

04 April, 2011.

Bio-Robotics and Human-Mechatronics Laboratory

Takafumi Matsumaru



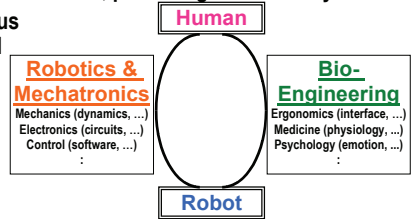
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Bio-Robotics and Human-Mechatronics (T. Matsumaru) Lab

April 2011

Bio-Robotics & Human-Mechatronics Laboratory

- Various themes between **human** and **robot**
- To make mechanical artificial systems more **friendly / useful** for users
- Developing **new functions**, producing **real-world systems**
- Applying various knowledge and technologies, as a **system integrator**



Better interaction / relationship between human and robot

Bio-Robotics and Human-Mechatronics (T. Matsumaru) Lab

April 2011

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Remote Operation System of Mobile Robot

- **Combination Control** of Manual and Autonomous
- **Environmental Map** around Remote Robot: Line method / Cell method
- **Operational Interface**: JS, Pupil mouse, HMD + gaze track, Voice, Touch disp.

Pre-Announcement of Robot's Intention

- **Method and Apparatus** to Display Direction and Speed: 4 kinds / 2 types
- **Experiment** in Simulated Interactive Situation: Human-Robot Motion Capture
- Comparing **Display** Announcement with **Voice** Announcement

Form / Movement of Human-Synergetic Robot

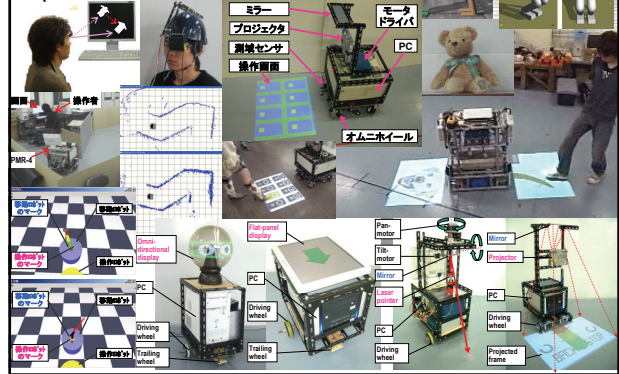
- **Emotional Motion**: Four Basic Emotions on Teddy Bear Robot
- **Informative Motion**: Hand-over and Throw-over for Humanoid Robot

Interaction with Human-Symbiotic Robot

- **Step-On Interface (SOI)** and **Friendly Amusing Mobile (FAM)** Function
- **Application**: Playing "Light" Tag – stepping animal tail / bomb fuse / footmark

Bio-Robotics and Human-Mechatronics (T. Matsumaru) Lab

BR&HM-Lab. (in Shizuoka Univ.)



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April 2011

Bio-Robotics & Human-Mechatronics Laboratory

Bio-Robotics & Human-Mechatronics

- New subjects in the viewpoint of **informatics** and **medical and biological engineering** are evolved, along with the previous subjects such as the form and movement of **human-synergetic robot** or the interaction with **human-symbiotic robot**.
- A new interdisciplinary field is pioneered by addressing new researches on biological or human body from an original viewpoint.
- In particular, it aims to establish the **design theory** and the **methodology** and to develop the **practical application technologies** targeting on an **intelligible** or **user-friendly** artificial systems.
- These activities, ranging over human being, object, information, and environment, can greatly contribute to people all over the world as a new integrated field or an interdisciplinary field to explore deeper relationship between a user and an artifact in ordinary life.

Bio-Robotics and Human-Mechatronics (T. Matsumaru) Lab

April 2011

Biographical Information

- **1985 B.S., Mechanical Engineering, Waseda University**
"Development of articulated manipulator aiming at force control"
(Supervised by late Prof. I.Kato)
- **1987 M.S., Mechanical Engineering, Waseda University**
"Basic theory on multi-dof compliance control on articulated manipulator"
(Supervised by late Prof. I.Kato)
- **1987-1999 R&D center, Toshiba Corporation**
 - Research on robots for specialized operations
 - Development of mechatronic systems using robotic tech
- **1998 Ph.D., Mechanical Engineering, Waseda University**
"Research on structure and control of working robot in a little space"
(supervised by Prof. S.Sugano)
- **1999-2010 Associated Professor, Shizuoka University**
 - Education and Research on Bio-Robotics and Human-Mechatronics
 - Invited Professor (2003), LSC (Laboratoire Systemes Complexe) – CNRS, Evry France.
 - Visiting Fellow (2002), Shizuoka Industrial Research Institute, Japan
- **2010- Professor, Waseda University**
 - Research and Education on Bio-Robotics and Human-Mechatronics



Ichiro Kato
1926-1994

TOSHIBA
Leading Innovation



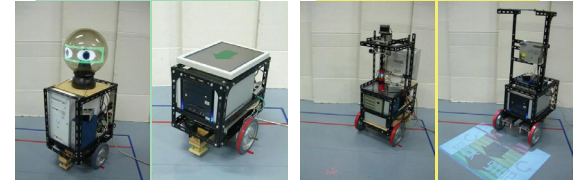
Interaction problem



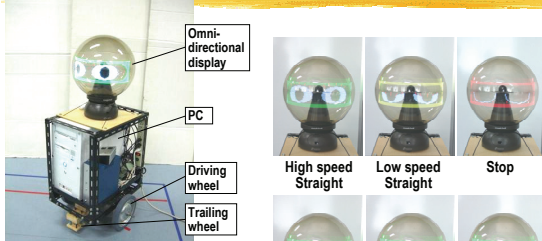
- **Lack of shared knowledge / common sense**
 - **Human beings**
 - Interact, signaling own and predicting others' action / intention
 - Non-verbally through body language, hand gestures, facial expressions, and whole body operations
 - ➔ Acquire social and physical skills that make movement practically second nature based on sense of affinity, familiarity, and common appearance – sharing “**common sense**”
 - **Robots**
 - ➔ Cause disaffinity, unfamiliarity, and uncommon appearance – no sharing of common sense that make robot movement predictable to people
- ➔ **Avoid risk of contact and collision**
- **Function to preliminary-announce robot's intention**
 - Mobile robots or transport vehicles – **speed / direction**

Prototype Robot

- **State of operation just after the present**
 - **Lamp**
 - **Blowout**
- **Operations from present to some future**
 - **Light ray**
 - **Projection**

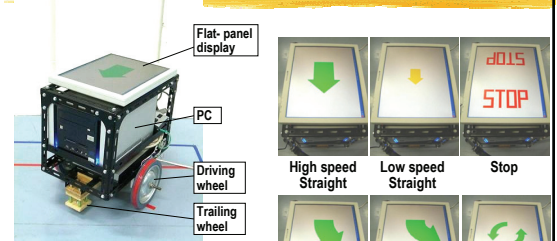


PMR-2R: Omni-directional Display



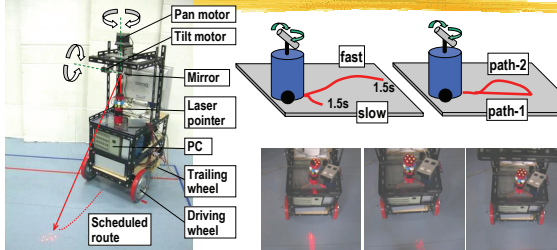
- **“Eyeball” (gaze)**
 - Friendly, familiarity
- **Operation at 1.5s-later**
 - **Speed** – degree of eye opening
 - **Direction** – eye positioning

PMR-6R: Flat-panel Display



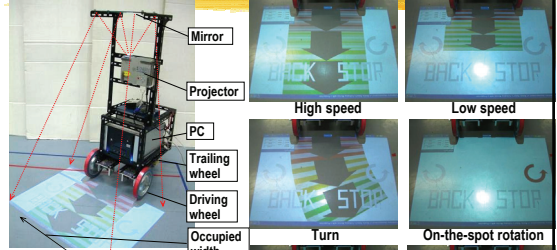
- **“Arrow”**
 - Commonly used, comprehensible
- **Operation at 1.5s-later**
 - **Speed** – size / color of arrow
 - **Direction** – curved condition

PMR-1R: Laser Pointer



- **“Scheduled route”**
 - Afterimage of radiant
- **Route until 1.5s-later**
 - **Speed** – length of route
 - **Direction** – direction of route

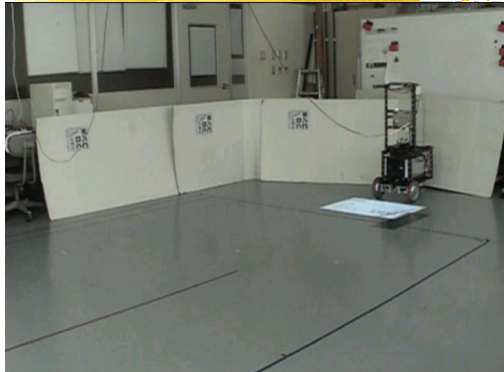
PMR-5R: Projector



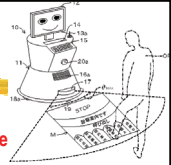
- **“Occupied area”**
 - Color-coded / striped belt
- **Area until 1.5s-later**
 - **Speed** – length of belt
 - **Direction** – curved belt

PMR-5R

March 2007



Step-On Interface (SOI)



SOI (Step-On Interface)

- Projected screen is used as a **bilateral interface**
 - Not only presents some information
 - But also delivers instructions
- Projector displays a **direction screen** on a surface
- 2-D Range scanner detects and measures the **user's stepping** to specify the selected button

Features:

- Hands-free – elderly, physically challenged, and users whose hands are full
- Anywhere without disturbing others and in noisy environment
- No special devices are needed – user's own foot or stick (cane)
- Requires little preliminary preparation or special setup
- Can use figures / pictures in addition to letters – language-independent, possible for beginners and non-native speakers
- Functions are easy to design, setup and change in software

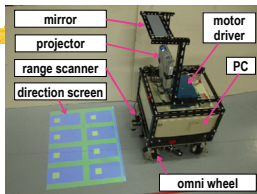
Human-Friendly Amusing Mobile Robot HFAMRO-1

Omni-dir. mobile platform

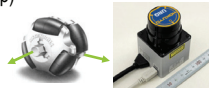
- Omni-wheel (4)
- HD-g geared DC-motor (4)

Step-On Interface (SOI)

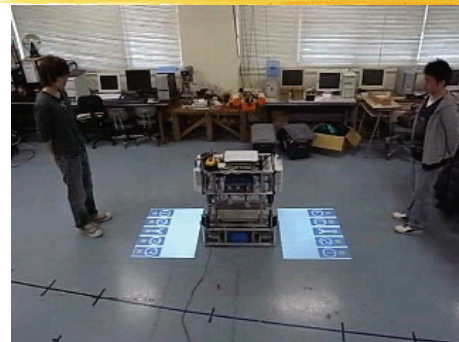
- Projector**
 - Min. distance: 1200mm
 - Screen size: W730–D550mm (36")
- Mirror**
 - W225–D125 mm
- Range scanner**
 - Area: 240deg / 682step (0.35deg/step)
 - Distance: 20–4095mm
 - PC acquires data every 100ms



Size	W450–D450–H960 mm
Weight	46.7 kg
Speed	max. 0.22m/s, 0.87rad/s
PS	AC100V

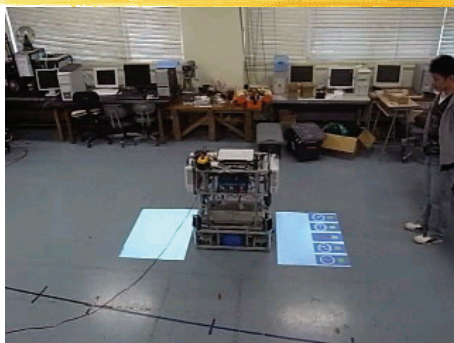


Basic movement from both sides



November 2009

Basic movement with announcement function



November 2009

Friendly Amusing Mobile (FAM) function

FAM (Friendly Amusing Mobile)

- Robots interact with users

Play 'tag'

- Play tag, with "light", similar to 'shadow' tag
- User pursues robot and steps on button on screen
- Robot responds by playing game, providing with information, moving to indicate 'emotion', etc.

Game: step on animal's tail

- Scenario**
 - Animal's head and tail are displayed
 - Moves characteristically, cocking head and wagging tail
 - Stop, cry out, and show anger, when caught up / stepped
- Technical aspect**
 - Self-contained mobile robot, independent without movement restriction
 - Playing tag with "light" function



Human-Friendly Amusing Mobile Robot HFAMRO-2

Two-wheel drive mobile platform

- D200-wheel (2), DC-motor (2)

Step-On Interface (SOI)

Projector

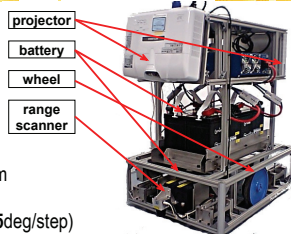
- Min. distance: 560mm
- Screen size: W850-D640mm

Range scanner

- Area: 240deg / 682step (0.35deg/step)
- Distance: 20-5695mm
- PC acquires data every 100ms

Power source

- Battery (mobile platform / SOIs)
- External AC100V cable



Size	W700-D520-H810mm
Weight	120kg
Speed	Max. 1.0m/s, 360deg/s
PS	Battery / AC100V

Demonstration video

Applications

- Stepping animal tail



- Stamping bomb fuse



- Stepping footprint



Stepping animal tail: Dog (fast)

Animal selection

- Dog / Cat / Pig

Start moving

- Cocking head
- Wagging tail
- Panting

Catch up with / step on tail

- Stop immediately
- Loud cry
- Anger expression

Removed

- Start again

Kept for a while

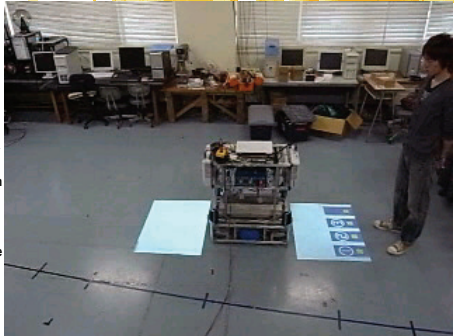
- Shake itself loose

Get away

- Turn around
- Call for

Come close

- Start again



November 2009

Stamping bomb fuse: failure

Fuse

- Spark at end
- Swinging

User

- Stamp on spark
- 15 times in 45 s

Moves

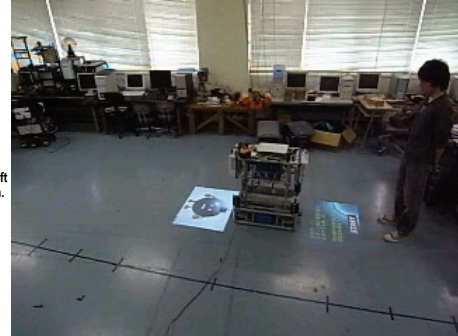
- Playing Background music
- Showing time left / remaining num. to stamp

Crash sound

- User hits spark

As time passes

- Moves faster
- Fuse shorter
- Pick up tempo



November 2009

Stepping footmark

Make user

- Strong desire to commit rehabilitation of walking

Initial screen

- Two marks of both feet

Session starts

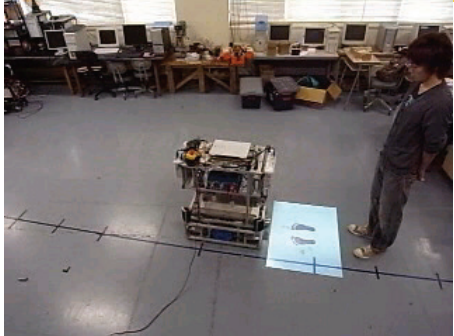
- User puts feet
- Makes sound, move forward, display mark

Sequential presentation

- User puts foot
- Makes sound, move forward, display the other

Gotten away

- Sound to call for



November 2009

Bio-Robotics & Human-Mechatronics Laboratory

Message

- Let's grow up together developing a new field as the meeting ground for people who have a new way of thinking and extraordinary abilities regardless of present areas and aspects.