·Special Paper·

Assistive Technology Based on Robotics and Rise in China

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Abstract

The concept of assistive technology based on robotics, rehabilitation robot and intelligent assistive devices. Domestic intelligence assistive devices include intelligent prosthetics, intelligent orthotics, intelligent walker, assistive devices for smart home environment control, intelligent life assistive devices; Domestic intelligent rehabilitation robot include upper limb rehabilitation robot, hand rehabilitation robot, lower limb rehabilitation robot, robotic smart wheelchair, intelligent nursing bed, daily care robot, the development trend of intelligent assistive devices and rehabilitation robot.

Key word assistive technology based on robotics; intelligent rehabilitation robot; intelligent assistive devices; China; domestic.

中图分类号:R496 文献标识码:A 文章编号:1001-1242(2013)-06-0511-06

Assistive device is one of the most straightforward and effective methods to help disabled people in compensating, improving function and quality of life, enhancing the participation of social life of ability[1].

In recent years, there has been significant progress in development of assistive technology based on robotics for people with physical disabilities. We will have to deal with the increasing number of healthcare cases, due to demographic changes resulting from higher life expectancy, civilization diseases and increased health awareness.

Assistive technology based on robotics or the rehabilitation robot is a new type of robot, it belongs to the scope of medical robots, classified as rehabilitation robot and assisted rehabilitation robot. The rehabilitation robot's main function is to help patients complete the recovery of motor function training, such as walking training, arm training, spine training, neck training and so on.

The Concept of Assistive Technology Based on Robotics

Latest ISO Robot Definitions

ISO TC184/SC2/WG7 ISO 13482 DIS2:

Service robot: robot that performs useful tasks for humans or equipment excluding industrial automation applications.

Personal care robot (non-medical): service robot that performs aiding actions contributing towards improvement in quality of life of humans, excluding medical applications. This may include physical contact with the human to perform.

Rehabilitation Robot

M. Hillman defined rehabilitation robotics as the application of robotic technology to rehabilitation needs of people with disabilities as well as the growing elderly population. This extended definition includes augmentative mobility, robots for therapeutic training, orthotics and prosthetics, social robots, and robots for help care-givers.

Rehabilitation robots which assisted the elderly in standing up and in sitting down and supported their weight in walking assistive devices for the elderly with weakened leg muscles. Rehabilitation robots have also been applied to physical and occupational therapy. Through taking thousands of repetitive actions to drive limb training, rehabilitation robot can stimulate and rebuild the nerve of the controlled limb movement, thereby restores limb motor function, this way is a new clinical intervention way.

DOI:10.3969/j.issn.1001-1242.2013.06.006

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Intelligent Assistive Devices

Artificial intelligence was used as the basic technology method into the intelligence assistive devices, assembling a model in the executive system of the assistive device which was directing the movement of all the organs of human body like the brain does, thus equip this device the ability of "perceiving the changing of external environment", "analysing and judging the current situation", "controlling all the body organs", and "providing feedback of the operation results". This assistive device has very quick perception and can make proper adjustments for varies requirements of different assignments as it highly simulated the human's ability of collecting information of sensory organs, analysing and concluding information of brain, and movement of body directed by the brain. The concept of the intelligent assistive devices is novel, first published in Chinese science and technology journal in the fifth issue of Zhang Xiaoyu "Robot Technique and Application" on the "Intelligent Assistive devices and robot technology"[2] in 2011. "The research and development of intelligent living assistive devices for disabled people" was brought into the top ten scientific and technological achievements in the field of social development in the 11th Five-Year Plan period by Social Development Division of the Ministry of Science and Technology in February, 2011.

Development of Intelligent Assistice Devices in China

Domestic Intelligent Prosthetics

Smart knee studies in China began in 1994. Biological-mechanical and electrical integration prosthetic prototype was invented in Shanghai Jiaotong University. The CIP-I intelligent artificial leg, which was invented in Central South University, would naturally follow the pace of the wearer. Hebei University of Technology, National Research Centre for Rehabilitation Technical Aids and Tsinghua University successfully jointly developed a domestic smart prosthetics pressure knee. The knee with a four-link and pneumatic cylinder integrated design use senor to get gait and pace recognition. Intelligent controller can be automatically adjusted cylinder valve opening according to the wearer's walking speed, real-time adjust swing speed of prosthetics.

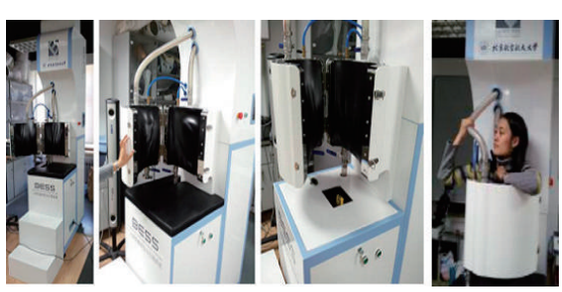
In 2012, air pressure damping adjustable intelligent prosthetic foot was developed, bionic ankle foot integration became true. The bionic thigh prosthetics coordination controllers simultaneously controlling the movement of the prosthetic knee and ankle foot and integration of ankle-foot devices have been developed, performance testing and clinical trial validation have been done for the devices (Figure 1).

Figure 1 Bionic Thigh Prosthetics

The research of the intelligent knee has been undertaken by Institute of Biomechanics and Rehabilitation Engineering of the University of Shanghai for Science and Technology in recent years, intelligent control following gait based on CMAC neural network.

In 2012, Biomedical Engineering School of Beijing University of Aeronautics and Astronautics Sitting position individualized measurement, analysis and evaluation methods for cerebral palsy patients were proposed in the subject. The sitting individualized measurement and analysis system were accomplished for the patients with cerebral palsy (Figure 2), the model of the cerebral palsy patients personalized posture analysis and evaluation and the software systems have been developed. The CAD/CAM system of the cerebral palsy patients personalized seating po-

Figure 2 Sitting Shaping System for Individual Measuring



sition assistive device, which is a 3D engraving and milling system made up of a gantry frame structure with three axes of motion, using parallel linear intercept method for tool path planning, suitable for more complex surface but less steep surface model, was also developed in the subject.

Domestic Intelligent Orthotics

In recent years, a wearable assisted exoskeleton was developed by Ge Yunjian, a researcher of Hefei Institute of Intelligent Machines of the Chinese Academy of Sciences, important results was achieved in the sensor signal acquisition recognition of human gesture. The lower limbs power bones based on the hydraulic control was developed by Professor Cao Heng in East China University of Science and Technology, he explored limbs supple problem under heavy load conditions. Much research work about power exoskeleton intelligent orthotics was done by Shanghai Jiao Tong University, Harbin Engineering University and other research institutes.

Domestic Upper Limb Exoskeleton Robot

During 1990s the study of human-machine integration theory began in State Key Laboratory of Fluid Power Transmission and Control in Zhejiang University, and gradually the technology of human-computer intelligent flexible exoskeleton has been derived, the upper extremity flexible exoskeleton control system which is actually an intelligent upper extremity orthotics has been developed. Tsinghua University and the People's Liberation Army General Hospital jointly developed upper limb rehabilitation robot, after ten years of development, the fourth generation of robot training plane can flip to expand the training ranges from two-dimensional to three-dimensional, adding dual-screen visual feedback. It's training effect is more obvious. There are three kinds of training mode which applies electrical stimulation to the rehabilitation process, joining the vibration feedback sensing system with the cooperation of Stanford University, achieving a certain effect. An "exoskeleton upper limb rehabilitation robot experimental prototype" was developed in Institute of Biomechanics and Rehabilitation Engineering of the University of Shanghai for Science and Technology. In 2012, the virtual training system for rehabilitation of the patients with upper limb amputation and the exoskeleton training system (Figure 3) for upper limb rehabilitation of the hemiplegic patients were developed by National Research Centre for Rehabilitation Technical Aids.

Domestic Intelligent Walker

Supine lower extremity walker robot and multifunction walker robot were successfully invented. The walking training system for paraplegia was developed by Tsinghua University and National Research Centre for Rehabilitation Technical Aids, with many key technologies, for example the joint reverse drive and waist with a mechanism, trajectory planning and hip and knee coordinated control and so on. According to the patient height automatically generated gait trajectory intelligent multi-joint coordinated motion control system was designed, to help patients with paraplegia and other lower extremity motor dysfunction doing ambulation training, restoring their walking function.

The full range of mobile walking aid robot with the man-machine coordinate security master-slave control technology was developed by Nankai University. It has a full range of zero turning radius, can identify the intent of the person, helping to walk.

Domestic Leg Motion Assistive Device

The paraplegia rehabilitation robot (Figure 4) jointly developed by Chang'an University, Shanxi Gospel Zhong-

Figure 3 Exoskeleton Training System for Upper limb

Figure 4 Paraplegia Rehabilitation Robot

da Electronic Science and Technology Co., Ltd., is mainly used for the rehabilitation of paraplegia and walking. It enables patients to stand up and walk like a normal person, is a wearable rehabilitation robot which is made up of motion control module, sensor module, the servo drive system and a mechanical linkage, low-voltage DC power supply, etc. as shown in Figure 8. The thigh and calf, respectively, with four servo motor drive, under the action of control module, the patients can do many actions for example stand up and sit down, walking single-step, continuous walking, standing still, and downstairs. The robot is gait natural, safe and reliable, with automatic and manual free switching function. This robot is suitable for paraplegia in T4 and T4 following completely or incomplete spinal cord injury as well as all lower extremity muscle weakness.

Domestic Exoskeleton Wearable Robot

The wearable lower extremity exoskeleton walking robot in Zhejiang University mainly helps stroke patients do rehabilitation in the room, preventing patients with muscle disuse atrophy,partial recovery the walking function of patients. Without power exoskeleton rehabilitation robot which was developed in Shanghai Jiaotong University has gravity compensation function, this robot is available for the incomplete paralysis or paresis whose muscle strength from two to five doing active movement training; Lower limb rehabilitation walker institutions were designed and developed in Harbin Institute of Technology, including uplift institutions of a walker walking institutions worn on the body. Through these two devices, patients can do functional exercises to restore health in the case of without the help of others. Recently a lower extremity gait orthotics is developed by Shanghai University.

Some related research institutions, for example Tsinghua University, Shanghai Jiaotong University, Xi'an Jiao Tong University, Tianjin University, Hebei University of Technology, Hefei Intelligent Machinery Institute of the Chinese Academy of Sciences, is doing research about the lower extremity exoskeleton technology, and also got some useful exploration in the field[4].

Domestic Wheeled Passenger Carrier

The automatic navigation intelligent wheelchair developed by Chinese Academy of Science, is the smart wheelchair with a visual and password navigation features and voice to interact with people. It is the country's first multi-modal interactive intelligent wheelchair prototype. The basic functions of the system of intelligent indoor electric wheelchairs helping move developed in 2012 is: change the attitude to meet the need of the user for lying, sitting and standing; take advantage of the visual servo technology independent traffic bedstead; up and down stairs. Shanghai Jiaotong University has developed a voice-activated wheelchair which was designed for people who lose their limb functions. The users can simply give some commands like "open","advance" "back", "left", "right", "fast "and"slow" and "stop".

Domestic Smart Home Environment Control Assistive Devices

Our smart home as the application of things in real life is more and more widespread concerned in society. Accessibility voice control system of home environment for severely handicapped was successfully developed in 2010. Smart home terminal, the instrument of smart bedroom eyes manipulation, the elderly smart home technology integration platform is prepared.

Domestic Daily Care Robot

May 18, 2011, a health care robot met with the audience in the "14th China Beijing International Science and Technology Industrial Expo" held in Beijing China International Exhibition Centre, the robot can communicate with the sick elderly and provide consultation, video playback and simple care.

A severe disability care robot (Figure 5) with the function of feeding water and food was developed by Harbin Engineering University.

The service robot for the elderly was developed by the Chinese Academy of Sciences hospital in Hefei Institutes of Physical Science in April, 2012. The life-size robot achieves many functions such as autonomous mobile, pick-up and delivery of commonly used items, speech recognition and simple dialogue, smart entertainment, fall detection and remote alarm function. If the elder at home fell, the robot will issue a requesting assistance message, to ensure that at the first time notify relatives of the elder; If they are thirsty, as long as issuing voice commands, it will immediately handed cups of water; It will also remind the elder to take medicine, accompany the elder chat, play chess, tai chi; The elder can watch part of

Figure 5 Severe Disability Care Robot

the entertainment through chest viewing screen, achieving psychological counselling.

Domestics Smart Home Environment Control Assistive Devices

A severe disability care robot (Figure 5) with the function of feeding water and food was developed by Harbin Engineering University.

Domestic the Severe Disables Smart Bath Assistive Devices

The severe disabilities smart bath assistive devices was jointly first developed by National Research Centre for Rehabilitation Technical Aids, Tianjin University of Science and Technology, Huazhong University of Science and Technology. If can systematically solve the problem of bath severe handicapped, improv the quality of life of severe disabilities. The project includes designing the structure of the bath devices based on the ergonomic, the technology of the intelligent control detection unit, web-based emergency call and alarm technology. Two auxiliary bath devices for severely disabled were developed: the one is a slide auxiliary bath device, the other is an auxiliary bathing device with lift platform. Severely disabled can control the water temperature by voice, the system can recognize more than 10 kinds voice commands, with preventing rollover function, alarm function for drowning and falling risk(Figure 6).

Domestic Smart Care Bed

Currently the domestic intelligent multifunction care bed is more similar to the robot. The product design is modular, plug-and-play. According to the division of the functional modules, nursing bed has five functions, each function can accord need to increase or decrease. Intelligent nursing bed with anti-dropping features and multi-functional new smart care bed were developed by the University of Shanghai for Science and Technology in 2011. E-Bed (Figure 7) was developed by Beijing University of Aeronautics and Astronautics in 2012, achieving bed - chair integration.

Figure 6 Smart Bath Assistive Device

Figure 7 E–Bed

Domestic Rehabilitation Robot

Jiangsu university (mechanical engineering institute) combined with Jimei university (mechanical engineering institute) developed a new type of traditional Chinese medicine department of traumatology medical massage robot. A robot which can give a person massage and bathing has been successfully developed by Mercury-person Company. This massage robot has realized three technological breakthroughs about automatic looking for positioning the human body acupuncture point, machine active massage, machine massage from up to down.

Domestic Upper Limb Intelligent Rehabilitation Robot

The research of a force feedback tele-operation robotics and web-based remote upper limb rehabilitation robot have been launched since 1992 by Sciences Institute of Intelligent Machines of the Chinese Academy, Shenyang Institute of Automation, Southeast University of Chinese Academy of Sciences, Beijing University of Aeronautics and Astronautics, Tsinghua University, Harbin University and other colleges and universities; Since 2001, the Harbin Institute of Technology, Tsinghua University, Southeast University, Harbin Engineering University, have conducted research for remote operation of the rehabilitation robotics. Southeast University in cooperation with

North-western University Intelligent Mechanical Systems Laboratory successfully developed a practical remote upper limb rehabilitation system, and also successfully developed the human neuromuscular electrical signal intelligent detector and EEG detector. In recent years, Many rehabilitation robots have been successfully developed, for example composite motion of shoulder and elbow rehabilitation robot, shoulder rehabilitation robot and hand rehabilitation robot and others, and clinical application were done, got a large number of clinical data, and preliminary results have been observed in the rehabilitation of the old hemiplegic patients; two-bar linkage rehabilitation device, 5 DOF upper limb rehabilitation robot, upper extremity hemiplegic rehabilitation robot and motor function rehabilitation robot have been developed.

Domestic Hand Intelligent Rehabilitation Robot

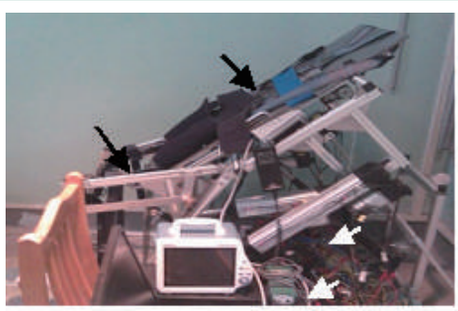
Domestic research institutions developed some of the non-market-oriented training devices, such as the hand function rehabilitation bionic gloves using stimulating electrodes for functional electrical stimulation on the muscles. The technology of wearable multi-degree-of-freedom hand function rehabilitation robotics mainly contains the development of hand rehabilitation robot prototype, cooperative control of the patients with active intent, virtual reality technology and so on. These research institutions carried out research for the technology of the rehabilitation robotics remote operation, successful researched the practical remote upper limb rehabilitation system, EMG signal intelligent detector and EEG intelligent detector.

Domestic Lower Limb Intelligent Rehabilitation Robot

Lower limb rehabilitation robotics is the international forefront of technology. Our research institutions have made great breakthroughs in many aspects such as the new mechanism design, control strategy, supple drive and control, human-computer interaction, virtual reality, biofeedback adaptive and so on. Research results have recumbent position lower limb rehabilitation robot, multi-function walker robots. The multi-functional lower extremity rehabilitation robot jointly developed by Harbin Engineering University, Tsinghua University, Industrial Technology Research Institute in Kunshan can simulate walking trajectories of normal people to train patients[8].

Professor Ji Linhong of the Tsinghua University developed the lower limb rehabilitation robot with more than posture based on the upright bed in 2011. The research group have in-depth study of human joints and exoskeletons inter-agency coordination and coupling; Put forward exoskeleton mechanism design method of adaptive joint; Put forward using non-rhythmic movement efficiently stimulate the central nervous system of the lower limbs rehabilitation training; Developed a number of the posture comprehensive ability training for early hemiplegic rehabilitation robotic system (Figure 8), "Flexbot multi postural intelligent lower limb rehabilitation robot system" has been running for more than one year in the rehabilitation Medical Centre of Jiaxing Second Hospital in Zhejiang Province, more than 50 stroke patients achieve early rehabilitation training.

Figure 8 Lower Extremity Rehabilitation Robot with Fixed Torso and Many Posture



With the development of robotics, artificial intelligence robot which is miniaturization and lightweight, but also closer to practical is continually developed, people is full of look forward to the future of intelligent assistive devices and rehabilitation robot.

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