Robotics Project
Grand Design

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Project Leader
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Mission

Robotics Research

based on a Computational theory of Mind

—Creating Invisible† Robots—

(†: We use this word metaphorically. It does not mean literal invisibility. But the robot's mind is invisible and the robot supports human without distracting his/her attention much.)

The goal is to elucidate the mechanisms of the human mind (cognitive functions such as perception, memory, reasoning, reflection, action, emotion and social interaction) computationally, and demonstrate them through the construction of an actual robot.

We use scientific methods (hypothesis–verification) together with a practical approach (engineering, tinkering, construction) to reach this goal.

Basic Strategy

Computational modeling of the mind

- Interpret research results of cognitive science and psychology computationally
- Explicate human cognitive and psychological mechanisms that can be implemented in robots

Robotics research

- Creating invisible robots based on brain-like AI (robot architecture)
- Robots support humans unintrusively and modestly (unnoticed support).

Computational modeling of the mind

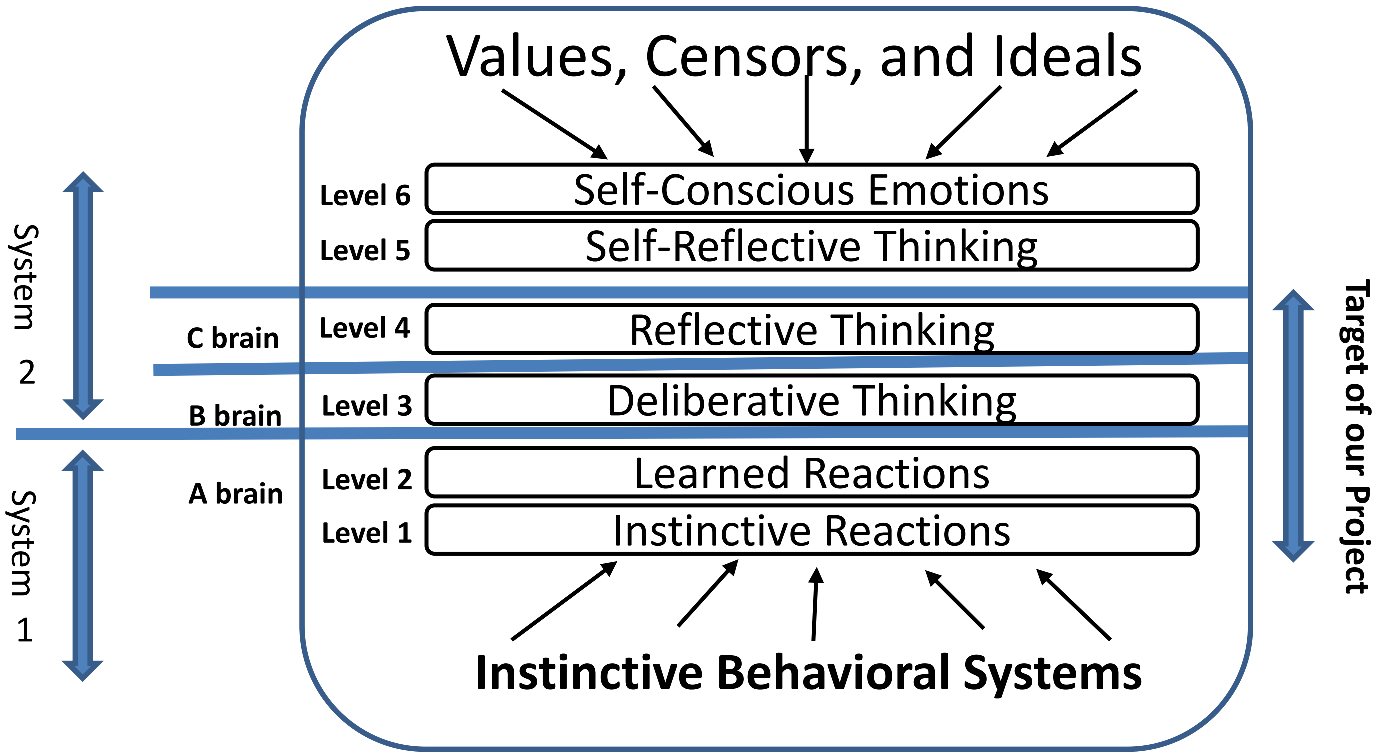
- Implement theories of Marvin Minsky and psychological findings of Daniel Kahneman
  - Minsky: many-layer reflective theory of mind
  - Kahneman: cognitive biases
- Use psychology to inform computational architecture of robots:
  - Emotional communication
  - Cognitive biases
  - Personality

Robotics research

- We create Invisible Robots:
  - Human (user) does not have clear awareness of using these robots
  - Robot's support does not disturb user's sense of agency (both on muscle activity level nor on thought level)
  - Robot is autonomous, it obeys user's orders and can support a user by itself
- Implementation:
  - Brain-like AI architecture
  - Framework of invisible support (unintrusive & modest)
  - Implement part of the functions of the human mind in the robot

Brain-like AI

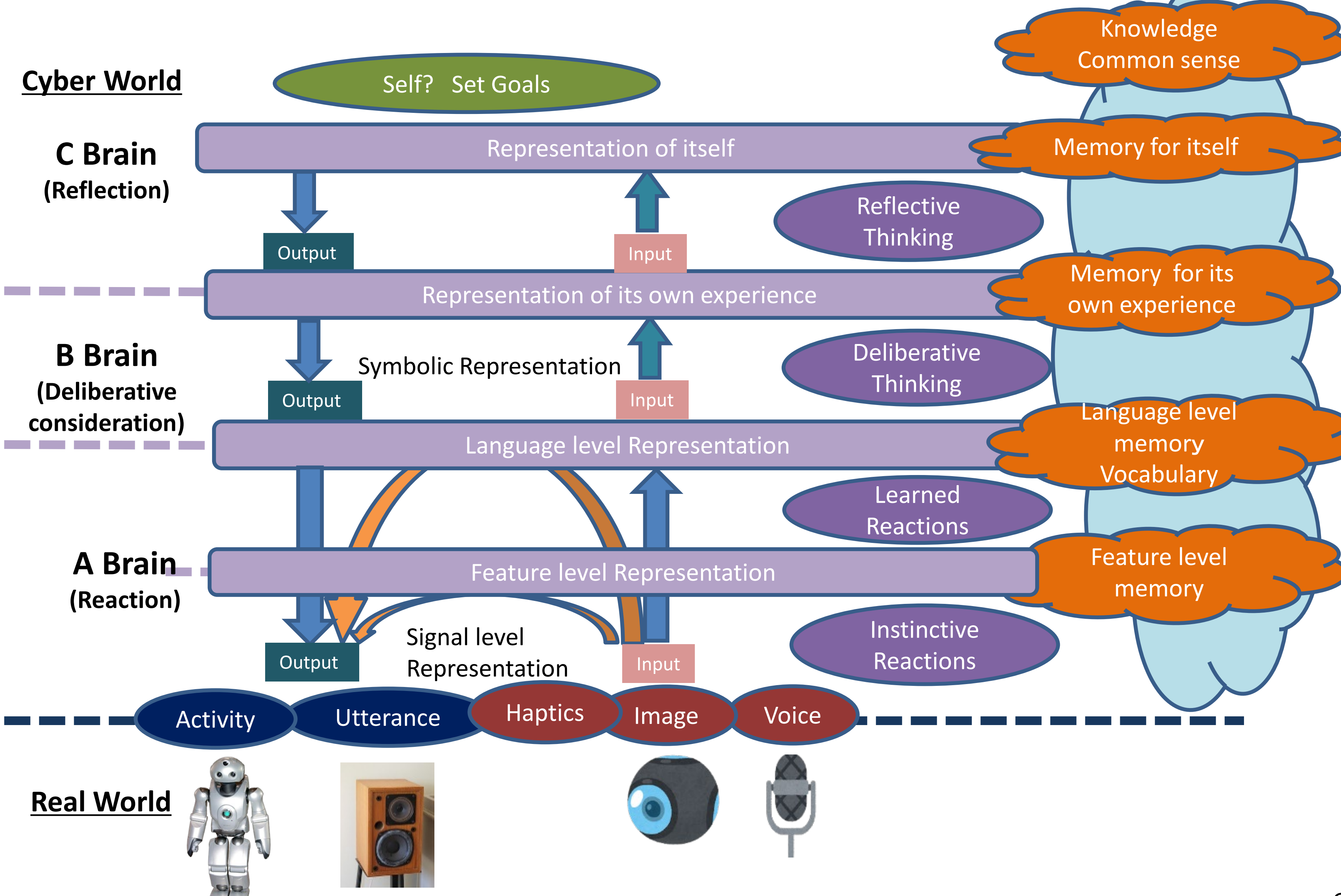
Architecture Design based on Minsky's Theory of Mind
— Level 1 to 4 are our target —



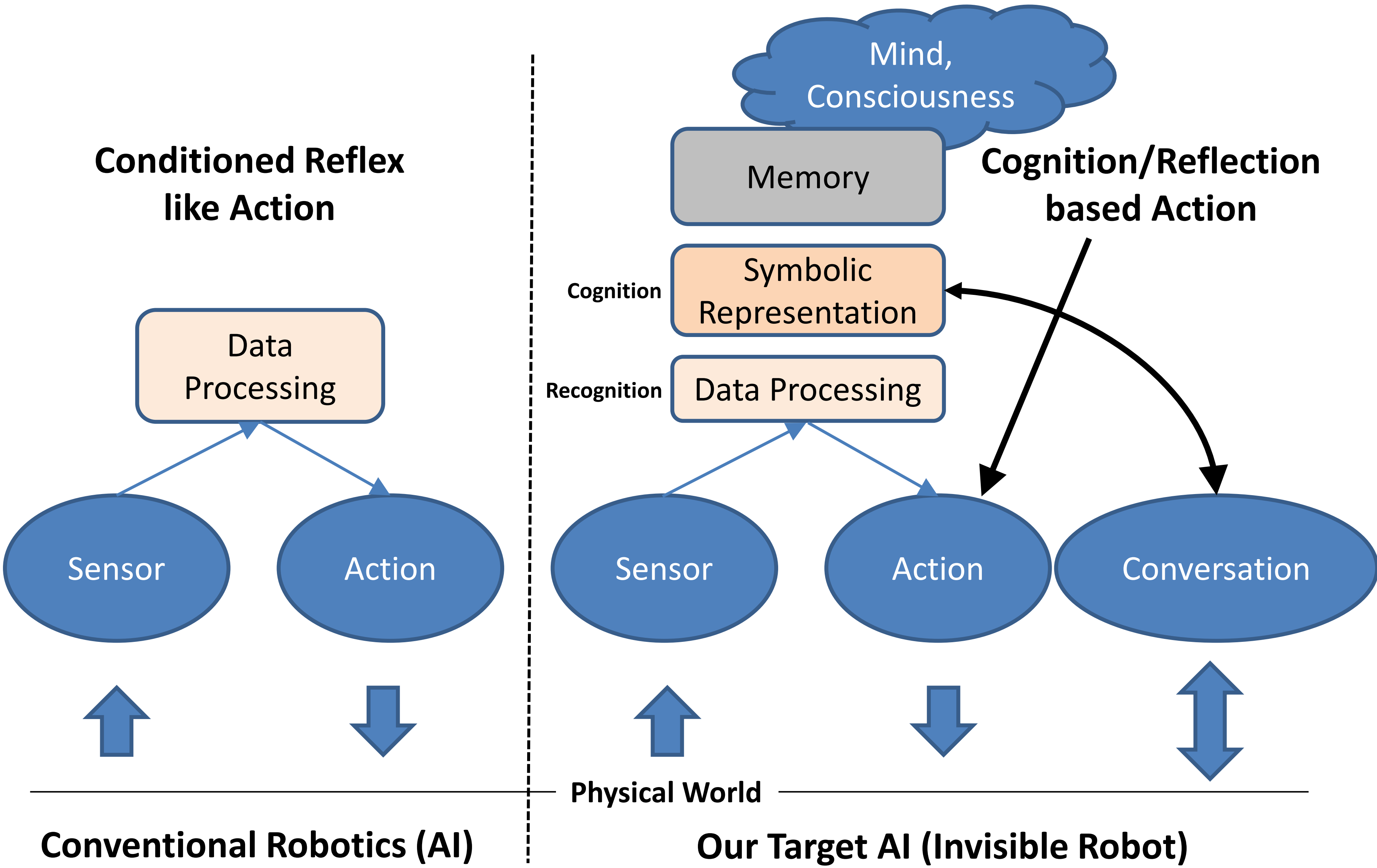
A Six-Level Model of Mental Activities

Marvin Minsky: The Emotion Machine, p.47, SIMON & SCHUSTER, 2006

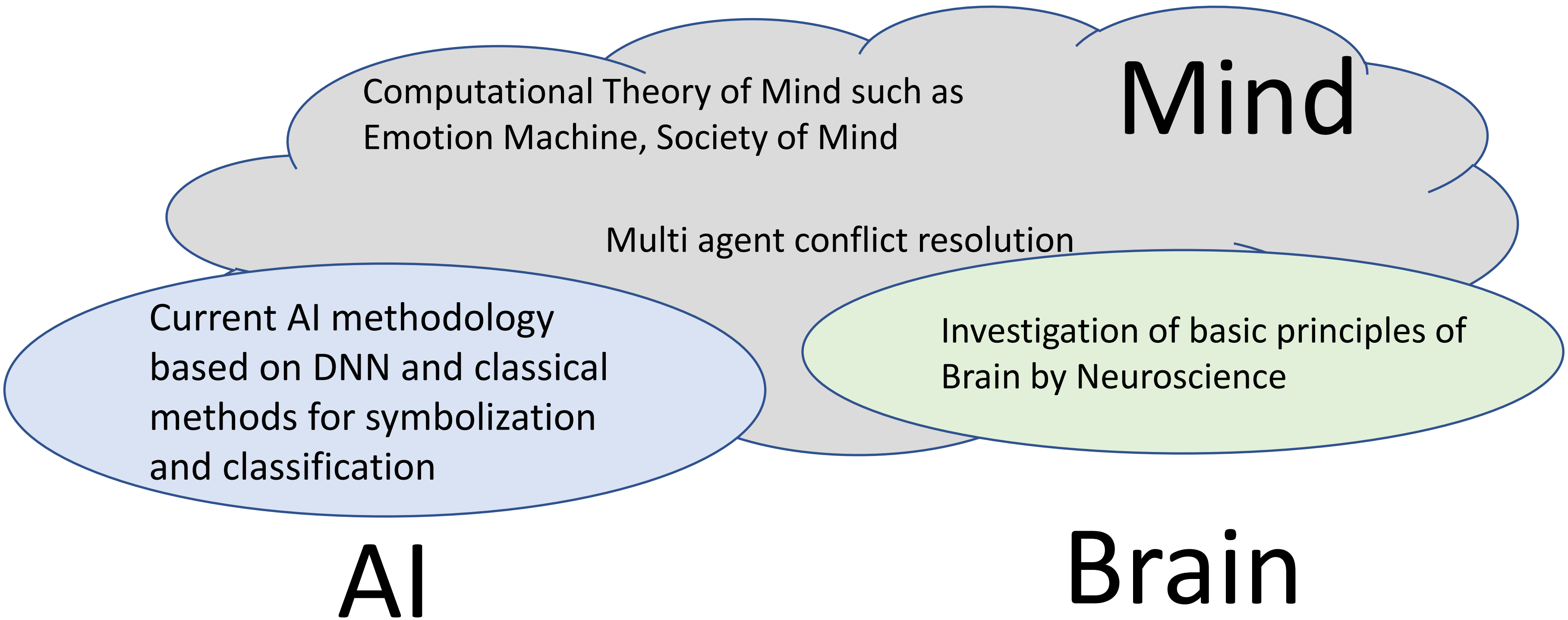
Architecture of Brain-like AI



Difference between our Project and conventional Robotics



Relations between Brain research, Mind research and AI



Robot realization of human-like cognitive functions ⟺ Research findings on human brain functionality and mechanisms of the mind

Framework to support humans unintrusively and modestly ("sarigenai")

- "Sarigenai" support:

  'What supportee wants to do' －

  'What supportee can do' ± Δ (Kanade's equation)

  - What supportee wants to do:
    - His/her intention is predicted from observation
  - What supportee can do
    - Investigate a way to estimate this from his/her past activity data
    - His/her abilities are estimated from past activity data
  - Δ: How to support, how to adjust amount of support
    - Decision of support methods and timing
    - Strategic selection of various support methods by situation

Research Strategy (Our Approach)

- Integrate AI, Engineering, Brain research and Cognitive science
  - Brain-like AI integrates lower level sensorimotor processing and symbol manipulation typical in higher level brain functions
  - Understanding and expressing emotions are handled within a same architecture
  - Combine classical symbol processing AI and newest machine learning based AI
- Brain–like AI implements human cognitive functions as much as possible
  - Human mental and physical states are observed broadly from muscle activity to cognitive activities and used to estimate the human's next action
- Implement functions to output mental state and emotions of robot
  - Design facial expressions and gestures
  - Use of non–verbal information in dialogue
- Decide how to represent and retrieve implicit and episodic memory, and synthesize facial expressions and utterances accordingly

Our Target: Invisible Robot

We build a robot that observes and recognizes a specific human and his environment, predicts their behavior, and unintrusively and modestly assists them.

[Physical Action] Exoskeletal Invisible Robots: motor function support

- To support daily activities and enhance physical functions
  - Physically support a human
  - Allow the supported human to have a sense of self-reliance (a sense of being proactive and moving by himself)

[Verbal Action] Self-reliant (talking) Invisible Robot: Preventing cognitive decline and improving well-being.

- Living with a specific individual.
  - Prevention and early detection of mental decline
  - Creating and maintaining an improved state of well-being
- Supporting older people through dialogue and physical support (emphasis is placed on the independence of the supported person)
- Giving the elderly a sense of autonomy by interacting and adapting to the individual
- Improving well-being by having the assisted person help the robot (the assisted person's autonomy is necessary)

Guidelines for health services based on the characteristics of the elderly:
https://www.mhlw.go.jp/file/06-Seisakujouhou12600000Seisakutoukatsukan/0000212400.pdf

The independence of the person being supported is emphasized.

Research Methods

All teams work together to implement the robot.

1. Designing the overall architecture of the robot, modularizing each function and designing the interface. A research team is assigned to each module.
2. Robot hardware is standardized and can be a platform for similar functions. It is treated in a unified manner regardless of its form, such as freestanding and auxiliary types of robots.
3. Define the tasks of the robot and evaluate its performance
    1. Does it have human-like cognitive abilities?
    2. Does it act like a human being?
    3. Is it helping its user? Can the user feel the heart (or mind of a robot) ?
4. Based on the evaluation we will review the architecture and will do research to improve and upgrade the functions of the modules.

Our Long-term Goal and Why it is difficult

- Build a robot that can actually work in an everyday life environment for a long period of time.
  - A robot that can be a true partner
  - A robot that can provide unintrusive and modest support.
  - Currently, there is no robot that has achieved this level of support
- Reason: Existing robots cannot communicate naturally
- Solution: In order to achieve natural communication, it is necessary to recognize and understand the supported person and his/her environment.
- The following KPIs are necessary to achieve this awareness and understanding!

Technical Goals (for KPIs)

- Autonomous collection of data:
  - Building a mechanism to autonomously collect data necessary for learning in robot implementation
- Sensor Integration:
  - Recognition and processing of signals corresponding to the five human senses in a unified manner
  - Perceptual recognition systems that can handle sensor information from different types of robots and environments in a unified manner
- Memory Encoding and Retrieval:
  - Associative memory functions (recalling memories from the past that are relevant to respond now) are essential
  - Memorize experiences (dialogue and actions) and use them for the future dialogue and action
  - Memory needs to be made into a story

Technical Goals (continued)

- Individual Adaptation:
  - The robot lives with a specific person, collects and remembers relevant information about that person, and makes use of it.
  - Technology for estimating what people want to do (intentions)
  - Technology for estimating human abilities
  - Robot’s expression strategies tailored to people (expressing robot’s personality)
- A robot that expresses emotions with its face:
  - Designing a robot that focuses on the face to enrich the expression of the robot
  - Eyes and mouth are especially important
  - The ability to control the size of the pupils and the facial expressions of joy, anger, sadness, and pleasure
- Explaining Rationale:
  - Making decisions based on reasoning and explaining the reasons for the support verbally while .