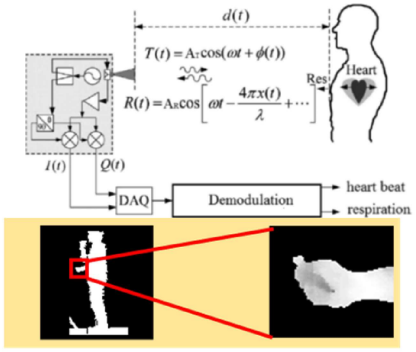
On-going: Urination, and Medication Behavior Modeling & Analysis

IRB ethics approval

Urination Behavior Modeling and Autominding for Dementia Persons



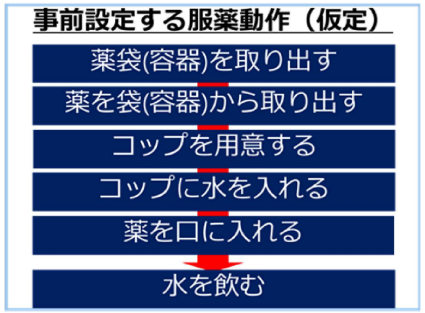
Behavior Model



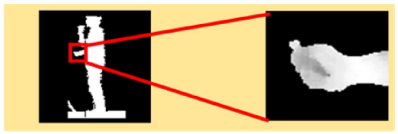
Sensor Module

Detecting urinary desire by non-contact measurement: **indicative gesture** and/or **physiological signals**

Medication Behavior Modeling and Autominding for Dementia Persons



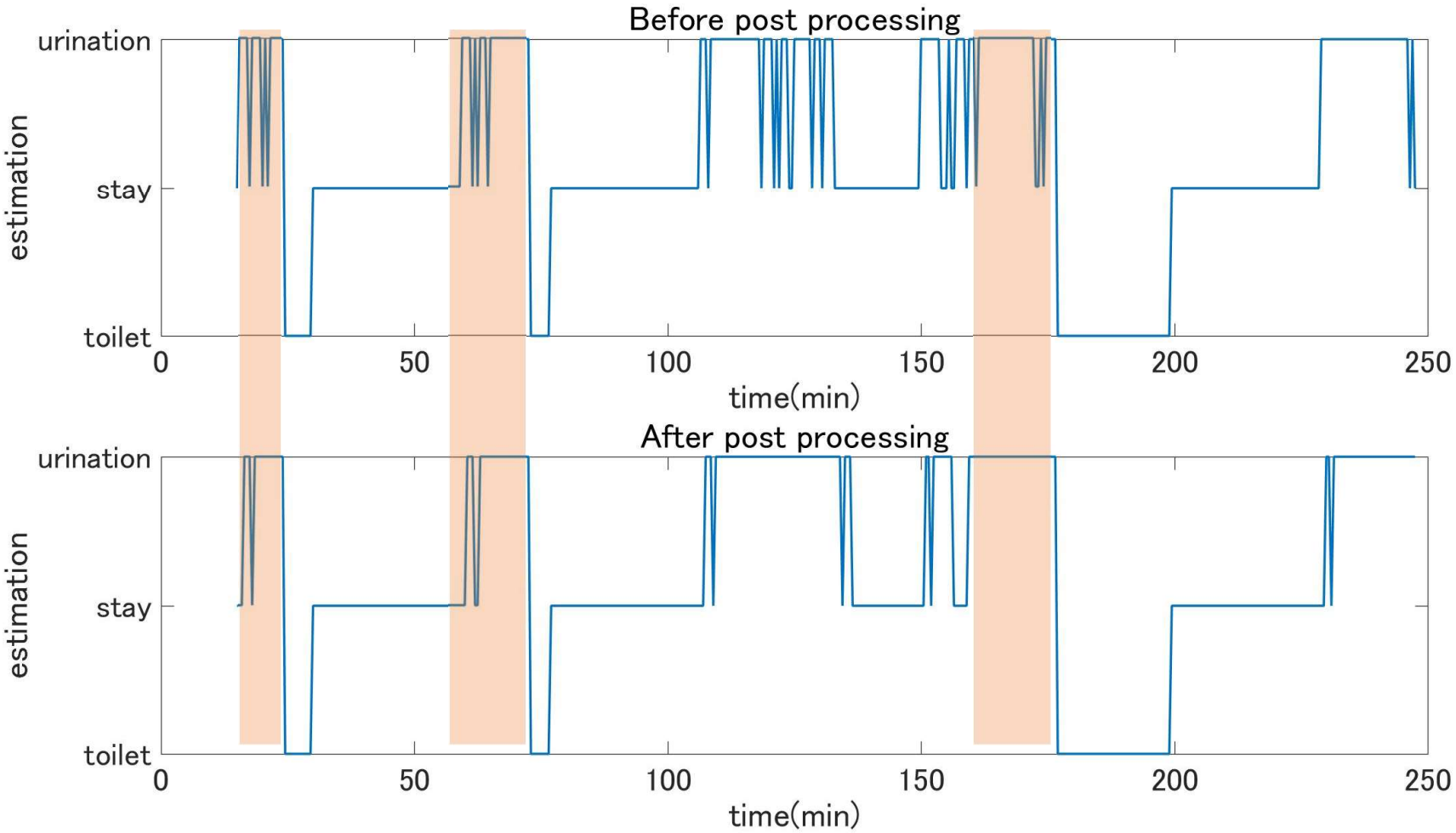
Behavior Model



Sensor Module

Medication behavior modelling by hand silhouette and trajectory

Results (one instance)



For this instance: Sensitivity 77.4%, Specificity 69.7%, Correct Rate 71.2%

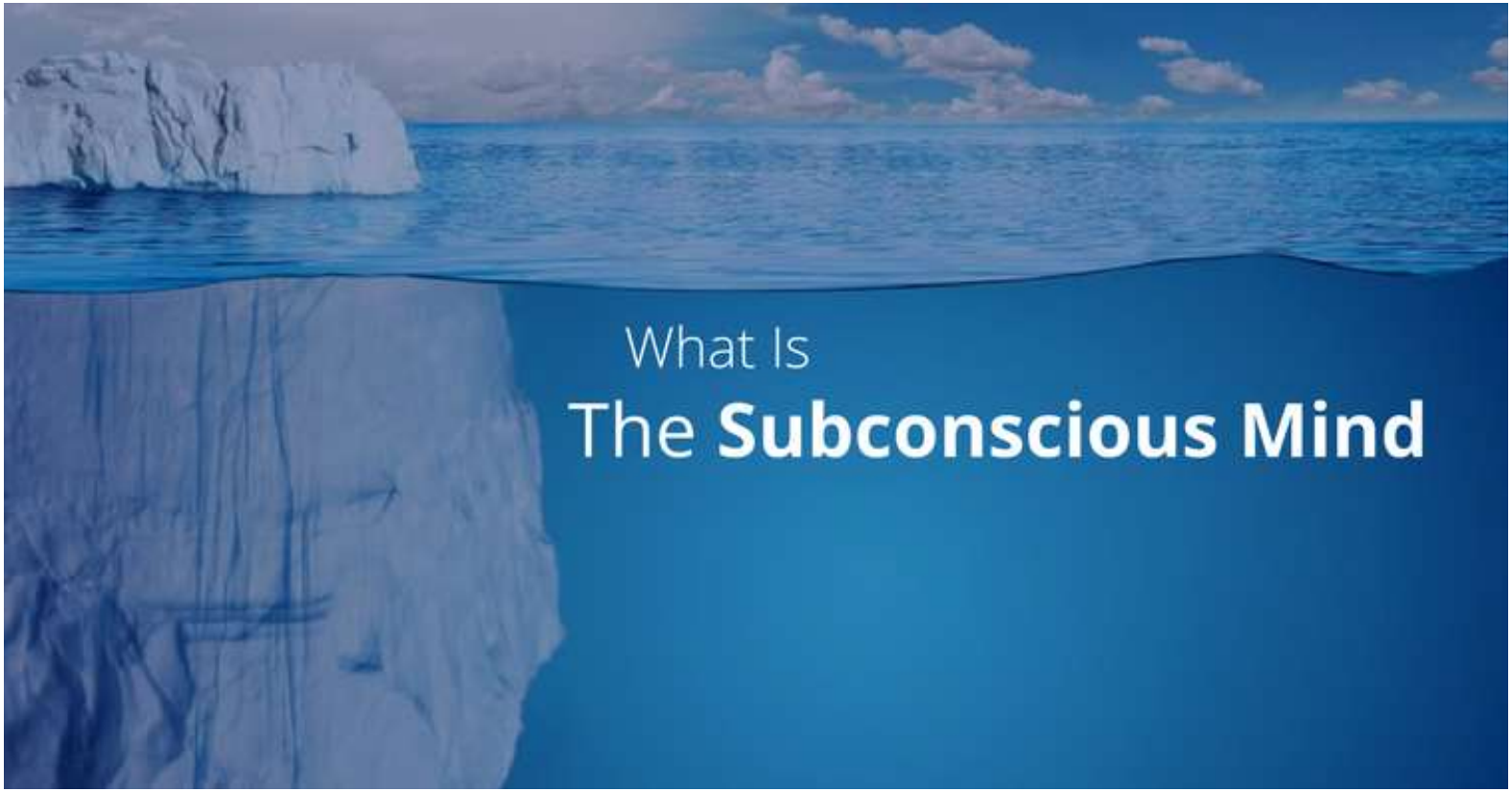
For all the 5 subjects: Correct Rate 69.5%

To further improve prediction accuracy:
with systolic, diastolic pressure & heart rate

		Summer			Winter		
		Quiet	Before Uri	After Uri	Quiet	Before Uri	After Uri
Systolic mmHg	通常時	104.2±3.4	110.5±0.9***	105.7±0.9	101.0±2.5	110.9±1.2***	108.4±1.1**
	抑制時	103.7±3.4	117.1±1.3***	108.6±1.2*	102.1±3.6	123.4±2.4***	113.1±1.9***
Diastolic mmHg	通常時	64.1±2.8	71.4±0.8***	67.0±0.7	65.2±1.8	73.8±0.9***	70.5±0.8**
	抑制時	63.9±2.2	80.5±1.4***	71.0±1.0***	66.1±2.8	81.2±2.0***	72.9±1.2***
heart rate Beat/min	通常時	68.1±2.9	77.9±1.0***	75.5±0.8***	71.7±1.3	79.8±1.0***	75.8±0.9***
	抑制時	68.9±2.8	89.6±1.9***	75.9±1.1***	69.4±0.9	88.0±2.0***	76.4±1.5***

- Matsumoto, Tawara et. al. Changes in blood pressure and heart rate on nature and endured micturition

Implication: the subconscious mind of dementia people could be explored



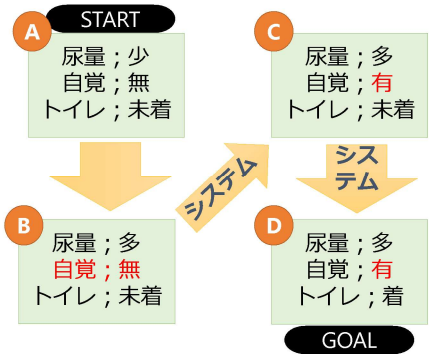
https://imotions.com/blog/what-is-the-subconscious-mind/

Possibility of a new communication channel

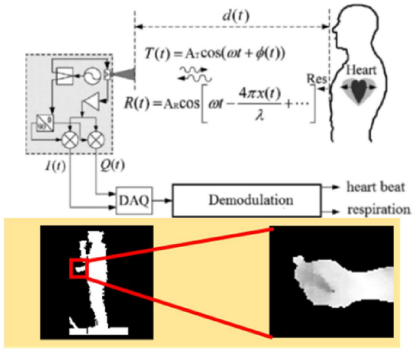
On-going: Urination, and Medication Behavior Modeling & Analysis

IRB ethics approval

Urination Behavior Modeling and Autominding for Dementia Persons



Behavior Model



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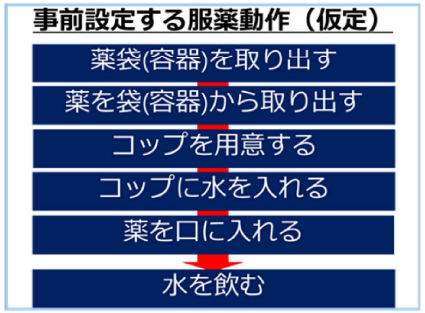
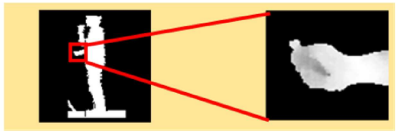


Behavior Model

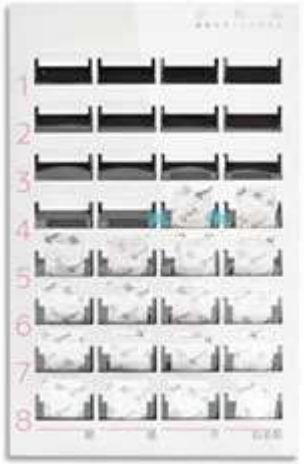


Sensor Module

Medication behavior modelling by hand silhouette and trajectory

Existing medication management support apparatus

Hitachi System: https://www.hitachi-systems.com/ind/robotics/robots/other/medication/index.html



Karen : http://lead-eng.co.jp/industry/karen.htm

Taking out medicine bags correctly
≠ Taking medicine correctly

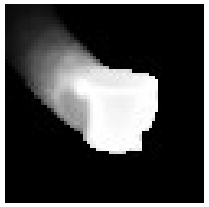
Medication Related Behavior Estimation -1

Open the bag

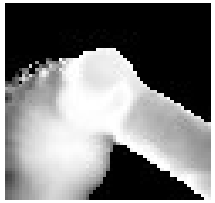
Take out pills

Hold the medicine

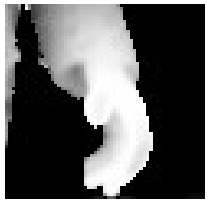
Move to mouth



Hold a cup



Drink water

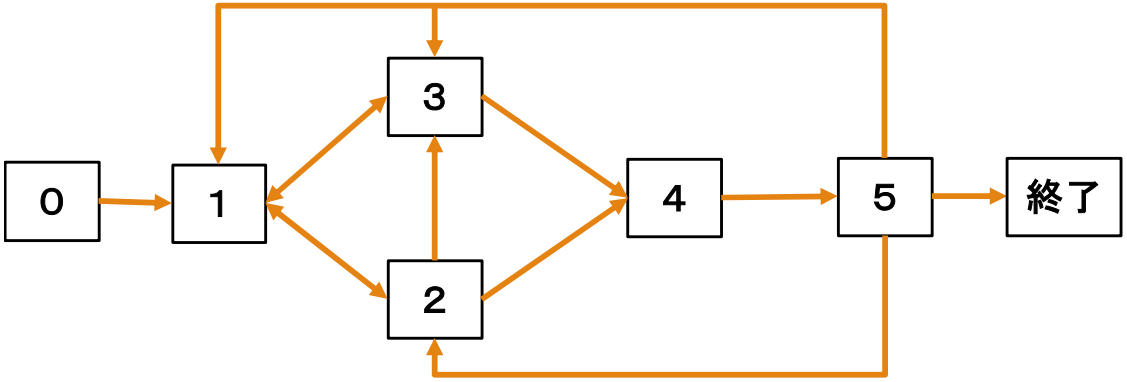


Nature

Recognition of hand motions

Medication Related Behavior Estimation -2

0 Normal
1 Tearing the bag
2 Getting the bag or pills
3 Putting pills on the palm
4 Taking the pills
5 Drinking water

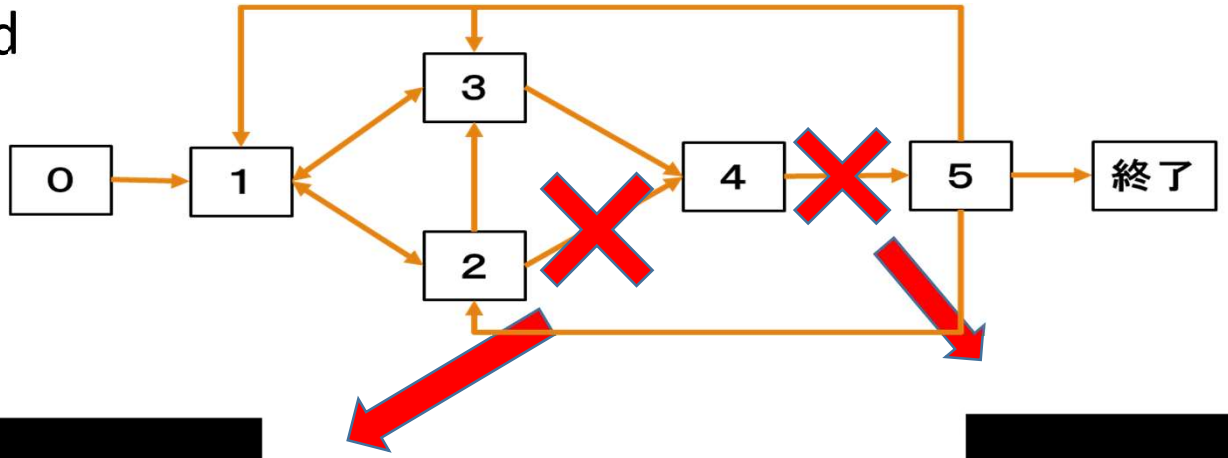


RightHand
7natural
LeftHand
7natural
state
5

Medication Related State Estimation

Medication Related Behavior Estimation -3

Interrupted patterns



With interruption at state 2

With interruption at state 4

Interruption Detection

In the remainder of this talk

- Case studies: Estimation of intention and states of ADLs for the older people
  - ✓ Sensing urinary desire for dementia people
  - ✓ Sensing medication process
  - ✓ Mobile and active sensing for recognizing ADLs in home environment
    - For safety
    - For measuring the ADLs, life style, rhythm …

Classification of existing bio-monitoring approaches

House-Distributed Sensors : HDS

High cost, difficult to maintain, delayed report

Blind spots due to furniture etc.

Smart House

Portable/Wearable Sensors : PWS

Constraints to wearers

Only work for local joints, not ready for bedtime

Possibly damaged in accidents like falls

Wearable Sensors

Mobile Robots for spatiotemporally seamless, reliable monitoring

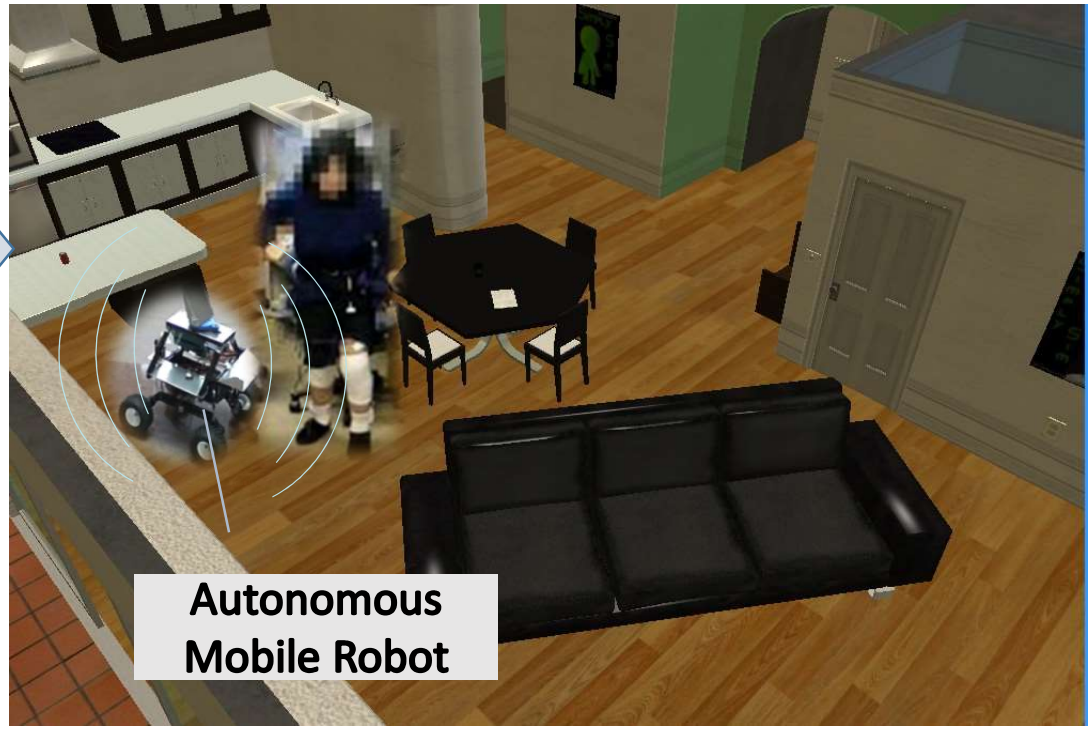
Our solution: autonomous mobile robots for home bio-monitoring

Instruction Center

As required
By the robot

Instruction

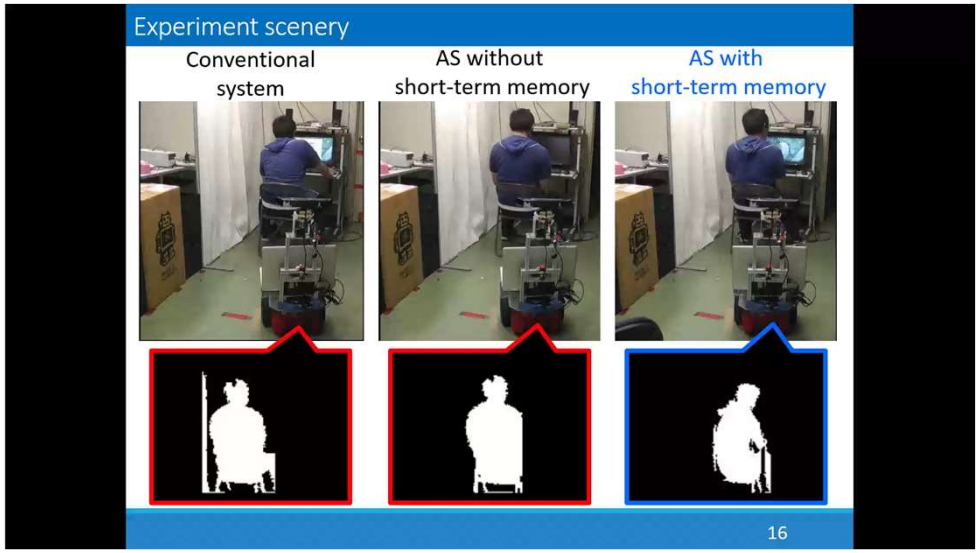
states



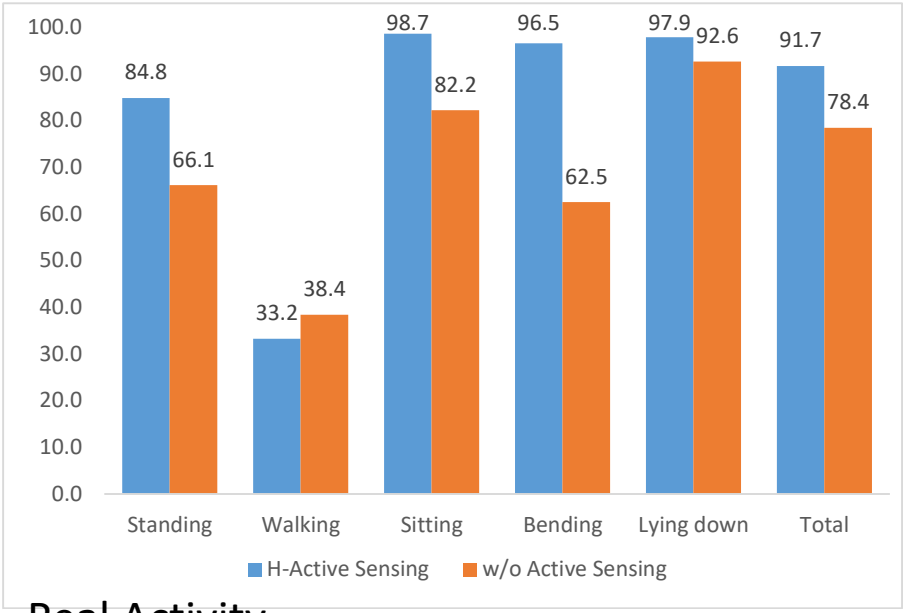
Subject following, measuring, behavior recognition, function evaluation

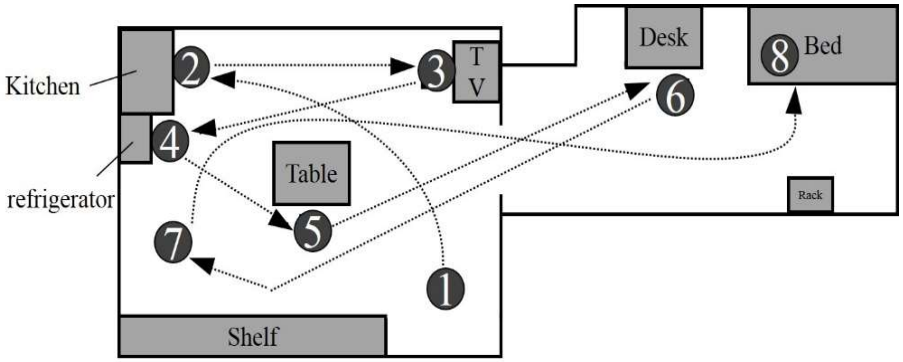
Chiba University Tele-Care in NHK World

Active Sensing > Passive Sensing

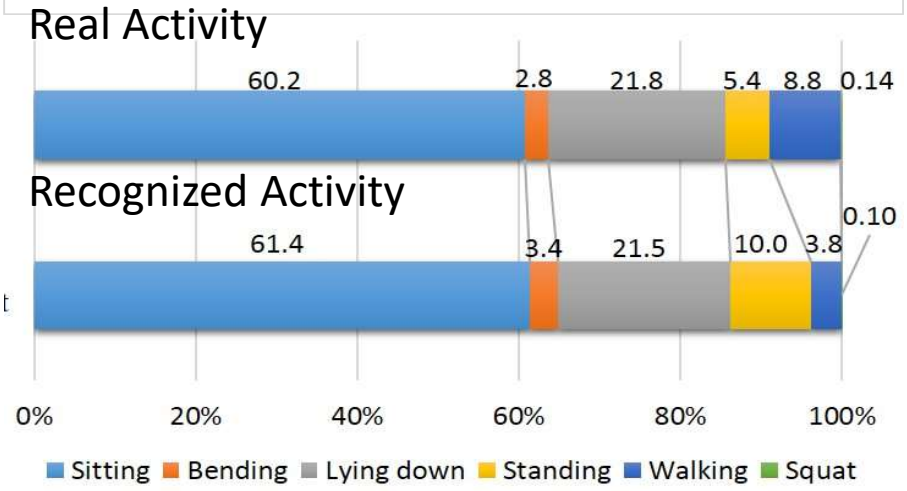


Passive Vs. Simple Active Vs. Learning Active Sensing for “Sitting”





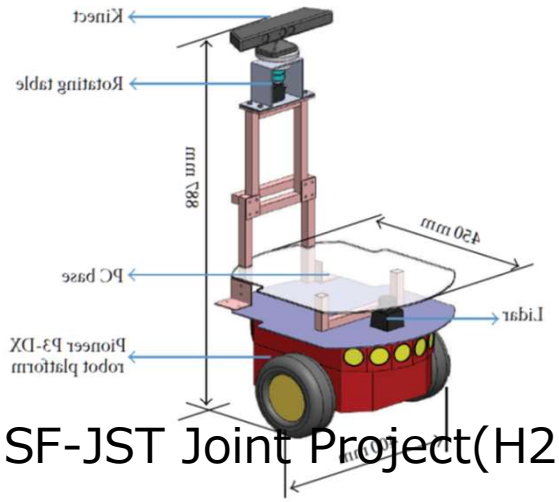
Daily Living Scenario Experiment



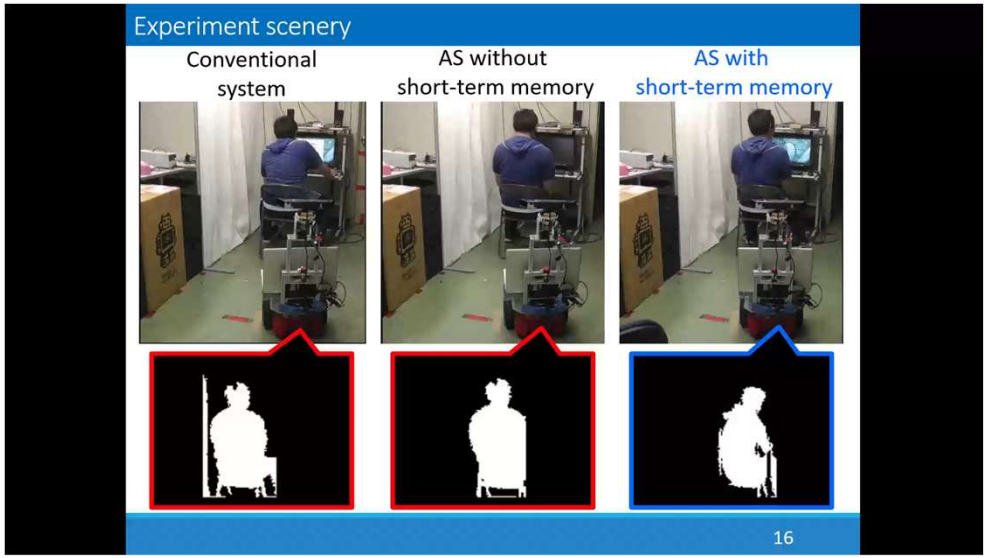
Wenwei Yu, et al, Journal of Healthcare Engineering, 2017

Active Sensing for Mobile Vision & Micro-wave Sensing

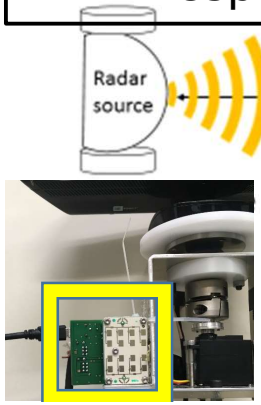
Non-contact Continuous Behavior Monitoring for Lonely Living Elderly

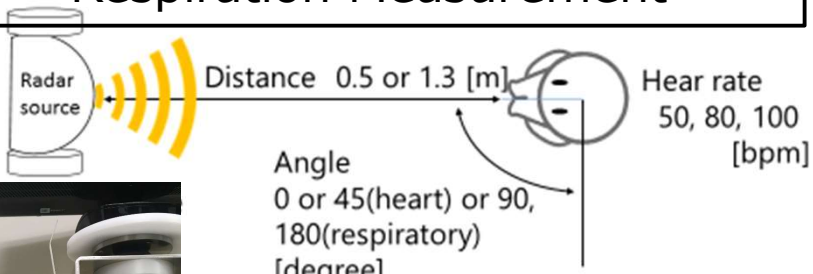


NSF-JST Joint Project(H23-25)

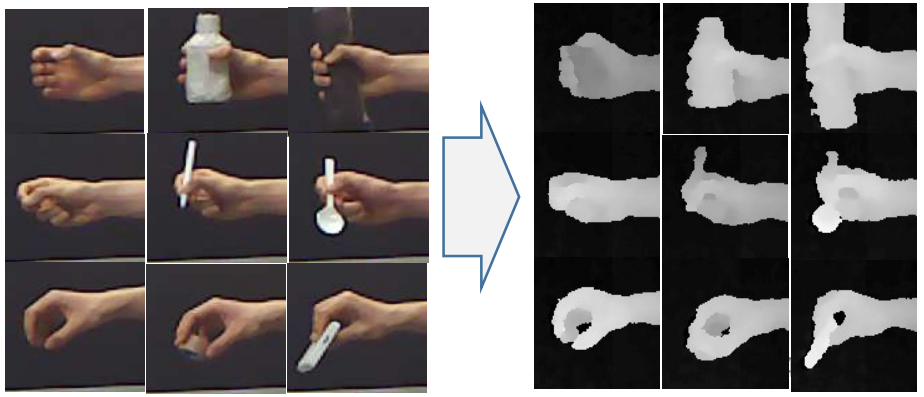


Non-contact Heart Beat Rate and Respiration Measurement





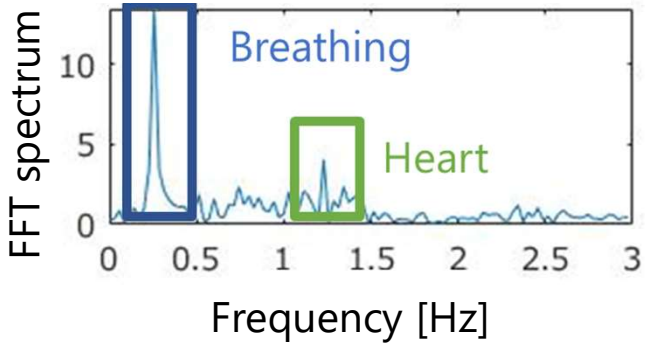
Instrumental ADL Analysis

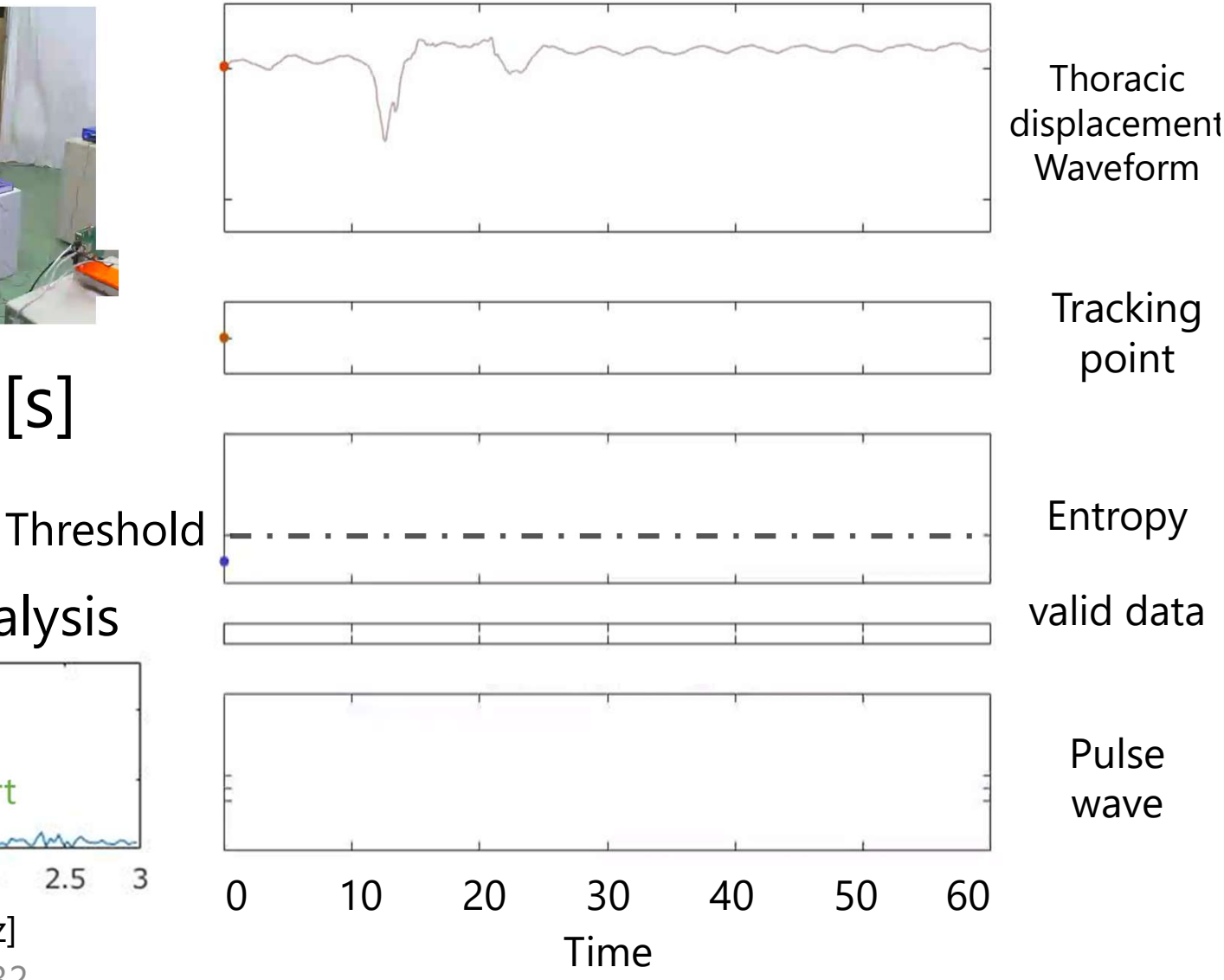


Experiment Results: HR measurement during daily living

Time :0.02 [s]

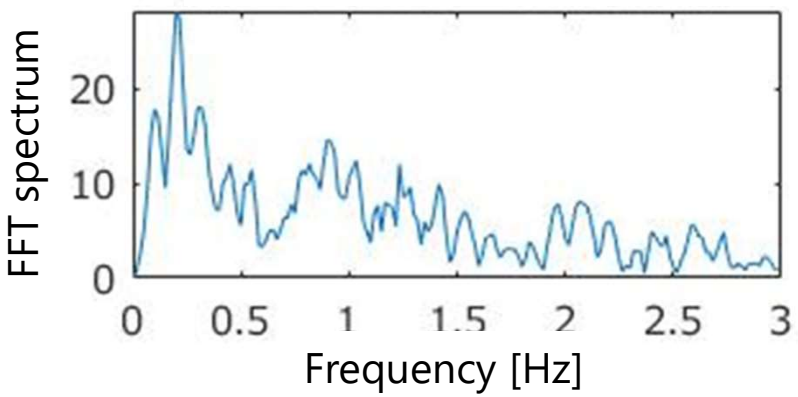
Frequency analysis



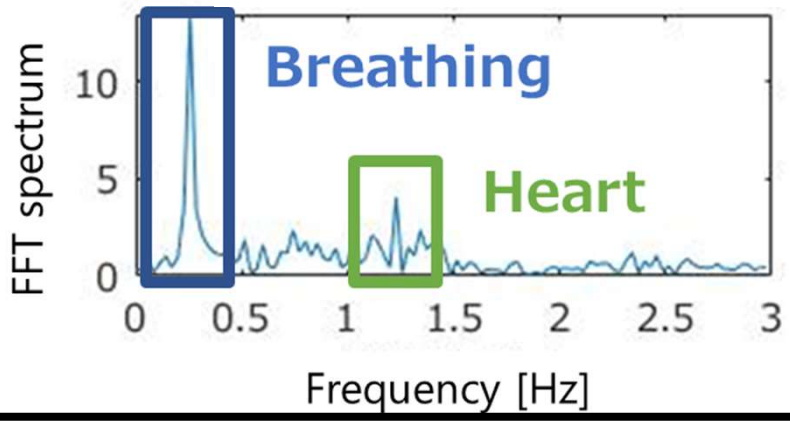


Experiment Results: HR measurement during daily living

Conventional method
No extraction

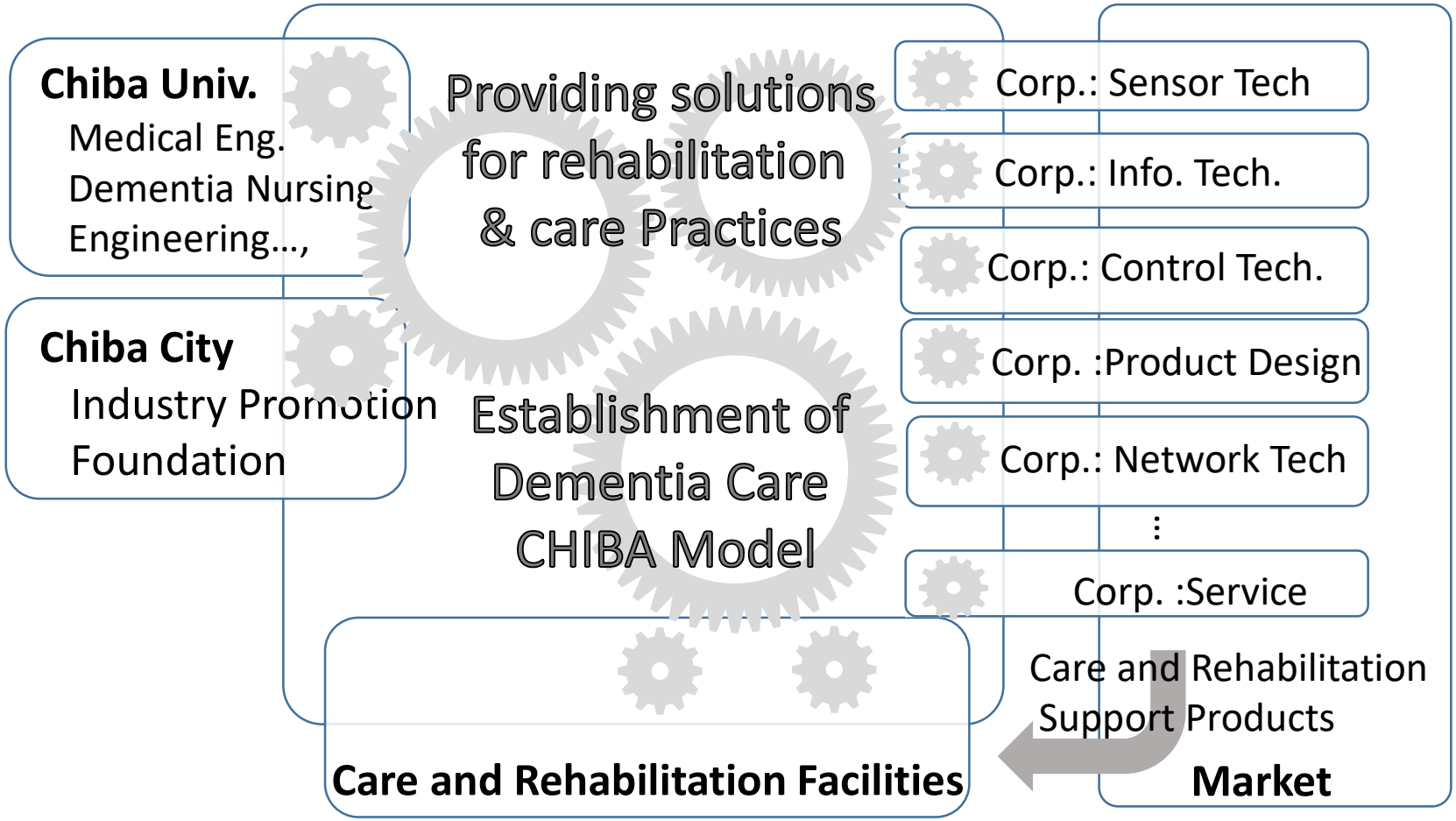


Proposal method
With extraction



	Reference value (How to get)	**Millimeter wave** Proposal method	**Millimeter wave** Conventional method
Heart rate estimate[Hz]	**1.2285** (Pulse wave)	**1.2290**	Unmeasurable
Respiratory rate estimate[Hz]	**0.2500** (Breathing cycle)	**0.2571**	0.2167

Dementia Care Innovation Consortium CHIBA (Founded at 3 April, 2019)



Conclusion for technology part

- Different sensing strategies can be explored
  - Conscious vs. unconscious, active vs. passive
- Human behaviors, including unconscious ones, if processed with suitable sensing technology, can transfer important information about people with dementia

➢ Long-term effect of the patient-centered care needs to be shown with evidence

✓ At least, it is necessary for the education of part of care sfaff

Thank you very much for your kind attention

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http://www.tms.chiba-u.jp/~yu/English/

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