Sub-Theme

# Human in the CPS Loop

Session Chair

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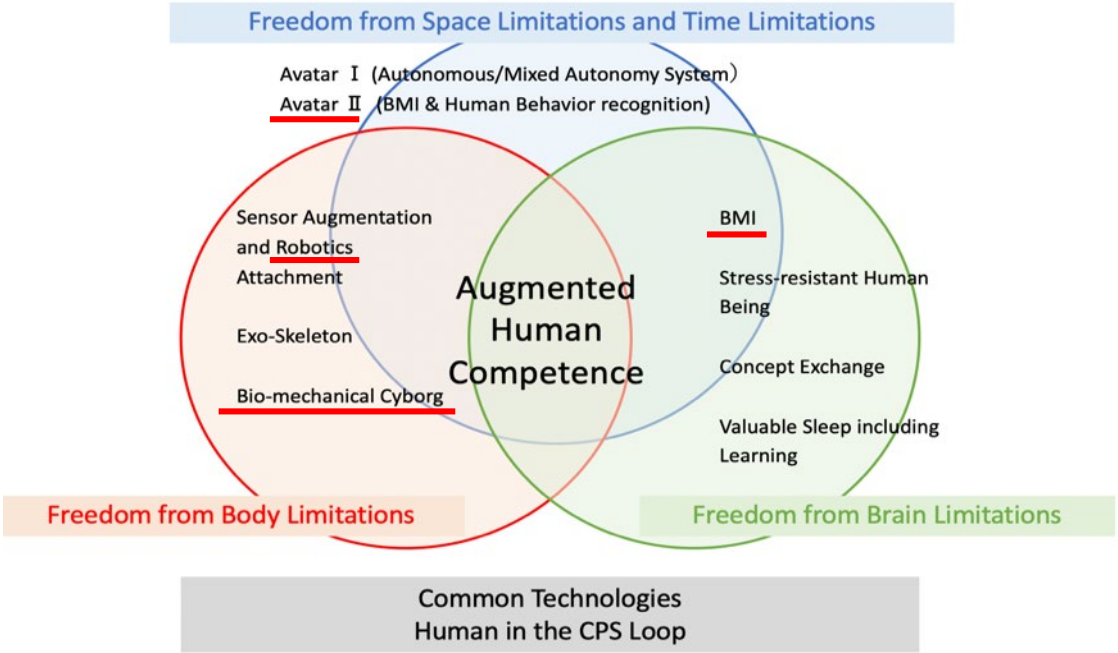
# Teruo Higashino

- Professor, Graduate School of Information Science and Technology, Osaka University, Japan
  - leading Mobile Computing Lab.
- We have studied the following research
  - Mobile & Ubiquitous Computing
  - IoT, localization & crowd sensing
  - ITS & Inter-Vehicle Communication
  - ICT for Smart City/Community & Edge Computing
  - Social Cyber Physical Systems (CPS), etc.
- PI of Japanese Government's "Society 5.0 Project" (MEXT), (2018-2023)
- Council Member of Science Council of Japan (SCJ), (2014-2020)
- Vice President of Information Processing Society of Japan (IPSJ), (2016-2018)
- Senior Program Officer of Japan Society for the Promotion of Science (JSPS : Japanese NSF), (2013-2016)

# Purpose of WG1

WG1：Expanding human potential toward a society in which everyone can pursue their dreams

- Our WG1 aims to achieve the three “Freedom”
  - “Freedom from Body Limitations”, “Freedom from Brain Limitation” and “Freedom from Space Limitations and Time Limitations”.

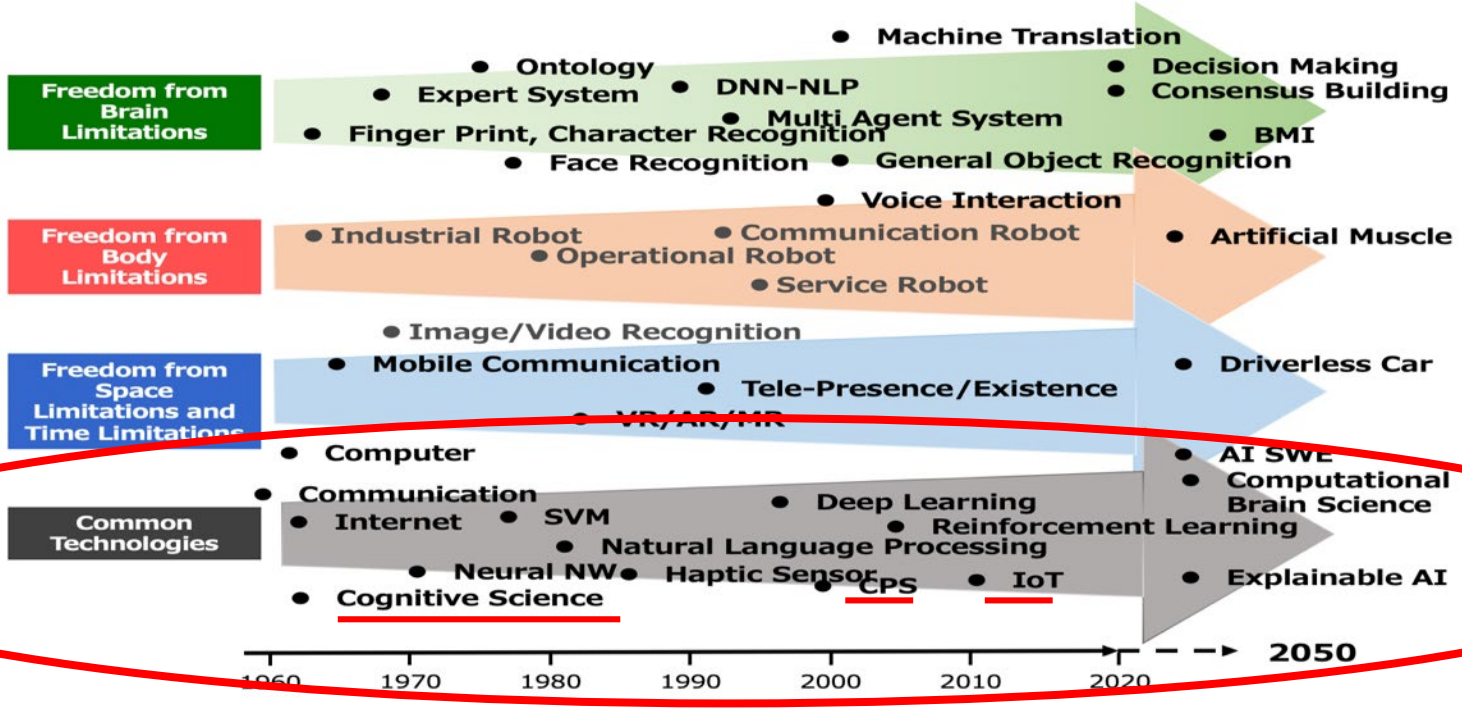



Cybernetic Avatar
（C-Avatar）
Society

Using AI, AR, sensing, high-speed communication technologies, we will achieve C-Avatar Society.

# Recent Technology Progress

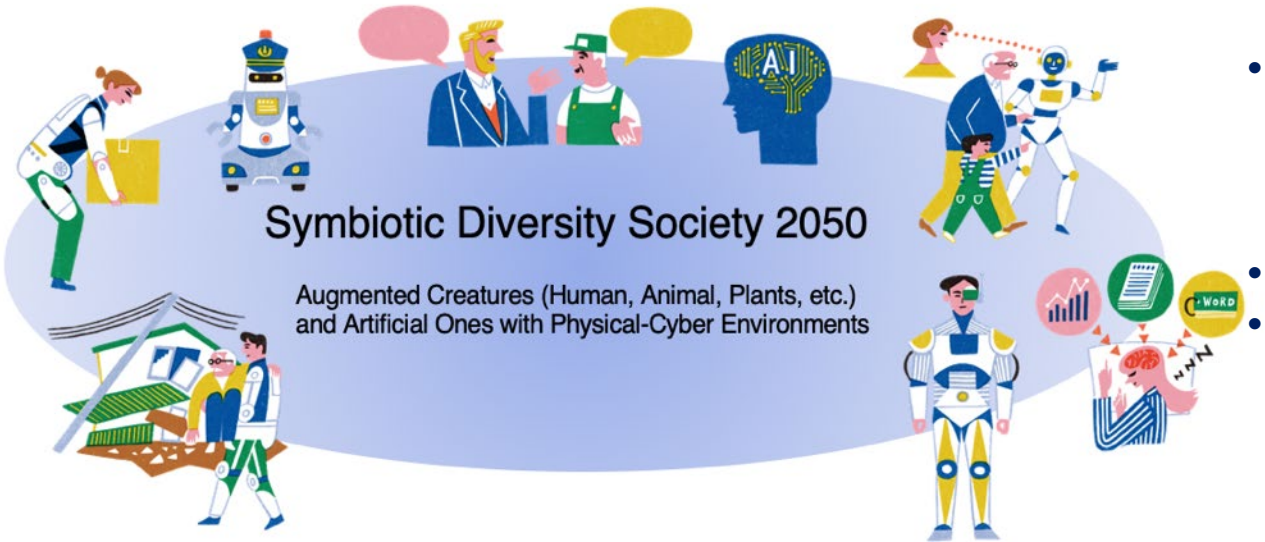
- The below figure shows recent technology progress for the four domains
- Common technologies provide ICT infrastructure for supporting our goal



# Social CPS Considering Human Behaviors

- It is expected that we can freely move in the city, interact with friends and people around, and enjoy daily life
- In order to achieve freeness from the limitations of body, brain, space and time, we need intellectual city-scale ICT infrastructure where humans are in the CPS loop

Challenging Theme



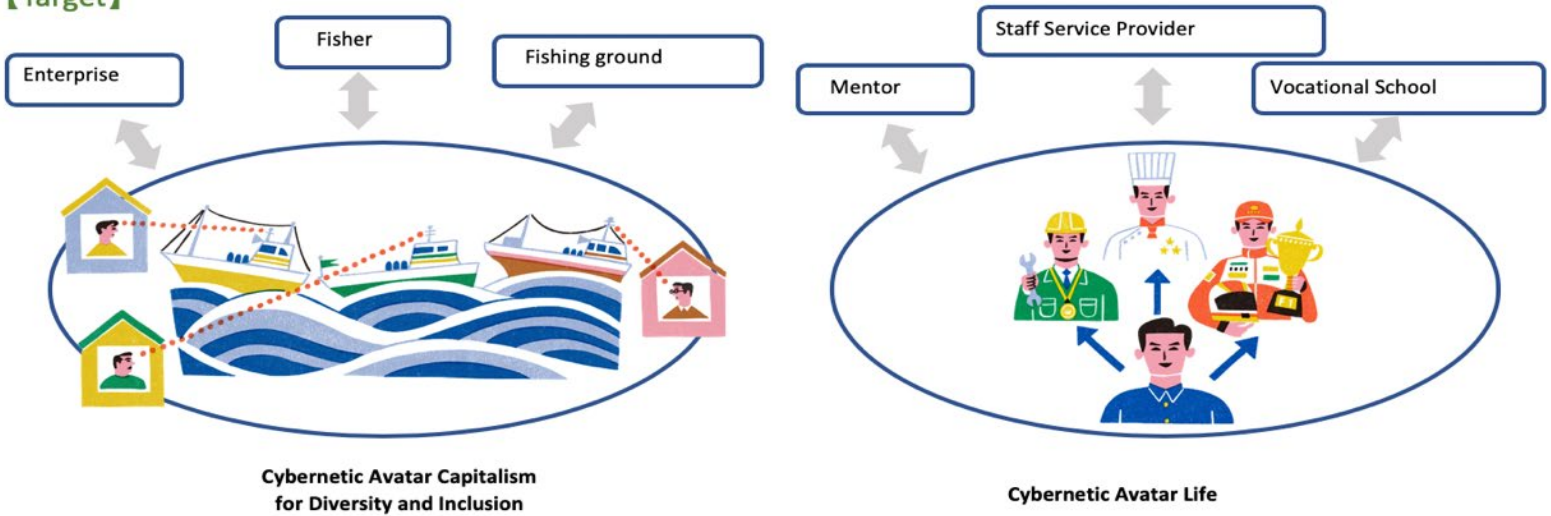

- Sensing in the real world, collecting such information in cyber space, and returning adequate actuation
- This is a typical CPS loop
- “Sensing in the real world” contains human behavior and mobility sensing

# Humans in the CPS Loop

What is necessary ICT infrastructure ?

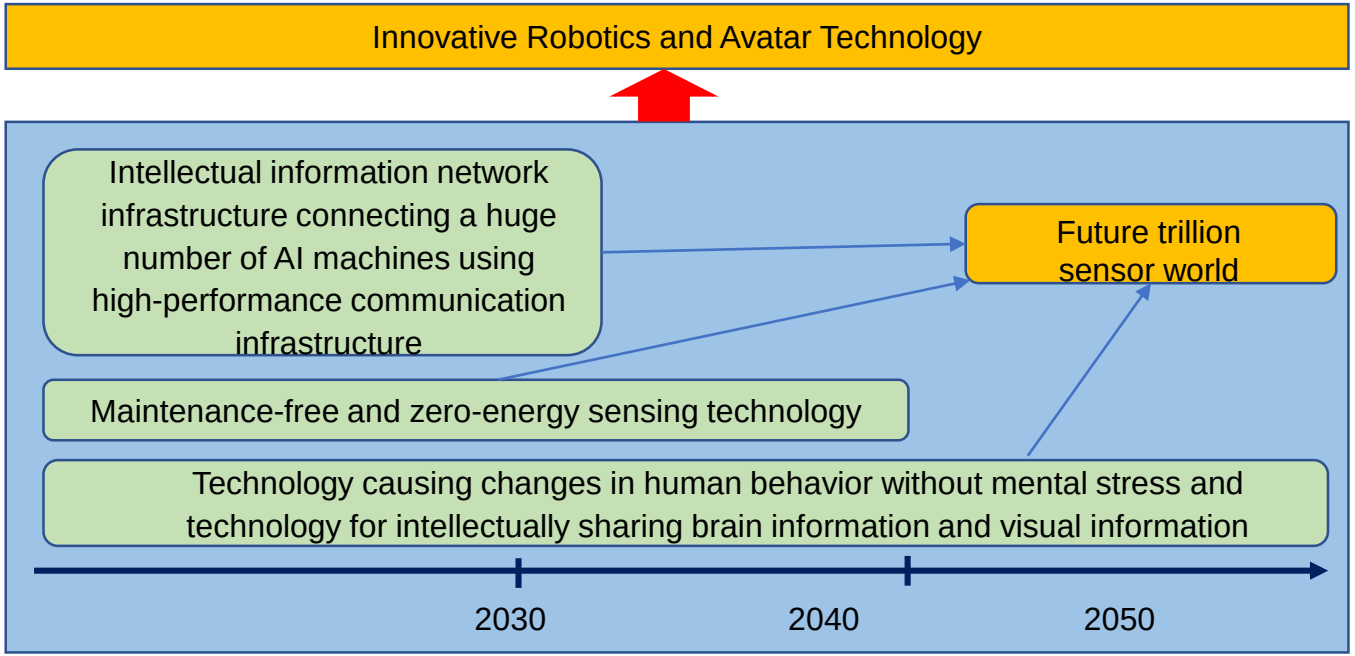
- Recently, Japanese government has issued a scientific motto “Society 5.0” where the realization of the “super smart society” is required (“Humans in the CPS Loop”)
- Our aim is to achieve ultimate “Humans in the CPS Loop” and create “C-Avatar Society”
- We need more advanced technologies using future high-speed network, AI, IoT, robotics and human sensing technologies, and incorporate them into the “Humans in the CPS Loop”

【Target】



# Research Issues for Future ICT Infrastructure

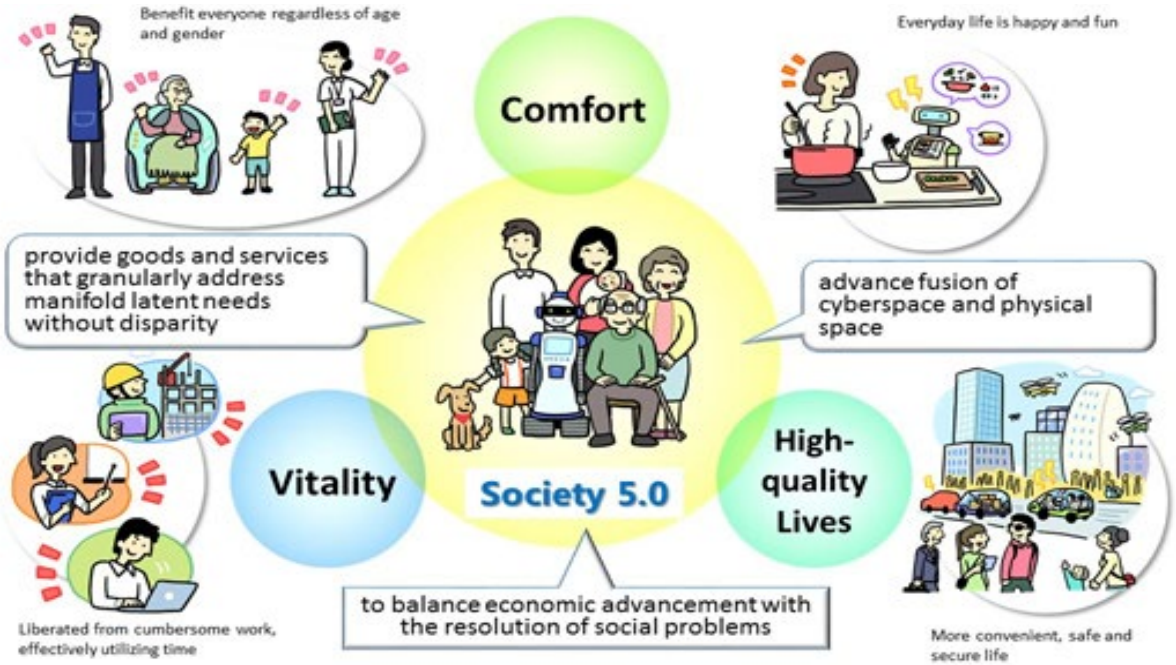
- What do we need for future city-scale communication infrastructure, IoT technology and cognitive science in order to create innovative robotics and avatar technology ?



# Future Communication Infrastructure

- 5G technology achieves ultra wideband (> 10Gbps), low latency (< 1ms) and massive machine type communications (> 1M devices/km$^2$)
  - However, it does not mean that those three features can be realized simultaneously
- In “beyond 5G” era, those three features will be realized simultaneously
  - The progress of communication technology is essential
  - However, we need not only such communication technology but also IT technology supporting massive machines/IoTs
    - e.g. SDN, network security, real-time, distributed, autonomous, etc.
    - Edge computing based ICT platform connecting massive machines/IoTs
    - We need collaboration with other WGs (e.g. WG7 for ELSI problems)
  - We can use AI functions everywhere and anytime (AI Networks)
- We also need to develop technology for intellectually sharing brain information and visual information

# Maintenance-free and Zero-energy Sensing Technology




Refer from https://www8.cao.go.jp/cstp/english/society5_0/index.html

- Energy Consumption
  - WiFi (100mW)
  - BLE (10mW)
  - Backscatter (10μW)
- Sensing (10μW)
  - Microphone
  - Accelerometer

- Energy reduction of wireless communication
- Wireless power supply

- Context recognition of humans and objects using IoT devices becomes important
- The number of such IoT devices is expected to be enormous (Trillion sensor world)
- It causes huge efforts to maintain their batteries

  ⇒ maintenance free & ultra low power IoT devices (Zero-Energy IoT Devices)

# Technology causing changes in human behavior without mental stress

- Several types of ubiquitous techniques have been developed so far, and those techniques can be used for human behavior sensing
  - Smartphones and small sensors can estimate several types of human behavior using AI technology and big data analyses
- In order to achieve the three “Freedom”, we need technology causing changes in human behavior without mental stress
  - It is very important how we can achieve “Humans in the CPS Loop”
- We also need to develop technology for intellectually sharing brain information and visual information
  - Such technology will be used for achieving the three “Freedom”

# Schedule of This Session

- Explanation of sub-theme from Teruo Higashino (Osaka Univ., Japan)
- Presentation from Dr. Kenneth Leonard Calvert (Division Director, CISE, NSF, USA)
- Discussion
  - Presentation from Dr. Hideyuki Tokuda (President, NICT, Japan)
  - Discussion for ”Humans in the CPS Loop”
    - Prospects for information network (beyond 5G, etc.)
    - Future ICT platform for achieving innovative IoT world
    - Future sensing technology
    - Future cognitive science
    - Use of AI functions everywhere and anytime (AI Networks)
    - ……
  - Q&A

# Dr. Kenneth Leonard Calvert

- Division Director, Division of Computer and Network Systems, Directorate for Computer and Information Science & Engineering (CISE), US National Science Foundation (NSF)
- Dr. Ken L. Calvert is the division director of NSF since May 2016 leaving from the University of Kentucky, where he is Gartner Group Professor in Network Engineering and former Chair of the Department of Computer Science.
- His research interests include future Internet architecture, software-defined networking, and network security. He received his Ph.D. in computer science from the University of Texas at Austin
- Prior to his appointment at the University of Kentucky, he was a Member of the Technical Staff at Bell Laboratories in Holmdel, NJ, and served on the faculty in the College of Computing at the Georgia Institute of Technology. He is an IEEE Fellow and a member of the ACM.

# Dr. Hideyuki Tokuda

- President, National Institute of Information and Communications Technology (NICT), Japan
  - Professor Emeritus of Keio University, Japan
- Dr. Hideyuki Tokuda obtained the B.S. and M.S. degrees from Keio University, Tokyo, Japan, in 1975 and 1977, respectively, and the Ph.D. degree in computer science from the University of Waterloo, Waterloo, ON, Canada, in 1983.
- After he completed the Ph.D., he joined the School of Computer Science, Carnegie Mellon University, Pittsburgh, PA, USA, and worked on distributed real-time operating systems such as real-time Mach, and the ARTS Kernel.
- In 1990, he returned to Keio University and worked on many national R&D projects. His research interests include OS, ubiquitous computing systems, IoT/IoE, cyber-physical systems, and smart cities. He is a Member of Science Council of Japan, and has served on the Vice President of IPSJ, an Assistant to National center of Incident readiness and Strategy for Cybersecurity (NISC).

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Thank you very much !!!