Towards the development of the first human-friendly system in the world

--- Robotics studies focusing on the dexterity of the human hand ---
Kawasaki & Mouri Lab

Intelligent Mechanical Engineering course
Department of Mechanical Engineering, Faculty of Engineering, Gifu University

Research labs: C322, E322, VBL Unit 2 (Last updated: June 24, 2013)
Research lab members: Haruhisa Kawasaki, Professor, Tetsuya Mouri, Associate Professor, Takahiro Endo, Assistant Professor, Vladimir Kotev & Emiliya Abadzhieva, Visiting Researchers: from Bulgarian Academy of Sciences, Miki Nomura, Technical Assistant, PhD students: 2, MS students: 7, RS students: 1, UG student: 10

Learning contents in our lab: Robotics, virtual reality (VR), control engineering, image processing

Our main theme: The faculty and students associated with the lab conduct research on developing futuristic human-friendly robots. We aim to establish "something new", which is our motto: “to contribute new science and engineering in the 21st century.”

Student advisory: We have three faculty in our lab to support students learning process.

Overview of our research: Focusing on robotics and VR, we conduct research on the interface robots and intelligent mechanical system that can work autonomously like human.

In the future, we are planning to conduct the following research:
1) Study of the robot artificial skill
2) An adaptive for arm and hand cooperative control
3) The hand control based on tactile sensor
4) A high-power industrial robot hand

2. Research on myoelectric prosthetic hand

A person who lost his/her upper limb by accident or illness uses a prosthetic hand to mimic the appearance and to replace the function of a missing limb. Body-powered prosthetics use electromyography strapped to the individual to mechanically maneuver the artificial hand movement. Researchers have actively conducted the myoelectric prosthetic hand, though it is not been applied in a real-world setting. We have been inventing a prosthetic hand with the high gripping force and light weight in referring to prosthetics users and authorized people. Our future research includes:

1) The development of artificial skin that is attached to the prosthetic hand
2) The study of the prosthetic hand operating by multiple biological signals
3) Experimental demonstrations
3. Research on robot hand for rehabilitation education

The purpose of the study is to help future therapists to efficiently learn rehabilitation skills. The robot imitates and moves like a patient hand with immobilized joints that may be helpful for the trainees to learn the rehabilitation education and training systems. The future therapists can simulate to treat patients who are suffered from joint immobilization of their hands. This system measures rehabilitation skills, and therefore it compares and evaluates the rehabilitation program as a whole. We are aiming to reduce the size of the arm and hand with larger range of motion, which hopefully is lighter but stronger. We will be conducting research as follows:

1) Robot hands that contributes to rehabilitation education
2) Tele-rehabilitation system

4. Research on hand rehabilitation support system

The rationale of this research is to provide a rehabilitation support system that can imitates delicate movements of human hands. In order to do so, we have been conducting experimental research on hand rehabilitation support system using a master-slave motion assistant for independent rehabilitation therapies. For this research, we have received the IEEE/ASME Transactions on Mechatronics (TMCH) Best Paper Award for 2013. In the near future, we will be conducting the research as follows:

1) Rehabilitation support system for patients with rheumatoid arthritis
2) Rehabilitation support system for patients who suffer from immobilized upper joints of their hands

5. Research on multi-fingered Haptic Interface

Robot: HIRO

We have developed the world-first multi-fingered haptic interface robot called HIRO, which consists of a five-fingered haptic hand and an arm. The haptic interface in the past is limited to 3D force feeling that applied to one finger tip and 1D force feeling at multiple fingertips. However, the HIRO can present 3D force at human five fingertips. The HIRO has great potential for many application areas such as tele-manipulation, scene simulation, and educational training in many situations such as performing medical examinations, treatments, and nursing cares. Our research results received the Funai’ Award from the Japan Society of Mechanical Engineers in 2009 and the 8th Industrial-Academia-Government Collaboration Promotion Award (the Ministry Award of Internal Affairs and Communications). From now on, we will be conducting the following research:

1) Research on transmitting expert skills using HIRO
2) Development of a software display device detecting softness
3) Research development of hand haptic interface for the surfaces of their hand and fingers

6. Research on a side-faced-type multi-fingered haptic interface

The haptic interface robot HIRO has five-haptic fingers with 3D finger tips force devices. This is the world-first multi-fingered haptic interface. It is hard to grasp and manipulate a small object because the interface is placed in front of the hand. As a solution to this problem, we have been attempting to invent multi-fingered haptic interface with contact points on the side attached to finger tips so that one can control the interface from the behind of the hand.

The new sided-faced-type multi-fingered haptic interface allows the user to grasp and manipulate a small virtual object using five fingers with 3D finger tips force sensation. It can be useful in several fields, such as tele-manipulation and nursing care (e.g., surgery, examination and treatment in medical fields), maintaining and handing the expert’s skills down to the next generation in manufacturing industry. Moreover, it could apply to extremely sophisticated tele-manipulation in a very limited environment such as nuclear plant and aerospace. Our next research plan is as follows:

1) Research on control in the side-faced-type multi-fingered haptic interface
2) Research on robot teaching system using the side-faced-type multi-fingered haptic interface

7. Research on robot teaching in VR environment

We have been conducting a research about the robot teaching system using virtual reality techniques. Our goal is to analyze one’s behavioral intention and automatically command the robot. Our next research would include:

1) Bimanual VR teaching system in assembly works using multi-fingered haptic interface
2) VR teaching that is considered the difference between the actual and virtual environment
3) Control of the hand robot by VR teaching system
8. Research on breast engorgement measurement system

In collaboration with the school of nursing, we conduct research on the breast engorgement measurement system for the purpose of breastfeeding support to quantify the diagnostic screening technology during the puerperal period.

Our main themes are:
1) The breast engorgement measurement system
2) The evaluation method of the breast engorgement measurement

9. Research on tele-manipulation for the humanoid robot hand

We have been researching and developing the basic technology of the tele-manipulation of humanoid robot hand. It is based on “decision-making and consensus building” between the user who controls the robot and the robot who intends to maintain the safety of the operation through the tele-manipulation. A person’s intention is assessed by the data analysis of primitive motion factors and its combination of the factors. Through the consensus will, we can remotely control the robot more smoothly and safely.

1) Research on decision making and consensus building methods
2) Research development of palpation diagnosis support information system

10. Research on pruning robot

The Japanese forestry industry has been in a decline due to a reduction of lumber prices and the rapid aging workers. Pruning robot prototype

We have been conducting a research to develop a “pruning robot” that can cut branches automatically. Our main themes are the following:

1) Research on high-speed climbing system that can deals with gravity problem
2) Research on high efficient pruning methods
3) The measurement and recognition of the branch in the natural environment
4) Dynamic simulation

11. The development on robot symbolic analysis system

We have developed a robot symbolic analysis system called ROSAM II that manipulates equation using a commercial computer algebra system, Maple. The ROSAM II allows the user to analyze the serial link mechanism, the tree structure link mechanism, one loop with closed link mechanism. This software is distributed to all over the world with free of charge.

The example of ROSAM

The research above has reported through mass media. Go to our homepage for more details.

Selected awards:

2) Gifu Newspaper Award - Academic Field, February 9th, 2013
3) Young Author’s Award, 2011 IEEE/SICE International Symposium on System Integration (SII20011), “Development of a Tweezers-type Device for a Multi-fingered Haptic Interface Robot,” 2011
4) The 8th Industrial-Academia-Government Collaboration Promotion Award, Ministry for Internal Affairs and Communications, “Implementation of Network Haptic Interface,” 2010
6) The Science and Technology Award of the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology of Japan; the “Development of Humanoid Robot Hand Gifu Hand,” 2006

Kawasaki & Mouri Laboratory
Intelligent Mechanical Engineering course
Department of Mechanical Engineering
Faculty of Engineering
Gifu University
Yanagido 1-1
Gifu, 501-1193, Japan