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Healthcare Robot Technology Development

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Abstract: The interest in a healthy and happy life for seniors has increased of late as the quality of life in old age has become a hot issue. Moreover, the interest in health has led industrial companies to concentrate on healthcare technology. Healthcare robot technology is one of the biggest issues in the robotics field, and many companies and institutes have sought to develop a healthcare robot technology. The healthcare robot must have certain abilities that would allow it to help a person mentally and/or physically. There is no common interface module, however, for healthcare robot platforms, and few robots that have healthcare abilities exist. Therefore, developing a common interface technology and applying the technology to robot platforms can pave the way for the development of a technology that could improve the physical and mental health of humans. This paper introduces the authors' research on a common interface module and a healthcare service robot platform. First, a common interface module is one that can be used in common in the healthcare robot area. The research on a common interface module contains the following technologies: biosignal processing modules; voice signal processing modules, which could recognize voice commands; control modules for robot actuators; and a human-friendly design for a healthcare system. Lastly, the research on a healthcare service robot platform contains three types of robot platforms: ChairBot for relaxation, RideBot for exercising, and LifecareBot for human emotions. Each robot platform has common interface modules for healthcare services and can provide specialized intelligent services based on their own objectives. In conclusion, the intellectual healthcare robot is expected to promote a new field and to pave the way for a new product.

1. INTRODUCTION

The interest in a healthy and happy life has increased of late due to the changing lifestyles of people, the increase in the number of nuclear families, and the emergence of aging societies. Moreover, the interest in health has led industrial companies to concentrate on the development of healthcare technologies. For example, Korean Institute of Science and Technology (KIST) has developed a human robot, "AMI," which can describe to humans their own emotions (Jung et al., 2004). In a joint research project, National Aeronautics and Space Administration (NASA) and Stanford University developed a wireless physiological monitoring device for health examination, "CPOD" (Mundt et al., 2005) and "Life Shirt" (Choon Po et al., 2006). In Japan, Matsushita corporations have developed a fitness riding robot, dubbed as "JOBA." Agency of Industrial Science and Technology (AIST), for its part, has developed a mental care robot, "PARO," which can give people a sense of stability and can provide aged people with intimacy (Shibata, 2004).

The healthcare robot needs certain abilities to be able to promote the physical and mental health of a person. These abilities pertain to functions of interaction with a person.

The authors' research and development efforts on healthcare technology are described in this paper. Section 2 contains the description of objectives for the healthcare robot. Section 3 contains the following: (1) a description of the efforts to develop a common interface technology for healthcare robots, such as the biosensor interface and software module technology; and (2) an introduction of healthcare robot platform developments based on the common interface technology.

2. OBJECTIVE

Fig. 1 describes the holistic development of a healthcare robot technology. Developing a common interface technology and applying the technology to a robot platform can pave the way for the development of a technology that can improve the physical and mental health of humans.

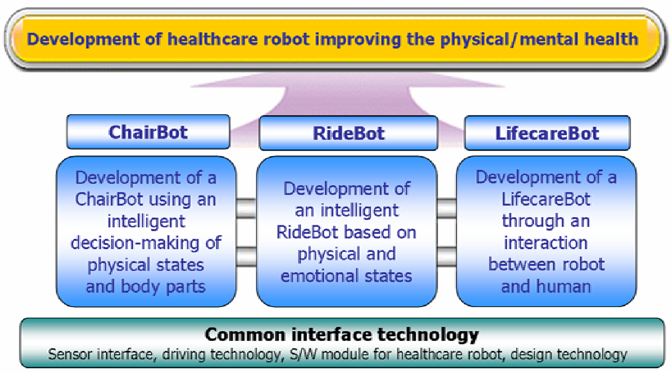

Fig. 1. Healthcare robot technology development for the physical and mental health of humans

This paper is divided into four subjects: a common interface technology, ChairBot, RideBot, and LifecareBot. The following sections contain a detailed description of each of these subjects (Fig. 2).

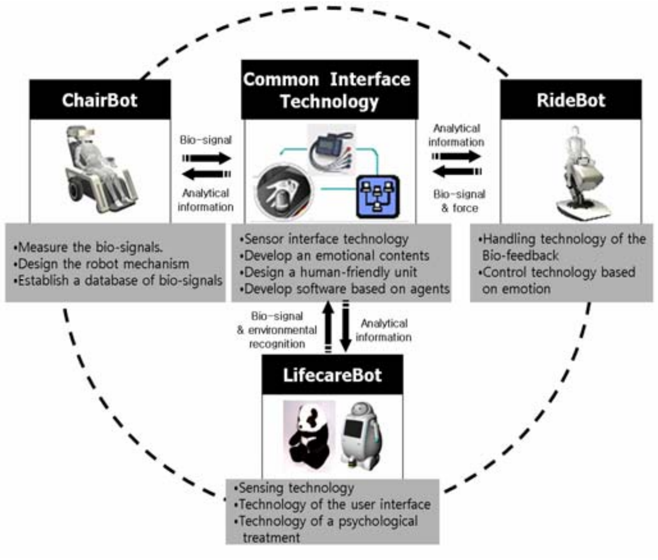

Fig. 2. Structure of the healthcare robot technology system

3. RESEARCH FOR HEALTHCARE ROBOT

3.1 Development of a Common Interface Technology

The objective of the common interface technology is to develop common processing modules and to support designs of robot bodies from the healthcare point of view.

3.1.1. Electrocardiogram (ECG) and Body Temperature Instrument

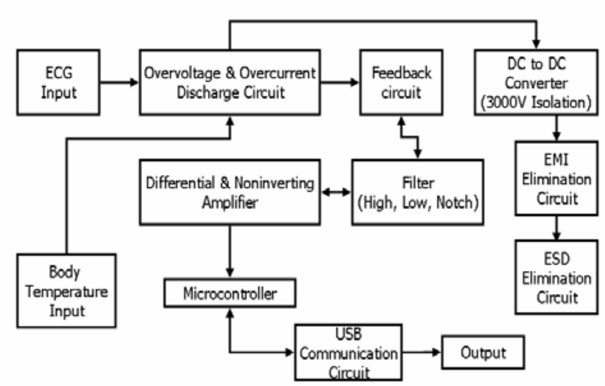

Fig. 3. Structure of the electrocardiogram and body temperature system

The system that was developed by these researchers consists of two parts: an electrocardiogram and a body temperature system. The former can be measured using two electrodes, the left and the right hands. The latter, on the other hand, can sense the body's temperature by inserting a temperature sensor in the two electrodes.

The developed instrument has many parts, some protecting the instrument from over-voltage and over-current and others eliminating the noise (e.g., 60Hz), amplifying the biosignal, relaying the information between the hardware and the PC, and isolating a high-level voltage of about 3000V.

3.1.2. Blood Pressure and Body Fat Instrument

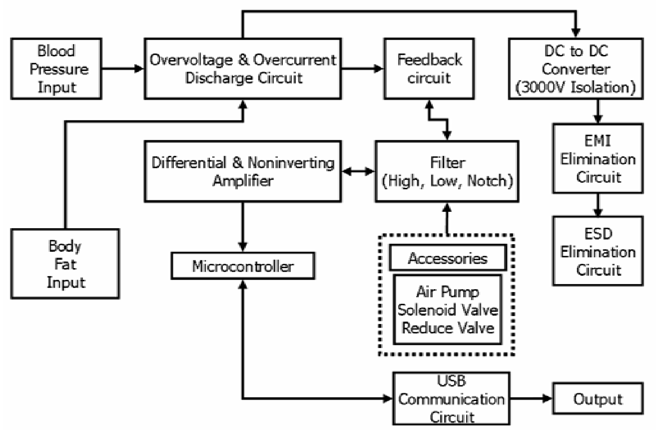

Fig. 4 Structure of the blood pressure and body fat system

The module that was developed by these researchers can be used for the measurement of blood pressure and body fat. The blood pressure system is made up of accessories like an air pump, a solenoid valve, a reduce valve, and a cuff. It can estimate the systolic and diastolic blood pressure. The body fat system uses four electrodes, conducts the current from the left hand to the right hand, and then detects a variation of body resistance.

The hardware of the biosignal-measuring instrument basically includes a protection part and a feedback part. The accessories for the measurement of blood pressure are used to cause the air to circulate into the blood pressure cuff.

3.1.3. Voice Recognition System

Through the development of a voice recognition module, a robot can be made to identify and interact with a user and to check the user's body condition and health indices.

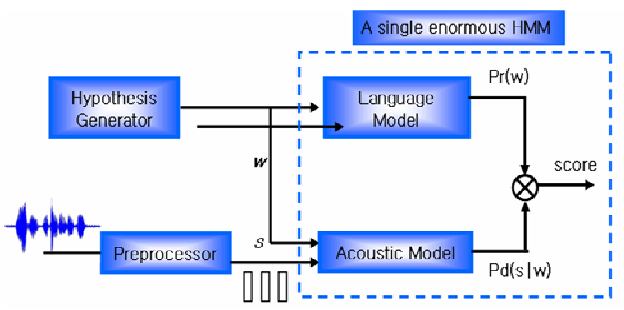

Fig. 5. Block diagram of the voice recognition system

The preprocessor is a real-time process and detects the voice interval using the cepstral mean subtraction for noise elimination.

The acoustic model includes three states and four mixture triphones. Its range is within 150 Kbytes to 100 Mbytes, according to an application field.

The language model includes the trigram transition probabilities and also has the function of rejecting out-of-vocabulary (OOV).

The recognition process is the dynamic Viterbi procedure, an algorithm in signal processing for distance talking. Finally, the memory and computation versus accuracy supports the fixed-point operation in the embedded DSP and the winCE.

3.1.4. Human-Friendly Design

An important consideration in the design of the instrument was that the user should be able to easily establish contact with the sensor and that he or she must have greater convenience in using the device. Moreover, a safe instrument was designed under IEC601-1, considering electromagnetic interference (EMI) and electromagnetic compatibility (EMC).

Fig. 6 is an integrated measuring sensor that consists of an electrocardiogram sensor, a body fat sensor, and a body temperature sensor.

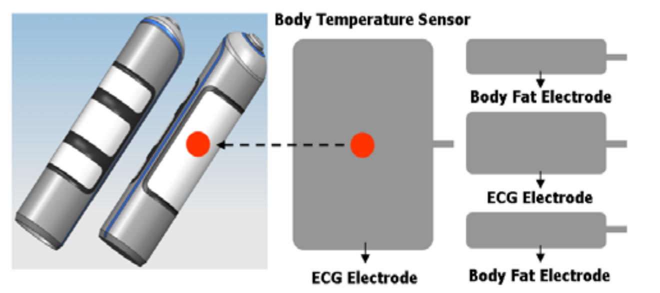

Fig. 6. The description of the sensor unit

Bio Check Unit (BCU) has the function of measuring the biosignals of the user, acting on the voice recognition module, managing the user's health information, and suggesting a pattern of behaviour or exercise to the user.

3.1.5. A Common Drive Module

Fig. 7 shows the structure of the multidimensional motor control module. The module has an advantage in terms of convenience. It is divided into two parts: the main control board and the subboard. The main control board can communicate with an upper-level controller such as a PC, and a user can develop a robot control software by using ANSI-C-based SDK (ANSI-C-based software development toolkit). The subboard can generate a pulse signal for motor control. A subboard can manage four motors and a main control board can manage four subboards. Therefore, a multidimensional motor control module can control up to 16 AC/DC servo motors. The objective of the motor control module is the convenience of the robot developer.

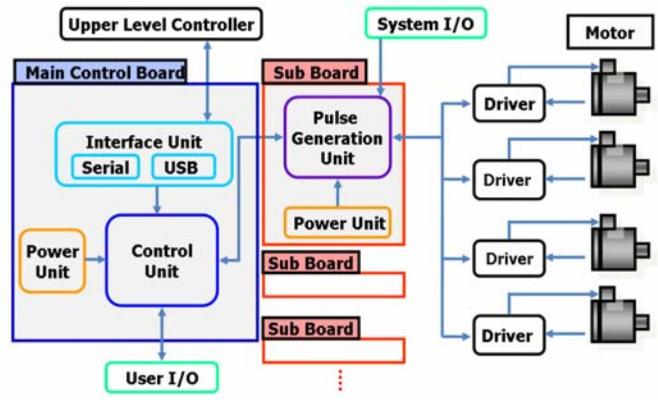

Fig. 7. Structure of the multidimensional motor control module

3.2. ChairBot

ChairBot is a robotic massage chair that uses the bio-information of its human user for health monitoring. It also estimates the user's body states and analyzes the massage regions of the body using an intelligent decision-making system. ChairBot significantly helps a user overcome fatigue by providing him or her with massage services.

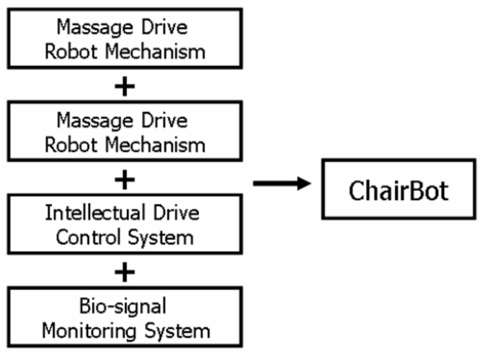

Fig. 8. The description of ChairBot

ChairBot utilizes a variety of technologies: the intellectual massage force feedback mechanism; the massage control technique, which applies the robot mechanism and senses pulses for diagnosis; an active seat for the user's convenience; and a sensor and interface technology for healthcare robots (Fig. 8).

3.2.1. The Intellectual Massage Force Feedback Mechanism

Fig. 9 contains a block diagram that explains the massage force feedback system. According to the user's health state and basic information, ChairBot performs its function with the proper user position and massage strength. It looks for the proper Nth actuator and an axis controller and could work efficiently based on the results of the health management program (HMP).

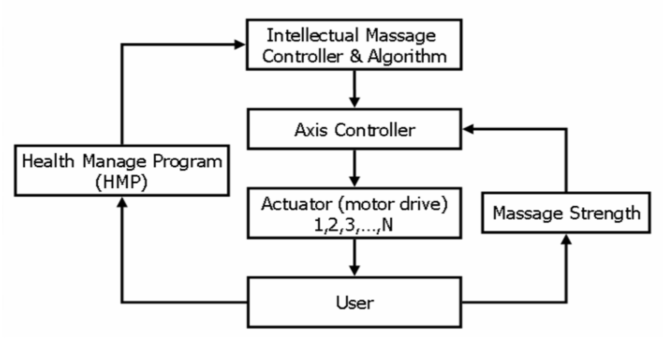

Fig. 9. Block diagram of the intellectual massage force feedback mechanism

3.2.2. Massage Control Technique

The results obtained from the intellectual controller present the user's massage pattern or taste. Lower-level modules are made up of the local controller, the position/velocity/pressure sensor, and the biofeedback sensor. The feedback loop remains firmly in place when the lower-level modules firmly connect to the sequent work.

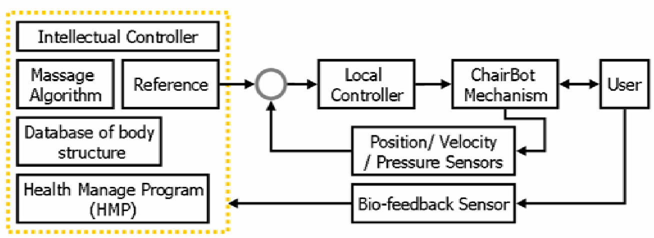

Fig. 10. Block diagram of the massage control technique

3.2.3. Active Seat Technology for User's convenience

The aim of active seat technology is to give its user an efficient massage.

A sensor was utilized to recognize the somatotype shown in Fig. 11. The sensor is made up of a probe tip with an acceleration sensor and a load cell. The important massage points for ChairBot are the neck, shoulder, and lumbar region. The hands are massaged repetitively from up downwards and from left to right, as real hands would.

First, ChairBot scans the whole body of the user. Second, the seat automatically adjusts to the proper size of the user's somatotype and then fastens in place. Lastly, the stiffness of the back area of the body could be graphically shown by analyzing the digitized data regarding the spot on the body that is suitable for acupuncture.

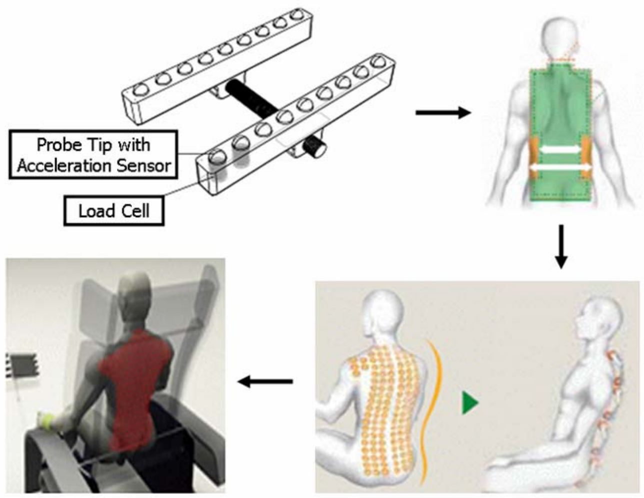

Fig. 11. The block diagram of the active seat technology

3.3. RideBot

RideBot is a robotic riding machine for fitness. It can estimate the user's bio-information so as to manage the amount of exercise that the user needs for good health. It also estimates the user's body pose and generates reactions like horseback-riding motion. The reaction is made by a 3DoF mechanism and a control technology in this research. RideBot significantly helps in a user's body fat reduction.

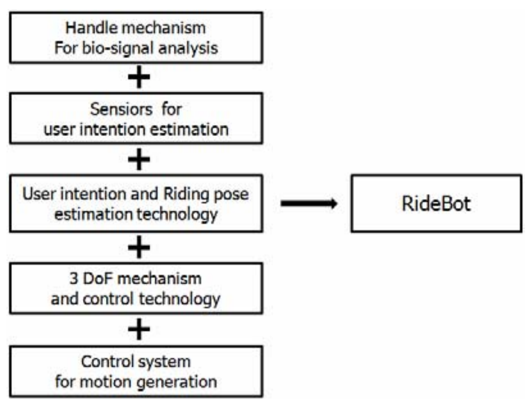

Fig. 12. The description of RideBot

RideBot utilizes a variety of technologies: the intellectual biosignal health index analyzer, a user intention and riding pose estimation technology for the intelligent interaction between a human and RideBot, and a 3DoF riding motion generation technology (Fig. 12) .

3.3.1. Intellectual Biosignal Health Index Analyzer

Fig. 13 describes the user's health management. RideBot uses bio-information, body fat, heart rate, and weight. Biosignal Analyzer estimates the user's body state and generates health index information, which is used as the basis of an exercise counselling program. The user can check his or her body state before and after exercising, and users can easily compare their body states.

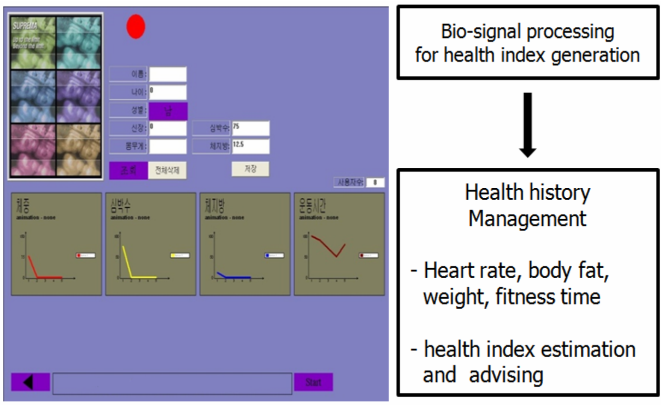

Fig. 13. Health management

3.3.2. User intention and Riding Pose Estimation Technology

Fig. 14 describes the system of user intention and the riding pose estimation system. The user intention estimation technology enables the robot to sense the user's intention, which enables the robot to generate riding motion intelligently. The riding pose estimation technology, on the other hand, enables the robot to sense the riding pose of the user. There are three riding poses in the RideBot system: walk, sitting trot, and rising trot. The robot automatically generates motions by sensing the user's riding pose. The system uses the following sensors for user intention and riding pose estimation: a saddle, reins, and joint bar sensors for horseback-riding key positions; and the voice recognition module described in section 3.1.3 for the user command.

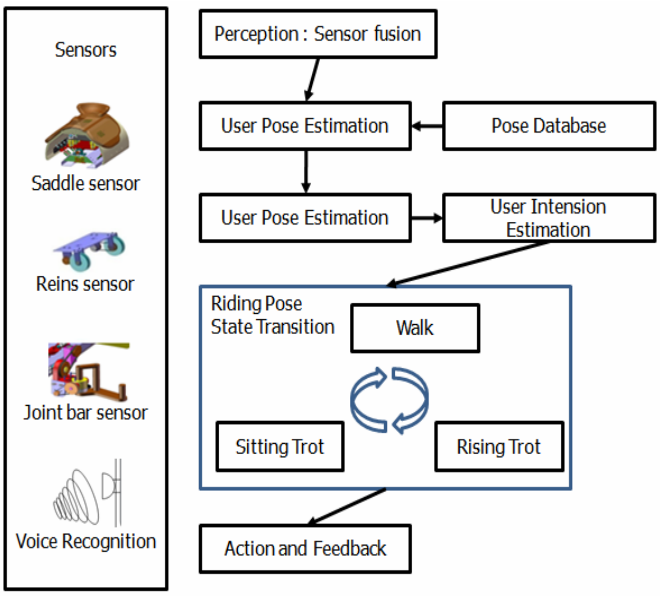

Fig. 14. User intention and riding pose estimation system

3.3.3. 3DoF Riding Motion Generation

The mechanism of RideBot has a design that is similar to that of a horse's rising motion. A motion simulator generates a virtual 3DoF motion using the real estimated horseback-riding motion. Fig. 15 shows three basic motions: roll, pitch, and bounce. The combination of motions makes the riding motion safe by using a potensionmeter and a limit sensor.

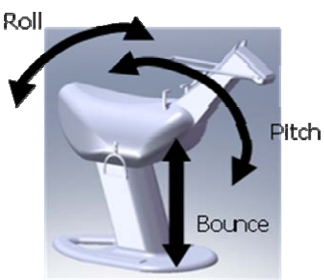

Fig. 15. Components of The 3DoF Riding Motion

3.4. LifecareBot

LifecareBot is a home service robot platform that can produce a positive mental, psychological, physiological, and social effect on its human users.

Fig. 16 shows the purpose of the LifecareBot system. LifecareBot has two main functions. The first is the health check function, for which biosensors are used. The second is an emotional care system, for which voice and heart rate information are used.

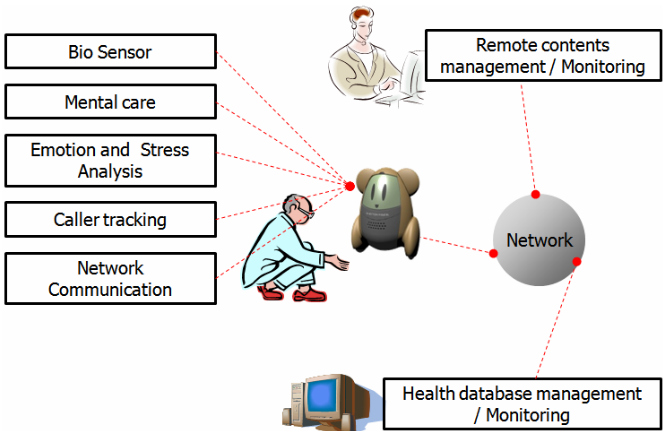

Fig. 16. The purpose of LifecareBot

3.4.1. Health checking functions for aged people

The robot platform has biosensors for the medical care of aged people. Moreover, the robot can connect to a network where aged people can obtain public welfare healthcare services.

3.4.2. Emotional care system

Fig. 17 describes the analysis module of human emotions. The robot uses tone data and heart rate, estimates the user's emotion, and reacts intelligently. The data fusion has been designed using fuzzy rules. By providing positive psychological effects to its users, the system can help prevent people from feeling lonely.

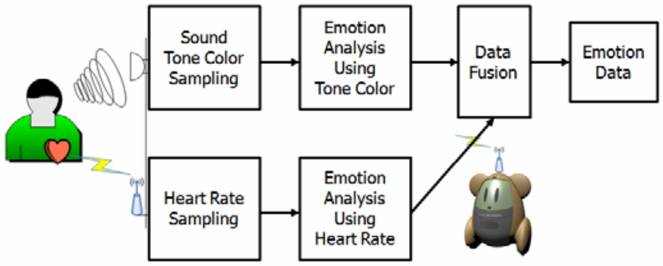

Fig. 17. The human emotion analysis module

3. CONCLUSIONS

The development of the healthcare robot has the advantage of opening up a new market through the development of the machinery and equipment related to health and advanced robotic technology. Products from various combined fields are manufactured, such as health support services that provide entertainment, health devices, and sport training systems. The healthcare robot is an interdisciplinary area that includes biotechnology, nanotechnology, information technology, and robot technology. Besides, the intellectual healthcare robot is expected to promote a new business field.

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