INTERACTION WITH VERY HUMANLIKE ROBOTS

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

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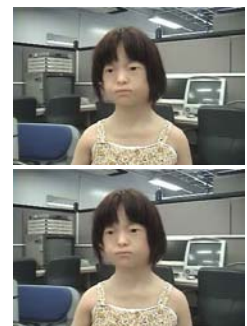

Android
(Child android)
Humanlike Appearance

Child android

- 120cm, 5years old
- Silicon skin
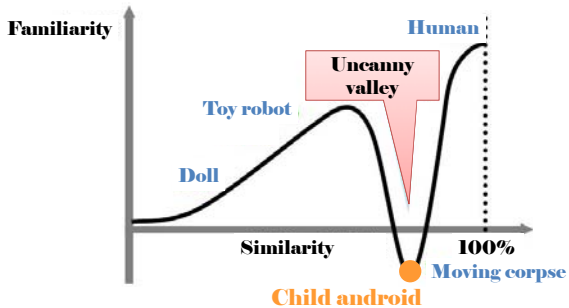- Sensitive Piezo sensor
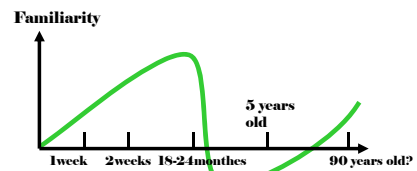- DOF
  - Eys:5, Mouth:1, Neck:3

The first contact

Uncanny valley
[Mori et al. '97]

Familiarity

Human

Uncanny valley

Toy robot

Doll

Similarity

100%

Moving corpse

Child android

Another uncanny valley
with Prof. Itakura, Kyoto University

Familiarity

5 years old

1week   2weeks   18-24monthes   90 years old?

- 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.

Neural network

Basal ganglion

Face recognition?

Human identification?

Growing process

Uncanny valley
Familiarity
Toy robot
Human

Age-dependent uncanny valley
Familiarity
3-4 years old
18-24 monthes
90 years old?

Android
(Adult android)

Humanlike appearance
Humanlike behaviors
Humanlike perception

Human behavior recognition by the sensor network

Distributed touch sensors	→	Position	Position model
Distributed vision / Gesture recognition by vision	→	Behavior	Behavior model
Distributed audition / Dynamic formation of Microphone arrays	→	Dialogue	Dialogue model

Uncanny valley

Familiarity
Human
Uncanny valley
Toy robot
Doll
Adult android
Similarity
100%
Moving contour
Child android

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

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

Static android
Android 77%, Human 23%

Android with subconscious movements
Android 30%, Human 70%

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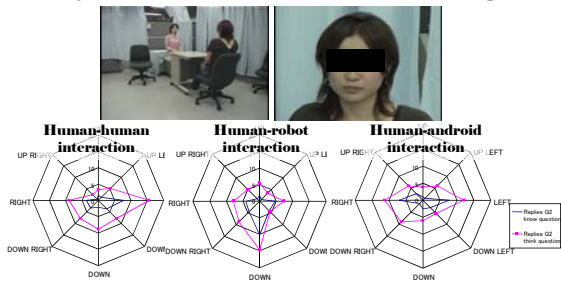

Subconscious recognition of androids
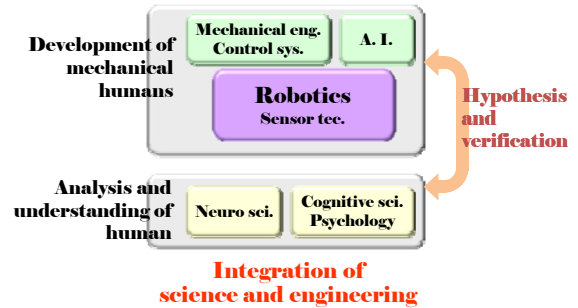**- Gazing points for the uncanny android -**

Human

The uncanny child android

Eye movements while talking

Human-human interaction   **Human-robot interaction**   **Human-android interaction**

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

Android Science
- Bridge between robotics and cognitive science -

Development of mechanical humans

| Mechanical eng. Control sys. | A. I. |

Robotics Sensor tec.

Hypothesis and verification

Analysis and understanding of human

| Neuro sci. | Cognitive sci. Psychology |

Integration of science and engineering

Constructive understanding
Understanding of humans as a total system

- Previous approaches in brain science

Analysis of human brain functions *Partial observations*

Development of human brain models & brain computers

Development of Humanlike machine

- 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*

Development of hypotheses on humanlike systems *Systematic understanding of humans*

Bottleneck of autonomous robots

Humanlike appearance
Humanlike behavior
Humanlike perception
Humanlike conversation?

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

Distributed touch sensors ➡ Position ➡ Position model
Distributed vision Gesture recognition by vision ➡ Behavior ➡ Behavior model
Distributed audition Dynamic formation of Microphone arrays ➡ Dialogue ➡ Dialogue model

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Geminoid

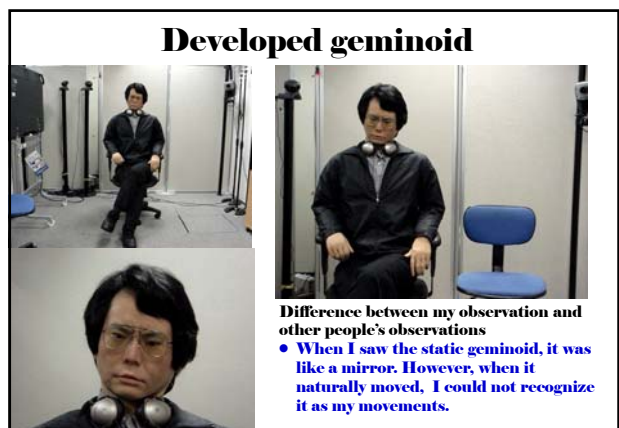**Humanlike Appearance**
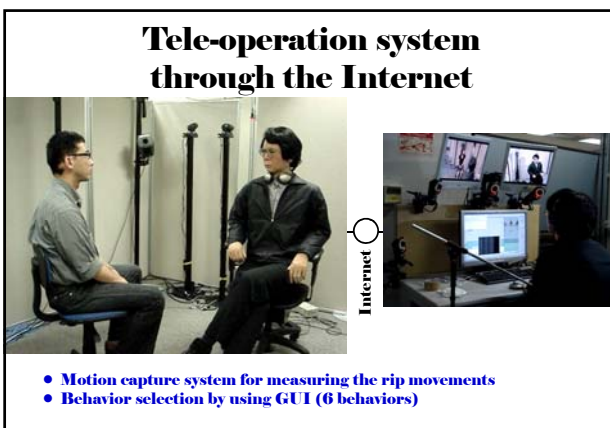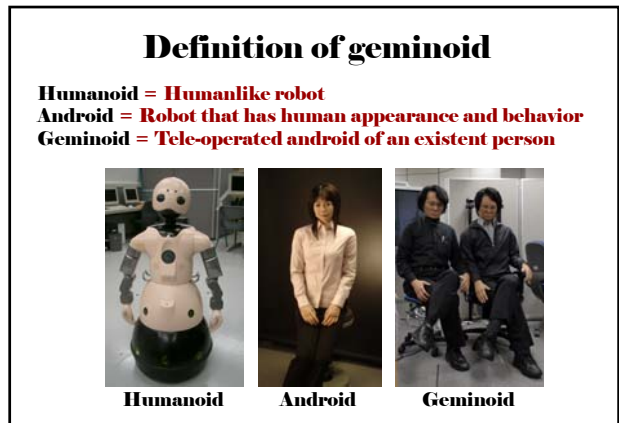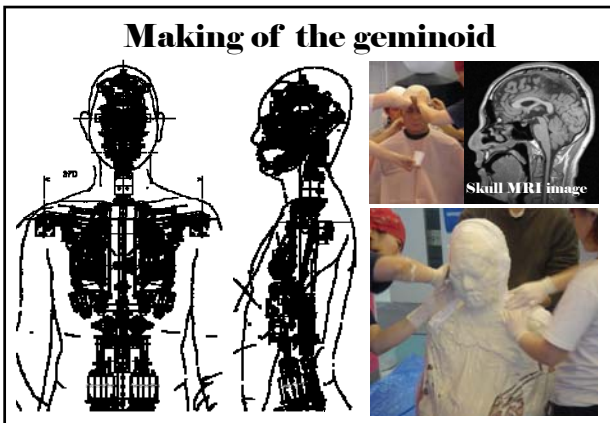**Humanlike behaviors**
Humanlike perception
Humanlike conversation

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

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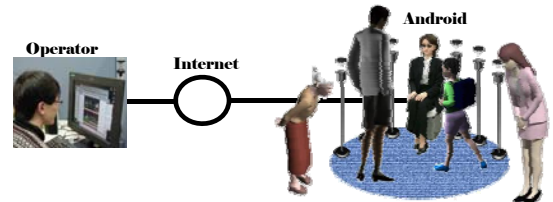
- Long term interaction and conversation
- More precise cognitive/psychological tests by using own androids
- Exist different places simultaneously

Making of the geminoid

Skull MRI image

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

Internet

- Motion capture system for measuring the rip 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

Internet

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 Geminod, 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 | Geminoid of the father

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

Tasks
- 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 gemioid -
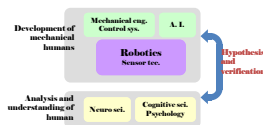

1st experiment

2nd experiment

Habituation

New issues in android science

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

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Necessity of humanlike mechanisms

Humanlike appearance
Humanlike behavior
Humanlike perception
Humanlike conversation
Humanlike mechanism?

- **The robot needs to have more humanlike mechanism for more flexible movement.**
- **How to control the complicated system?**

Operator   Internet   Android

Synergistic Intelligence
JST ERATO Asada Project with Prof. Asada

www.jeap.org

- Understanding the developmental process of human/robot through interaction with humans
- Realizing developmental systems that includes robots and programmers/ caregivers

M³: Growing Man-Made-Man

Self-organizing controller networks for sensory motor mapping

Deliberative behavior

Abstraction Tree

Behavior

Reaction

Sensors   Actuators

- 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.

Yuragi Project in Osaka University
Center of excellence for new-creating innovations
with Prof. Yanagida

Life Science Area

Information System Area

Development robot software utilizing "Yuragi"

Study basic principles of biological "Yuragi"

Nano Material Area

Development of hardware for "Yuragi"

Develop bio-inspired high-performance systems utilizing biological "Yuragi"

Robotics Area

Development robotics systems using biological "Yuragi"

Bio-inspired robotics and Cyborg systems

activity

Attractors and their switching

Sensor

Action A   Action B

Action C   Action D

External noise   Internal noise

Environment

$$\frac{d}{dt}x = f(x) \cdot activity + \eta$$

System represented with attractors | Control parameter (Sensor) | Noise

- Biological system utilizes noise.
- The complicated system is represented with attractors
- Select better solutions by controlling activity
- From micro to meta levels

Development of linear actuators
with Prof. Hirata (Osaka Univ.)

Idea actuators for the robots
- No gears and linear
- Flexible control of the stiffness
- Long stroke
- High torque

Pneumatic actuator

Halbach array of magnets

Motor driver

Proposed actuator | Controlling circuit

Effective voltage [V]	3.5
Number of turns [Turns]	525
Resistance [Ω]	5
Mass of mover [g]	238
Friction force [N]	0.93
Viscous damping coefficient [N·s/m]	1.0

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