Social and ethical issue ...
Why have I developed the android?

- Practical robot systems in the near future
- Interactive robots as basic research

Android
(Child android)
Humanlike Appearance

- 120cm, 5 years old
- Silicon skin
- Sensitive Piezo sensor
- Degrees of Freedom (DOF): Eyes: 5, Mouth: 1, Neck: 3

The first contact

Uncanny valley

- Similarity
  - Toy robot
  - Doll
  - Moving corpse
  - Human

Uncanny valley
(Mori et al. '97)

Another uncanny valley
with Prof. Itakura, Kyoto University

- Subjects from different ages (2 weeks to 5 years)
- Record subjects' behaviors and eye motions
Lateral Inhibition Hypothesis

Lateral inhibition is perhaps the most fundamental operation of brain circuitry and integral to the operation of all structures.

Human behavior recognition by the sensor network

Uncanny valley

Conscious recognition of androids - The subject looks at 2 sec. -

Subconscious recognition of androids - Gazing points for the uncanny android -

Android (Adult android)

Humanlike appearance
Humanlike behaviors
Humanlike perception

- How to compensate the gap between androids and humans?
- Engineering knowledge is not enough...

• Unconscious movements contribute to the reality.
• Young people (around 20) are more sensitive than elderly people (over 30)
Eye movements while talking

- Subjects change the gazing direction when talk with the sophisticated android.
- Subjects unconsciously feel social relationships with the android.

Human-human interaction

Human-robot interaction

Human-android interaction

Constructive understanding
Understanding of humans as a total system

- Previous approaches in brain science
  - Development of human brain models & brain computers
  - Analysis of human brain functions
  - Partial observations

- New approaches in robotics and cognitive & social science
  - Verification of the human likeness in inter-personal and social situations
  - Development of humanoids and androids
  - Constructive approach

Bottleneck of autonomous robots

- People expect that humanlike robots can talk.
- However, it is a very hard problem...

Android Science
- Bridge between robotics and cognitive science -

Development of mechanical humans

Analysis and understanding of human

Integration of science and engineering

An approach for solving the bottleneck of autonomous robots
Tele-interaction by using semi-autonomous androids and humanoids

- Long term interaction and conversation
- More precise cognitive/psychological tests by using own androids
- Exist different places simultaneously

Geminoid

Humanlike Appearance
Humanlike behaviors
Humanlike perception
Humanlike conversation
Making of the geminoid

Definition of geminoid

Humanoid = Humanlike robot
Android = Robot that has human appearance and behavior
Geminoid = Tele-operated android of an existent person

Humanoid  Android  Geminoid

Tele-operation system through the Internet

- Motion capture system for measuring the lip movements
- Behavior selection by using GUI (6 behaviors)

Developed geminoid

Difference between my observation and other people's observations
- When I saw the static geminoid, it was like a mirror. However, when it naturally moved, I could not recognize it as my movements.

Touch by someone

Adaptation to the different body
- While I operate the geminoid, I unconsciously adapt my movements to the geminoid's movements.

Sharing of information through the geminoid
- When the visitor touch to the Geminoid, I get a feeling to be toughed (demeaning).

Meeting by using the geminoid

Strong entrainment in the conversation
- Both of I and the visitors can quickly, less than 5 minutes, adapt to the conversation through the geminoid.
Geminoid as a father

**Father**
- Look at pictures together
- Play last and first
- Find a card and give it to the geminoid

**Geminoid of the father**
- Look at pictures together
- Play last and first
- Find a card and give it to the geminoid
- Touch to the geminoid
- Comment on the geminoid

Habituation in the beginning of the second experiment

Geminoid and children
- Children can quickly adapt to the geminoid

New issues in android science

- **Scientific issue**: Human likeness (appearance, movement, perception)
- **Engineering issues**: simple and iterative communication tasks

New issues (more philosophical)

- **Scientific issue**: Human presence
  - How does the self-observation matches to the other's observations?
  - What is ego?
  - What is human presence? What is authority?
  - Entrainment by conversation and Adaptation to the different body. Is it possible to separate mind and body?
  - Sharing of information through the geminoid
- **Engineering issue**: tele-presence technologies using geminoids

Necessity of humanlike mechanisms

- Humanlike appearance
- Humanlike behavior
- Humanlike perception
- Humanlike conversation

- The robot needs to have more humanlike mechanism for more flexible movement.
- How to control the complicated system?
M³: Growing Man-Made-Man

- Develop software by imitating the human developmental process.
- Develop fundamental mechanisms that generate a class of cognitive phenomena.
- The robotic mechanism is used as a hypothesis in cognitive studies.

Bio-inspired robotics and Cyborg systems

- Attractors and their switching
- Activity: $\frac{d}{dt}x = f(x) \cdot \text{activity} + \eta$
- Biological system utilizes noise.
- The complicated system is represented with attractors
- Select better solutions by controlling activity
- From micro to meta levels

Yuragi Project in Osaka University

- Center of excellence for new-creating innovations with Prof. Yanagida
- Develop bio-inspired high-performance systems utilizing biological “Yuragi”
- System Area
- Information System Area
- Nano Material Area
- ROBOTS Area
- Development robust software utilizing “Yuragi”
- Development bio-inspired high-performance systems utilizing biological “Yuragi”
- Study basic principles of Information System Area
- Development of hardware for “Yuragi”
- Development robotics systems using biological “Yuragi” principles of biological “Yuragi”

Development of linear actuators

- Idea actuators for the robots
  - No gears and linear
  - Flexible control of the stiffness
  - Long stroke
  - High torque
- Pneumatic actuator
- Halbach array of magnets

Development of linear actuators

- Linear actuator
- Linear bearings
- Linear potentiometers
- Linear position
- Linear displacement

Conclusion

Robotics is science for understanding humans.
Robotics is engineering for developing our future life.
Various research areas are integrated in robotics.

Information and Robot Society