R&D Issues in the Development of Human-friendly Welfare Robot Systems

Z. Zenn Bien
Dept. of Electrical Engineering
KAIST
Taejon, 305-701
Republic of Korea
zbien@ee.kaist.ac.kr

Won-Chul Bang
Dept. of Electrical Engineering
KAIST
Taejon, 305-701
Republic of Korea

Jung-Bae Kim
Dept. of Electrical Engineering
KAIST
Taejon, 305-701
Republic of Korea

Kwang-Hyun Park
Dept. of Electrical Engineering
KAIST
Taejon, 305-701
Republic of Korea

***Abstract* – Future society must be utopia in which every constituent can share equal welfare. In particular, it should be a society where the elderly and the physically handicapped can lead their lives happily along with the normal. In order to realize such a welfare-driven society, it is essential to build an infrastructure with a variety of facilities based on advanced technology or devices and systems that are human friendly. To comply with the needs of human beings to lead more convenient and safe lives, human-friendly and effective man-machine interaction systems are desired for the human being and robots to coexist and collaborate. Of various areas of welfare robot systems, the following four issues will be discussed in this paper: (1) intelligent residential space system for the weak-elderly/handicapped, (2) state-of-the-art medical robot system, (3) entertainment/educational robot system including soccer robots, and (4) disaster control and rescue robot.**

I. INTRODUCTION

Humans desire to lead more convenient and safe lives. In particular, the elderly and the handicapped may like to get the benefits and support of ever-progressing scientific technology. It is instructive to note that in the forthcoming age of 21st century, the number of the elderly will be drastically increasing along with the number of the handicapped caused by a variety of accidents in the complicated and diversified society [1]. To cope with such desire and demand, human-friendly man-machine interaction systems are desired as means of care-giving aids such as intelligent robot systems that is capable of coexistence with human beings.

It is well known that the technology related to industrial robots gets now quite matured whereas that of service robotic systems including the rehabilitation robots is in its infancy as long as its usage is concerned. To promote the research on service robotics, HWRS-ERC (Human-friendly Welfare Robot System Research Center) has lately been established with the goal of 'realizing welfare service robots and systems' that can collaborate with humans or assist them.

Of various areas of welfare robot systems, the following four research programs are selected as key objects of the center research activity: (1) Intelligent residential space system for the weak-elderly/handicapped including human health monitoring system, intelligent human-machine interfaces, nursing robot, moving helper robot, self-reliant walking system and signal transformation system for the disabled, (2) State-of-the-art medical robot system, (3) Entertainment/Educational robot system including soccer robots, and (4) Disaster control and rescue robot.

To design and realize the robots/systems mentioned above, it is essential to secure some basic technologies in an early stage which we have identified as: (1) Human-friendly man/machine interface, (2) Telematics based on digital communication, (3) Biomechatronic intelligent system, and (4) Harmonious symbiotic coexistence of humans, robots, and systems.

With these researches, there are two positive outcomes. First, the advancement of science and technology can insure the technology of developing intelligent residential space, a variety of robots such as nursing robots, soccer robots, and pet robots, operation skills through robots for remote surgery and methods of robot-aided surgery, and auto-monitoring system of locating positions. Second, industrial-economic development enables applying the technologies of the man/machine interaction and intelligent controller system integration to the industrial field, commercial production of walking-aiding robots, and pet robots. It also makes it possible to produce remote surgery robot and micro robot for surgical assistance, establish the disaster control and rescue system in an emergency.

In this paper we presents the issues on human-friendly welfare robotic systems. Section 2 discusses how to design an intelligence residential space with emphasis on its components for the disabled and the elderly. Section 3 considers the design and implementation issues on medical robot systems and the entertainment/educational robot system is dealt with in Section 4. In Section 5, disaster control and rescue robots technologies are investigated. Finally, Section 6 provides concluding remarks.

II. INTELLIGENT RESIDENTIAL SPACE

Intelligent residential system that ensures the handicapped and the elderly to lead an independent life, is researched to realize the welfare society. The research for the system includes various topics such as human-machine interfaces, health monitoring system, interactive robot, nursing robot, moving helper robot, self-reliant walking system, signal transformation systems for auditory/visually disabled.

Human health monitoring system is being developed, which can check out and analyze the condition of the patient, physically unstable and have the physician examine him through established network in an emergency or in a particular condition in need of examination. To achieve this, the technology of measuring residents' vital signs, the system that can estimate the state of health, and network technology for mutual communication with hospitals or emergency center, are essential. Though researchers have been progressed to some extent in some advanced countries, some came into market. However, there are some problems. For example, monitoring is possible only when the resident touches the measuring equipment [2].

Intelligent human-machine interface, which is more human-oriented for replacing the traditional interface with soft remote controller and pointing recognition between human and computer via keyboard or mouse, is pursued. Soft Remocon is a means of operating electrical equipment by certain predefined manual gesture, and the conductor can perform the serial procedure of choosing the equipment and operate with own manual gesture. It might be more useful to use rather difficult equipment to adjust. Pointing recognition is having certain object moved or activated by pointing it with hands. For example, the act of pointing a glass can be the sign of ordering to bring it, and indicating switch of lighting means that the switch should be turned on or off. In this context, to give the user interactive response, it also includes directing an object with the laser pointer. In the procedure of pointing recognition as shown in Fig. 1, it goes through the processes of 'catching the pointed spot,' 'pointing with the laser pointer,' 'recognition the pointed object,' and 'operating robot.'

Nursing robot system aims to reach the goal of developing intelligent moving robot with the manipulator that can provide the weak and the handicapped with light service. Intelligent nursing robot system takes advantage of man-machine interface based on recognition of the conductor's emotions for smooth communication. It also has the communication system that enables the mutual correspondence between the main computer and the robot.

Moving helper robot system is developed for training, clinical supervision and technical support for the handicapped with walking disability. The system consists of a mobile base, a small industrial robot arm and a sensor system with ultrasonic transducers. The mobile base moves the whole system in accordance with the patient's intention and robot arm help support the patient's weight for walking in a predefined posture. Sensor system detects objects along the path and warns the patient using the robot.

Self-reliant walking system is established for the paralyzed in the lower half. The system receives the EMG signals of the upper half muscles, reads the intention of patients, and generate the control signals over FES. Also, accepting the EMG signals of lower half muscles exercised by electrical stimulation, the system checks out the degree of fatigue, and moderates the intensity of stimulation. However, since the EMG signals are quite arbitrary and irregular to get the intended information, researches on several modelings and analysis methods in both frequency range and time range were performed.

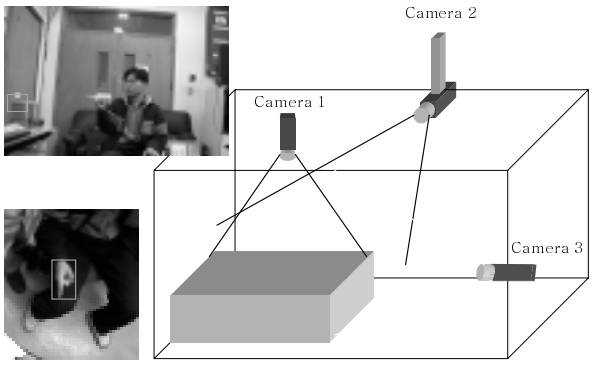

Fig.1 Pointing recognition system

Sing language recognition system has been developed for using in communication between the hearing impaired and normal person. Attempts at sign language recognition have begun to appear in the literature over the past ten years. However, these systems have generally concentrated on isolated signs, immobile systems, and small training and test sets. Research in the area can be divided into image based systems and instrumented glove systems. We developed a Korean sign language recognizer that can recognize about 500 Korean sign words and 31 Korean manual alphabets in real time with 92% accuracy. It uses CyberGlove and camera vision system for input devices and Indigo2 W/S for the main computer program [3].

Finally, the signal transformation system aims to enhance the life quality of the visually-disabled by supplying them environmental information with a state of the art system can transform visual signal to auditory signal.

III. MEDICAL ROBOT SYSTEMS

The state-of-the-art medical robots will be able to perform in real-time various kinds of sophisticated work and operations on the planned path in a surgery scene. To construct the system, we design and implement a master arm controller for minimal invasive surgical robot with force reflection capability, intelligent catheter, micro tools and sensors for robot-aided surgery, remote surgical robot using VR, and the assistant robot for endoscopy. Also we are doing research on the operation methods for medical robots including the design and implementation of the gauge to put into the human body to decide which parts to replace.

Medical operation is the field that demands specialty, skill and promptness. Recently, to enhance the quality of medical service, medical robots, new operation methods and surgical tools of advanced polymer are highly drawing attentions. Medical robots should be able to perform sophisticated work and surgery on the planned path, or can be manipulated in real time by surgeons. Particularly, it is urgent to design human-friendly robots and develop high precision human-robot-computer interface. It's because surgical robots should be manipulated by the operating surgeon, should work near the assistants, and can be adjusted easily and safely without harming human organs during surgery. The ultimate goal of the medical robot system lies in the development of medical robot systems along with the development of medical robots and artificial joint replacement surgery using state of the art sensor. Based on these technologies, the state-of-the-art medical robot system is being developed as well as paving the way for manufacturing commercial medical robots in conjunction with industries. Accordingly, in this system, development of surgical robots, robot systems hat can aid surgery, and brand-new surgical method using robots are pursued.

In demand of remote control technology and accurate control technique in the surgical field, a remote surgery robot system is needed, and it refers to the system that helps enable a physician to perform operations through robots with a control device. When the well-experienced surgeon makes

the most of the accuracy of robots, the surgery can be done more precisely. Moreover, this system can provide the surgeon who operates the controller with the force reflection or feeling measured from the surgical tools, so that he would feel as if he touches the patient. It also enables the surgeon to see the parts on monitor helping him perform the surgery more efficiently. One of the developed intelligent controllers for medical robots is shown in Fig. 2.

The intelligent catheter is used in the surgery for digestive organ, urinary organ, and cardiovascular disease. With this catheter, intricate and various surgeries can be done. To downsize the catheter, shape memory alloy spring that can be energized more per smaller volume, is adopted, and by heat processing of shape memory alloy cord, shape memory alloy spring is currently implemented.

At the same time, we are doing research on total hip joint replacement surgery. In the case of patients suffering from rheumatism in hip joint, it is frequent that they go under surgery to get their hip joints replaced with the artificial ones. In hip joint surgery, medical robots are used to get the femur precisely treated in a short period of time. If the work of machining the femur on the surface is done and the prostheses are inserted, patients recover fast after surgery due to minimal space between the bone and the femur. It is not different from the existing surgical method that a surgeon exposes the femur of a patient and decides which parts to cut out. However, for the matter, the registration method has been suggested because the previous complicated works become fast and simple by attaching small robots instead of a rasp and a saw.

IV. ENTERTAINMENT/EDUCATIONAL ROBOTS

At the end of 20th century, on account of much part of life industrialized and automated, leading an affluent life and enjoying more spare time, the desire for entertainment of human beings are relatively rising high. To meet the demand of time, high technologies of electronics and computer were developed and applied for entertainment, and high technology penetrated so deeply into human life in virtual forms of computer game or cinema. Furthermore, robots exploited only in industrial fields started to run into our everyday life. Pet robot should basically be able to remember and recognize its master and to interact with him in any ways. Ultimately, growing and learning robots that can trigger any kind of emotions from human are necessary to be developed.

Fig.2 Intelligent controller for medical robots

Entertainment/Educational robots, including intelligent soccer robots, are studied especially for robot-to-robot cooperation, humanoid type robot motion, and robust control. In this study, we implement a pet robot with reinforcement learning capability and with emotions. Also we are developing an educational robot system which will be a human-friendly acrobat/sport robot type having bio-mimetic control function by analyzing behavioral pattern of real animals.

Robot soccer systems are versatilely marketable for providing not only scientific research like individuals' coordination, real-time decision-making, recognition and learning, vision system, and communication, but also entertaining effect. Of these robot soccer systems, a newly improved RoboSot, for example, has no outer camera but contains inner camera. Since the surrounding the counterpart and the ball changes actively, an omnidirectional camera structure that can point in any direction, is advantageous.

Link biped robots, a nonlinear high-order system, have been much researched in the problem of stability and control. In this research, the link biped robot in Fig. 3 is being developed to have minimal degree of freedom to walk and patterning after human or insect gaits is to be visualized. The biped robot is very simple. It only has 4 joints and 3 links; but it is powerful. Various walking styles, like crossing, crawling and turning, can be implemented. Also ascending or descending obstacles including stairs is possible. Moreover, most biped robots including our 4-joint and 3-link biped robots can walk forward on uneven terrains while other robots, which have wheels, cannot.

V. DISASTER CONTROL AND RESCUE ROBOTS

A rescue robot used in a disaster situation such as in fire fighting is being studied. It will be equipped with the multipurpose remote-controlled redundant arm and autonomous mobile subsystem. The robot system will have various functions such as obstacle avoidance/passing function and wireless image communication capability. And it will be equipped with an auto-monitoring subsystem of location positions of emergency patients in a disaster using GPS and a mobile phone. The rescue robot must be fault-tolerant with a highly efficient drive system because of dangerous environment. We shall eventually develop a fire-resistant drive system in the scene of a fire and the drive system of high density and high efficiency. The conceptual model of the mobile robot is shown in Fig. 4.

Fig.3 4 joint 3 link biped robot

Fig.4 Conceptual model of the mobile robot for disaster control

When there is a fire, firemen come up, put the fire down, and save lives. However, it is extremely dangerous to do their job in the fire because of the hazardous surroundings. So it might be a safe idea to dispatch a robot into the site instead of firemen. As a result, to equip the robot to handle such tasks, it is necessary to develop functions for avoiding narrow areas and obstacles. Also, we need to have remote controlled robot arm attached on moving equipment robots to handle exit doors and extinguish the fire in such narrow places.

Fire service robots must recognize the exact main cause of the fire in short period of time, extinguish the fire and locate the injured people, and call an emergency. We need to have wireless voice and image communication for measuring location of risked people and objects under foggy poor situation using vision sensor, supersonic waves sensor, radar, and other sensors.

VI. CONCLUDING REMARKS

In this paper, we have presented the issues on human-friendly welfare robotic systems and have investigated on intelligent residential systems and its components, medical robot systems, entertainment/educational robot system, and disaster control and rescue robot system in detail.

Technologies for care-giving robots are considerably interdisciplinary as shown in Fig. 1. That is, academic efforts in various backgrounds, such as medicine, rehabilitation engineering, industrial design, and material engineering as well as electrical and mechanical engineering should be combined together to come up with effective realization.

VIII. REFERENCES

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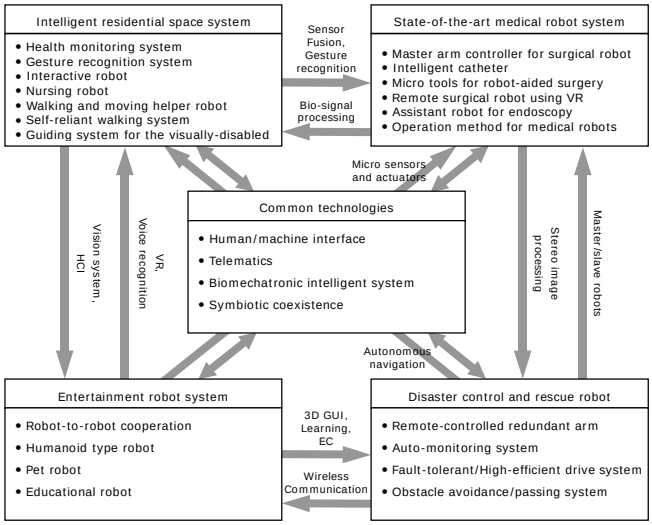

Fig.5 Related technologies for human-friendly welfare robot systems

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