Human–Robot Interactions: Robots in Healthcare

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Sponsor:

WTEC.org
OVERVIEW

- Robots as Assistive Devices
  - Robot caregiver
  - Robots as patient assistants
  - Robots for replacing motor functions
- Robotics in neuro-rehabilitation neural restoration
  - Assist as needed/biofeedback
  - Socially Assistive Robots
- Robotics in Tele-health
- Brain Computer Interface
ROBOT AS ASSISTIVE DEVICE: Robot as Caregiver

- The Sungkyunkwan University (Date Visited: October 21, 2011) Hosts: Sukhan Lee PhD and Dong Ryeol Shin, PhD

Overview:
- The Sungkyunkwan University (SKKU) is over 600 years old; it was originally established to study the philosophy of Confucious.
- Today it is a large university with undergraduate and graduate educational programs (including a medical school).

HRI focus:
- Human–Robotic interface for creating a potential mass market for service robots, health care and home care assistive robots, robots in the consumer sector (stores), robots for educating children.

Research focus: A major focus is developing new service robots & and robotic platforms.
An evolving product of this research is “HomeMate”—developed to function as one of a group of “cognitive, consumer robots”: to perform human-like, robotic services, such as elder-care, home security, errand services, assistive robots for persons with disability.

- “HomeMate” is now in a second generation phase: and applications that are being developed and tested include: errands, video chatting, medicine delivery.
- Penn State University is going to start testing these robotic devices in Skilled nursing facilities to establish feasibility and efficacy.
Host: Dr. Yuichiro Yoshikawa (visited October 17)

“Infant/child” robots are created that learn motor skills based on environmental experiences.
  ◦ A goal of this research is to gain insight into how infants acquire skills.

A different but other potential goal of this line of robotic development is to study and train human caregivers through interactions with these robots.
Professor Sugano at Waseda University with WTEC Team

Figure 1:
“Twendy-one robot” for patients with mobility limitations. The robot approaches a patient who needs to move for his bed to a wheelchair. The robot arms are remarkably strong enough to hold the weight of the patient. The robot then rotates towards the wheelchair and the human rotates with it, and then the human can seat on the wheelchair when he is over it. “The demonstration was compelling both in terms of the functionality it provided to the human, and the robustness of the robot body. We were able to experiment with the passive control of the arm and its safe arm motion was also demonstrated.”
Robot promoting community access and participation

- Home based person (disabled/elderly) can actively participate in community activities:
  - Site Visit: Kyoto University
    - October 18, 2011 Laboratory
    - Professor Toyoaki Nishida
Nishida–Sumi Laboratory

- Nishida–Sumi Laboratory is focused on applied intelligent information processing, “social intelligence” design and conversational informatics.
  - Conversational informatics analyzes human conversational behavior including verbal/nonverbal interactions during conversation with a goal of developing improvements in human–computer interaction.
  - One very practical application of this system is for directing a community based robot from a remote location. (For example someone homebased who wishes to participate in the process of grocery shopping).
Robots as Assistive Devices

- Robots for replacing motor functions
- Advances in robotic technologies and miniaturization of computers, have recently led to the possibility of:
  - Exoskeleton Robotic Orthoses
Wheel Chair Mounted Assistive Robotic Arm

- Shigeki Sugano, Dr.
- Professor Department of Mechanical Engineering, Waseda University
Rehabilitation Robotics LAB

2011. 10
People

- Leader
  - HS Park, Ph.D.
- Researcher
  - IH Jang, Ph.D.
- Doctorial Students
  - JY Jung
  - HD Yang
  - CJ Park
Standing up and walking is an important goal for most people living with spinal cord injury (SCI). Although neural restoration with treatments such as stem cells, growth factors and transplant remain areas of intense scientific study, such solutions will likely not be available in the near future.

Rehabilitation strategies for enabling gait have included orthotic devices such as reciprocating gait orthoses and knee–ankle–foot orthoses have limited utility because they are so labor intensive and physically exhausting for the user, and gait velocities are not functional.

Advances in robotic technologies and miniaturization of computers, however, have recently led to the possibility of exoskeleton robotic orthoses for the lower limbs (EROLLs) which have been shown to enable individuals with SCI to walk, at functional velocities without excessive cardiovascular demand.
I. RobIn–P1

- R&D Trends of RR for SCI

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<th>ReWalk</th>
<th>Rex</th>
<th>eLEGS</th>
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- Approval of FDA, 2011
- Clinical test with 6 patients - 2011
- Rental Business
• **R&D Trends of RR for Stroke**

- **treadmill**
- **ground**

  - Free gait
  - Guided gait
I. RobIn-P1

• Robot for Independent Life

● System

○ Intelligent Crutch
○ Foot Sensor
○ Motor, Battery

● Applications

- Walking assistance for SCI Patient

● Main Functions

- Stand-up
- Sit-down
- Walk
- Stair-up
- Stair-down
Clinical Test at Chung-Nam University Hospital
In normal development, perceptual motor learning is spontaneous and usually occurs without the need for intervention.

Motor functions can be improved by induced motor learning of gross and fine motor functions (in the healthy and the damaged nervous system).

Verbal motivation improves reaction time in a given task.

Also, providing a functional context for the performance of a task may enhance the quality of reaching movements of the affected arm persons with hemiparesis.

There is now strong clinical evidence that intensive, task specific and engaging practice enhances recovery in the children and adults with subacute or chronic stroke brain disorders.
Motor rehabilitation requires intensive task specific practice, feedback, and motivation on the part of the patient.

This is a labor intensive process and to provide sufficient therapy by an occupational or physical therapist represents a prohibitively expensive solution.

A socially assistive robot can potentially provide the guidance necessary to achieve intensive motor learning rehabilitation therapy, though a number of challenges must be studied, elucidated and be deployed practically when developing the appropriate device.
“The Uncanny Valley”

- The optimal appearance and the nature of human robotic interaction for the SAR is an area of intense study throughout numerous sites visited by the October 2011 HRI WTEC Panel.
- These sites focused on how humans react and respond to android, geminoid, mechanical robots and the development of “emotionally intelligent” artificial intelligence.
Conversational informatics analyzes human conversational behavior including verbal/nonverbal interactions during conversation with a goal of developing improvements in human–computer interaction.

- Specific research relevant to human–robotic interaction is the development of Embodied Interactive Control Architecture (EICA), for training a robot to show human–like interactions as a result of autonomous learning.
Range sensor (Swiss Ranger)

Step Recognition

Body Direction

Step count

YES

Go Forward

NO

Subtract between body and cart

Diff > Threshold

YES

Turn

NO

Stop

Cart Direction

Compass

Control

Real World

Pressure sensor

Via the Internet
This Laboratory develops robotic infrastructures for promoting and studying social interactions between humans and robots.

Robots are created 1. for promoting human interaction and 2. measuring human response through real-time sensor networks.
  - Analyses of these responses are used to iteratively improve robotic devices for becoming a better human partner.

An objective is to develop technologies for collecting new information about human robotic interaction based on Computer Vision, Robotics and Artificial Intelligence.
Osaka has created lifelike humanoid robots and geminoid robots (“twins” of actual human beings).

- Some of these robots exceed human abilities (for example in the performing arts), and some are extremely simplistic and used for promoting and monitoring emotional responses of human to robot.
Another area of research involves placing robots in real world commercial situations, and in home environments and recording then analyzing human reactions and responses.

- Technologies used include laser range finder networks, wifi devices and sensor networks (which provide robots with “human like” perception).
- The academic effort is multidisciplinary with input from cognitive science, psychology and engineering disciplines.
Application focus: Android Robots for Emotional Communication between Humans and Robots
This group has been developing Android Robots for human cultural communication, cultural/entertainment/art. since 2006.
  ◦ The android series is known as Eve (for the biblical first woman) R (for robot) There are now four versions of EveR: (1, 2, 3, 4.).
  ◦ The robot resembles a beautiful young Korean woman.
An additional focus planned for the future is Android Robots for interaction with humans with neurological conditions such as Alzheimer’s or Autism.
People

- **Leader**
  - Ho–Gil Lee, Ph. D.
  - Dong–Wook Lee, Ph. D.

- **Researcher**
  - Dongwoon Choi
  - Deuk–Yeon Lee
  - Hoseok Ahn, Ph. D.
  - Man–Hong Hur
Android for Emotional Communication Between Human and Robot
Android for Emotional Communication Between Human and Robot

Facial Expression

- Neutral
- Happiness
- Sadness
- Anger
- Smile
- surprise
- Fear
- Interest
- Disgust
- Blink
- Wink
- Sleep
Android for Emotional Communication Between Human and Robot

Applications

- Announcer
- Singer
- Actress
- Guide
- Kindergarten Teacher
- Friend
- M.C.
Robotics in Tele-health

Professor Sugano at Waseda University
Remotely-operated sonogram system.

A medical doctor can remotely operate
the sensing device over the body of a
patient to diagnose possible internal
bleeding areas and extent.
Robotic sonogram system. A medical doctor can remotely operate and interpret the evidence internal bleeding.
Site: Toyohashi University of Technology (TUT)
Host Professor Makato Ishida

Overview:
- The Integrated Circuit Group (ICG) at Toyohashi University of Technology develops integrated circuits (ICs) and sensor devices using new materials and structures.
- The Electronics–Inspired Interdisciplinary Research Institute (EIRIS) established in 2009 for bringing together expertise in electrical engineering with academic medicine and medical diagnostics.
- Examples of successful interdisciplinary development and commercialization include sensor microchips and ultra-high capacity memory chips.

“Our ultimate goal is to realize high-performance integrated circuits and intelligent sensors.”

Research areas:
- There is a focus on designing and manufacture of the EIRIS “layout chip” which locates seizure focus and injects antiepileptics locally (trials in Monkeys and rats—none in humans yet). This represents novel interdisciplinary research efforts employing science and applied technology: creating an integrated array of micro probes/tubes.
There is an effort to organize approaches vertically: integrating nanosensors: optical, physical, biological, and chemical.

Another biological research focus is creating silicon substrates for in situ monitoring of cellular electrical activity—this could lead to implanted wireless communication with brain tissues (brain computer interface applications are a possibility).

Using silicon may be superior for biological applications because of the low impedance requirements.

Other areas of active research are enhanced electrode probes with very low impedance and on encapsulation of devices.

The technology has been tested in animal models: for example the rat cortex, where they have successfully recorded whisker evoked signal. The focus of the research group is on creating the device prototype—not testing in humans.
Brain Computer Interface (cont.)

- FUTURE research goals: ever smaller very high density highly precise electrodes and electrode tube arrays.
  - Practical applications would include superior ability to treat epilepsy and treat cardiac arrhythmias.
  - Other applications are retinal implants and brain computer interface
- Robotics is a future goal.
- Commercialization & technology transfer:
  - The n vivo/in vitro recording devices were first developed for the use of the scientific community.
  - However, the group is now engaged in working with commercial partners:
- Laboratory organization:
  - ICG has full time 60 people, including 10 faculty, 11 doctoral candidate, 30 masters student, and 13 undergraduates; EIRIS institute: 20 faculty.
Robots as Assistive Devices
  ◦ Robot caregiver
  ◦ Robots as caregiver assistants
  ◦ Robots for replacing motor functions

Robotics in neuro-rehabilitation neural restoration
  ◦ Socially Assistive Robots

Exploring the “uncanny valley” : studies have shown that when a robot becomes “too human” in appearance and behavior, human beings find interacting with the devices unpleasant or frightening.
  ◦ These researchers conducted many surveys with people of different backgrounds before embarking on designing the devices. Sungkyunkwan University (SKKU), Korea Institute of Industrial Technology (KITECH), Osaka University
Kyoto University: we discussed their work involving development of a telecommunication system which seeks to control a humanoid robot by using multiple range sensors and a pressure sensors.

- The human controller’s actions are reconstructed from range sensors, and the system estimates his directional pose by a 3D body model, but it is possible that the technology they are developing could serve to guide at home rehabilitation therapy through monitoring activities of people who need to perform therapy.

- Assist as needed/biofeedback

Korea Institute of Industrial Technology (KITECH): work on exoskeleton replacement of motor strength—could be made interactive and create something that not only enhances function as an assistive device, but could provide “neurological rehabilitation” by providing feedback and by providing only assist as needed and enhancing motor learning.

- Robotics in Tele-health
- Robotic Surgery
- Brain Computer Interface