The Role of Service Robots and Robotic Systems in the Treatment of Patients in Medical Institutions

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Abstract The development of new technologies has contributed to the development of robot technology. Information technologies and sensor technologies gave the largest contribution to the development of robot technology. Parallel with their development, the development of robot technology took place. The development of service robotics comes along with the development of industrial robotics. Over 300 of service robots for non-production applications have designed as result of development of information technologies as well as the advancement in sensor and servo-drive technology. Service robots are designed to perform professional job tasks as well as for service used in areas of everyday life. One of the fields for service robots application is medicine. Medicine can be categorized as a scientific, research, human discipline—and thus, application of service robots in medicine represents a scientific contribution, due to a huge application of different robotic devices for various purposes, different technological achievements in various fields of medicine. These robotic devices are used to replace missing limbs, perform complex surgical procedures, serve patients in hospital rooms, perform laboratory tests, diagnose diseases, and help in rehabilitation after stroke. This paper will review the presence of service robots in medicine, as well as the application in various areas of medicine such as: surgery, orthopaedics, rehabilitation, distance treatment, serving patients, etc. We have conducted a comparative analysis of the service robots application in medicine with the service robots application in military industry, after which conclusions have been drawn.

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1 Introduction

Robotics technology is engaged in the development and implementation of industrial robots, as well as service robots. Robotic technology is a multidisciplinary scientific discipline that combines much of systemic knowledge such as mechanical engineering, electrical engineering, information technology, industrial engineering, ergonomics and marketing. Because of its great importance in the post-industrial society, it also enters the domains of medicine, economic, sociology, philosophy and art. Robotics technology is very attractive, challenging and imaginative discipline. Robotics as a science has a task, i.e. a noble objective—for example, to replace a man in performing tiresome, monotonous or dangerous and health-endangering jobs. Service robots are increasingly becoming the subject of research and a very important area of science so that the 21st century will be marked as the century of development of service robots. Service robots are an excellent “System Engineering” research example because it includes a lot of scientific research, namely in the area of mechanical engineering, electrical engineering, electronics, computer science, social science, and more. People in the 21st century want to lead a healthy lifestyle and are concerned because they do not want to get a job with 3Ds (Dirty, Dangerous and Demeaning), nor a position where task performance is monotonous and tedious. Due to aforementioned reasons, service robots that perform these jobs instead of people are the main focus of research nowadays. Many countries in the world are faced with the aging of population, for instance, the population in Japan which needs help and care. Service robotics is among the most promising technologies when it comes to solution to this problem concerning the elderly. Service robots, in some cases, may replace home care (a caregiver) so as to take care of the elderly. In addition, service robots help maintain an increased level of dignity in the course of receiving assistance, such as the cases of using toilet. The user may request service from a service robot without inconvenience. For this reason, it is possible to receive a better service from the intelligent service robot than of a human caregiver. As service robots perform their tasks in the same environment as humans, service robots should have the abilities people have. The service robots should be able to recognize faces, gestures, signs, objects, speech and atmosphere. Successful realization of set tasks results in bypassing obstacles without collision and destruction in the shortest possible time and distance. They should communicate with people on the basis of emotion. During the 1980s and early 1990s, advances in new technologies, sensor technologies, computers and servo-drive led to the development of hundreds of different types of service robots for non-production applications. After a relatively long period of trials and disappointments, robots have finally come out of stores to find their way into our homes, offices, museums and other public spaces, in the form of a self-governing air purifiers, lawn mowers, vacuum cleaners, window washers, toys, surgical operators, etc. Service robots are designed to perform professional tasks in civil engineering, maintenance, inspection, agriculture, medicine, as well as other fields of application in everyday life: at home, at work, in public environment, etc.

[1–13, 14]. These are robots that take over and successfully execute ever more challenging tasks. Robots will sooner or later change our daily lives, such as: assistants, servants, helpers, friends, assistant to surgeons in medical operations, intervention in hazardous environments of any search or rescue, in agriculture and forestry, cleaning, digging, dangerous transportation, construction, and demolition. Service robots are becoming ever more important for scientific research as well as industry because they are and will be used in new areas of industrial branches. Robots and artificial intelligence today live with each other, but it is also difficult to imagine a robot of today which is not some type of artificial intelligence. With robots, androids and fusion of all three life forms—as with artificial intelligence too—there is a question what if they get out of control. According to one of the robot/AI experts, Hans Moravec, robots will become as smart as a man by 2040, and we are sure it will be even smarter than many of the inhabitants. Unlike pessimistic and paranoid predictions, Moravec is not worried. He believes our robots and artificial intelligence will actually extend the life of man and improve the quality of life in general. It is difficult for laymen to assess which of the scientists are right; the truth is some of the possibilities and theories are alarming, but we realized that even by reading some of the great works of science fiction. As it seems, evolution will do its part—it has led a man nearly to the degree that it can build an intelligent being like himself! The whole thing is now far advanced and probably impossible to control. We could maybe just try to turn it in our favour. As we noticed preparing the paper about artificial intelligence, the only real danger is the man, who perhaps (is) used his time to destroy nature, waging war and sowing hatred. On the other hand, some of the science fiction works have shown that the coexistence of artificial intelligence/robots/androids and humans is possible, but only under the condition that a man progresses together with these creatures. In any case, the century we live in has already brought a good deal of scientific excitement and those who do not perceive this outcome positively are actually rare. We live in a time that will undoubtedly be remembered for many things in the distant future, and it would be a shame if we are not aware of it now. A major break-through in robotics is that robots and humans work closely together, as servants or helpers in everyday life. Robotics is a relatively young technical branch, but it al-ready has a rich tradition. It turned out that robots, just like people, passed generation cycles. Each new generation of robots received the more advanced features than the previous one, which is primarily related to the actual degree of intelligence, supporting computing power, enhanced dynamic indicators, and more advanced control algorithms. With a rapid computerization of all forms of business and a vast expansion of the Internet, it is expected there will be a large gap in the 21st century between those who are technologically advanced and those who have lost their connection with modern times. Most people are not even aware of the extent to which robots are already represented within their lives. Their cars and computers are almost certainly partially assembled with the help of a robot. The price of robots is declining steadily and they are coming into ever wider use. It is only a matter of time before robots become available to the population of today's high school students, just as it happened with computers and cell phones. The chapter will be dedicated to researchers in medicine, students, and engineers, who want to restore and expand their knowledge with modern and innovative service robots applications in medicine. We hope the ideas and concepts presented in the chapter will be useful to many who deal with these issues, as well as that they will contribute to solving numerous problems and improving service robots application in all segments of society as a whole. Our aim will be to offer readers as much useful information as possible and attract their interest in service robots application.

2 Application of the Service Robots in the World

UNECE (*United National Economic Commission for Europe*) and IFR (*International Federation of Robotics*) created and adopted classification of robots where service robots are divided into two groups:

1. professional service robots,
2. personal/home service robots,

and detailed description of the use is given in [2]. Annual supply and overall application of service robots in the world according to their application is presented, based on the statistical data given in the literature [2–5].

Based on Fig. 1, we see that service robots application for professional services has a growing trend, so that about 5000 units of service robots were supplied in 2005, with a growing trend year after year, and thus it reached application value of about 24,000 units of service robots in 2014. We conclude that the increase takes place by linear progression. This trend of service robots application is due to the development of new technologies, primarily information and sensor technologies that are the wind at the back of robotic technologies. We analyze Fig. 1 (right chart) and see that annual supply of service robots for household and personal use from 2005 to 2014 has a growing trend. A total of 871,822 units of robots were applied in 2005 and 4,915,500 units of service robots in 2014, which means that the trend of application increased by 5.6 times in ten years. In 2009, the use of service robots

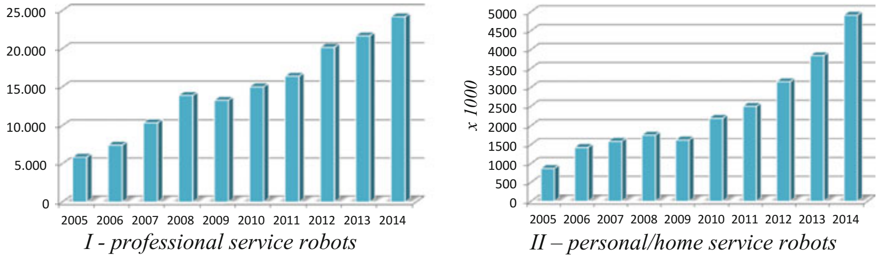


Fig. 1 Annual supply of service robots for professional services, as well as household and personal use from 2005 to 2014 [2–5, 15, 16]

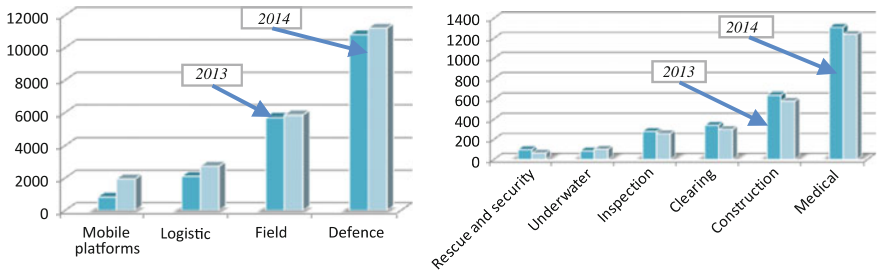


Fig. 2 Annual supply of service robots for professional services in 2013 and 2014 [2–4]

somewhat decreased, so that 1,624,803 units of robots have been applied—which is a reflection of the global economic and industrial crisis. In order to get the complete picture of the application of service robots for professional services – which is the topic of this paper, we will analyze the application of these robots in the last two years.

Figure 2 shows the total annual supply of service robots for professional use in logistics, agriculture, defence, mobile platforms, rescue and safety, underwater use, inspections, cleaning, construction and medicine in 2013 and 2014. Based on the first figure, we can conclude that more service robots have been applied for mobile platforms, logistics, agriculture and defence, in 2014 then in 2013. The first place is occupied by service robots for defence because about 11,000 units of robots have been applied in 2013 and 2014 In the past years, they have the trend of always taking the first place when it comes to professional robots. If we also analyse the application of service robots in medicine, we conclude that they occupy the fifth place in 2013 and 2014, which results from the fact that about 1225 units of robots were applied in 2013 and 2014. This trend is irrational if viewed from the standpoint of protection and assistance to the man as a human being. For this reason, we will conduct the analysis of the application of service robots in medicine and defence in the last ten years.

The application of service robots in medicine and defence for the period from 2005 to 2014 is shown in Fig. 3. If we perform an analysis of service robots

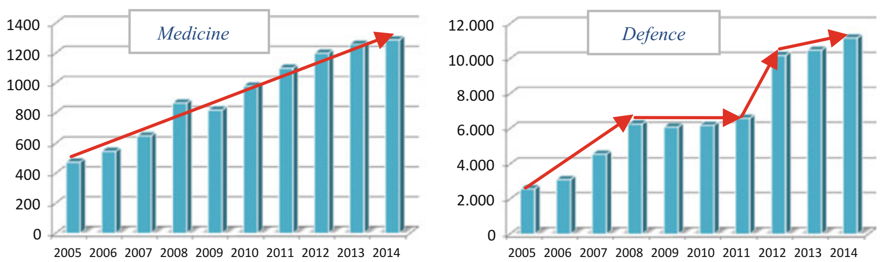


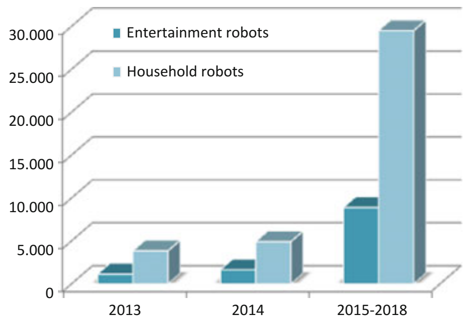
Fig. 3 Total annual application of service robots in medicine and defence from 2005 to 2014 [2–5, 15, 16]

application at the annual level in the medical field, we see that there is a growing trend. It can be said that it is a linear progression so that 476 units of robots were applied in 2005, and 1290 units of robots were applied in 2014. Based on Fig. 3, we conclude that there has been an increase almost every year. However, the application of service robots for defence purposes is somewhat different: it can be concluded that the application has been increasing each year in the period from 2005 to 2008, so that 3355 units of robots were applied in 2005 and 5029 units of robots were applied in 2008. It can be said that it is almost a linear progression in the application of service robots in this period. Based on Fig. 3, it can be concluded that there was a constant application of about 6000 units of robots at an annual level from 2008 to 2011. When it comes to the period 2012–2014, there was a linear increase in application from 8796 units to 11,256 units of the robot in 2014.

Comparing the periods of service robots application in defence, we see that the trend is different in different periods, which can be related to the security situation in the world at that time. When we analyse the number of service robots applications in medicine and defence, we obtain shocking information: the service robots application in defence is 10 times higher than the application in medicine, which is not a common sense. It would be logical to have more service robots used, not in the defence, but in medicine—in order to help people because health is the matter of concern. However, the use of service robots is dictated by the market, and thus the situation is just the way it is.

To see what the application of service robots will be in the future, we presented a projection of the application of service robots for entertainment and household for the period 2015–2018. in Fig. 4 [2]. It can be concluded that there will be an expansion of service robots application in the future. It is expected that about 28 million service robots will be used in households in 2018. A growing trend in service robots application is expected in all areas of application, for professional use as well as entertainment and household.

Fig. 4 The projection of service robots application for entertainment and in household from 2015 to 2018 [1, 2]



3 Service Robots in Medicine

Medicine is an interesting field for service robots application. Service robots are applied in medicine for the following purposes: neurosurgery, orthopaedics, endoscopy, surgery, spot radiation, colonoscopy, serving patients, performing delicate surgical procedures, delivering neurorehabilitation therapy to patients who have experienced stroke, teaching children with learning disabilities, enabling visits to patients and guiding, i.e. monitoring operating procedures remotely (*telesurgery*). These also include helping patients during rehabilitation that they must undergo after the stroke, helping in cases of fractures and other damages, as well as performing a growing number of other similar tasks related to patients' recovery [1–4, 17]. The development of information technologies, new materials and robotic technology gives the opportunity to overcome the problems that could not be solved previously, as well as to enhance orthopaedics and help patients to recover quickly and return to the normal state in which they were before the injury. Nowadays, service robots have an important place in medicine:

- these robots provided numerous benefits to clinical practice,
- facilitate medical processes by providing precise control of instruments,
- the application of diagnostic equipment and tools for diagnosis and therapy,
- an increase safety and overall quality of a surgery,
- better care for patients, education and staff training performed through simulation, and
- promotion of the use of information in diagnosis and therapy.

The goal is to develop service robots that meet real needs in the areas of social assistance, as well as in nursing people, the area that demands high-level technology. The application of such next-generation robots will be promoted in areas where robots have more physical contact with people, provided that man safety is secured. For this reason, the idea is aimed to design robots that support rehabilitation exercises and specific movements that a person cannot perform alone, as well as robots that assist a man in performing certain tasks. Service robots application in medicine for 2014 was 1290 units, which is only 5.32 % of the total application of service robots for professional use in 2014. Different areas of application are shown in percentage in Fig. 5.

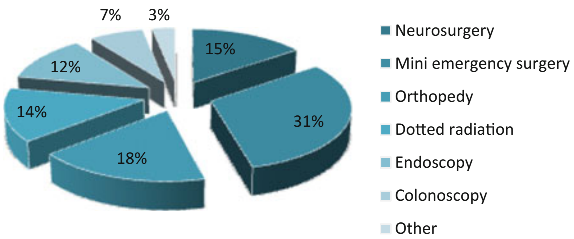


Fig. 5 Percentage of service robots application in medicine by areas for 2014 [1, 2]

Based on Fig. 5, we conclude that service robots in medicine are mainly used for small interventions in surgery (31 % in 2014). Orthopedics is the second place with 18 %—which can be explained by service robots application in handling solid entities, such as bones (because these are not flexible like tissue), and in rehabilitation, which is an integral part of orthopedics. Neurosurgery is the third place (15 % in 2014). The fourth place in service robots application is occupied by spot radiation (14 %). The rest of the statistics is as follows: endoscopy 12 %, colonoscopy 7 %, all other activities of service robots application in medicine 3 %. Service robots in medicine have found application in diagnostics, therapy, surgery, and patients care. They enable paramedics to determine the anatomic location of catheter placement (regardless of the location at the body to which it is going to be set), to diagnose patients and perform surgical procedures. Robotic diagnostic apparatus may be placed at a certain distance from a human body, directly on a patient's body, or in a patient's body. Service robots make the job easier for a surgeon because they ensure precision and accuracy, which leads to great enhancement. They are used for the following purposes: to assist, hold, place and direct instruments; for telesurgery potentials; for navigation, positioning, and application in surgical procedures. A three-dimensional tumour scanning is performed prior to treatment using the CT scanner, based on which the dose and the density of radiation are calculated. The apparatus for radiation is placed on a robotic arm so that it is possible to perform radiation of different strength and density for various positions according to the pre-determined plan. Service robots are characterized by a programmed dose of radiation from the proper position, except that it does not damage adjacent tissue. Let us name a few of the robotic systems helping patients' fast recovery and movement. AutoAmbulator, developed by Health South Corporation (USA), consists of two robot arms that help patients to stand and distribute their body weight on demand. The interface for patient's legs is secured using bands at the thigh and ankle. ReWalk is a wearable, motorized quasi robotic system, manufactured by Argo, which is working on the design of medical equipment (Israel). The user walks using crutches; movement is controlled depending on the patient's motion through subtle changes in center of gravity and upper body. HAL (The Hybrid Assistive Limb) is a series of robots designed by Professor Sankai at the University of Tsukuba (Japan) and has been launched by the Cyberdyne company (Japan). The exoskeleton has been developed to increase patient's existing power by a factor between 2 and 10. Socially useful robotics focuses on helping people through social rather than physical interaction.

It has the aim to improve the quality of life for the general population of users: the elderly, people with physical disabilities as well as people with cognitive and social impairment. We will show some applications of service robots usage in medicine Fig. 6.

Robotic systems *DA VINCI, ZEUS, AESOP* and *Neuro Arm* and other newly designed automated systems are used in surgery. The robotic systems are sophisticated and designed to expand surgeons' capabilities and enable complex surgeries using a minimally invasive approach. DA VINCI surgical system (Fig. 7) is a minimally invasive surgical system consisting of these components: *InSite Vision*

Fig. 6 Examples of service robots for application in medicine for spot radiation, surgical procedures, and skeleton to help patients who have mobility issues [1, 15–18]

System, *Surgical Arm Cart* (that have two or three interactive robotic arms) and EndoWrist instruments, as well as *Surgeon Console*. Using this device, a surgeon sits comfortably in the control panel and performs a surgery on the basis of a presented high-quality 3D image. This system performs advanced surgical techniques; a surgery is performed through a small incision of only one to two centimetres, and a surgeon can use a wide range of laparoscopic instruments. Certain instruments have seven degrees of freedom of movement, allowing them to emulate the skill of a wrist. Each instrument has a specific application, which allows them to perform operations such as cutting, sewing, and tissue manipulation. Devices for visualization provide high-quality 3D image of the operating area. This device ensures the transfer of refined and optimized real-time image of instruments in surgery to the surgeon in the management console. Improved visualization allows the increase of image to several times, which enables a greater precision for a surgeon when performing a procedure; the conventional methods are far surpassed when it comes to precision.

ZEUS robotic surgical system (designed by company Computer Motion, year 1995, shown in Fig. 8) was approved for use in 2002, to be applied in general and laparoscopic surgery (minimally invasive surgery within the abdominal cavity) with a patient and a surgeon in the same room. Zeus is a surgical robot which consists of three robotic arms placed at a table, where one of them holds an AESOP (*Automated Endoscopic System for Optimal Positioning*), which provides a view of the interior of the operating field, while the other two arms hold surgical

Fig. 7 DA VINCI robotic surgical system [1, 19]

Fig. 8 Elements and the principle of managing ZEUS robotic surgical system [1, 18, 20–30]

instruments. Robotic arms are controlled by a surgeon, who sits at the control console a few feet away from a patient. During surgical operation, surgeon has possibility of visualization on the screen, voice communication and working robot arm is under the complete control of the surgeon. There are more than fifty medical instruments that are designed for Zeus surgical system. These include various scissors, forceps, dissectors, needle holders, stabilizers and scalpels.

This service robot is used for assisting surgeons in surgeries such as a beating heart bypass surgery. Zeus system is designed to provide the following benefits: small incisions in the body, about the diameter of a pencil; significantly reduced pain in patients and trauma in cases of minimally invasive surgery; shorter hospital stay and recovery time in cases with minimally invasive surgery; usable in the approach of beating heart as well as non-beating heart; improved surgical precision and skill; improved visualization in 2D and 3D fields; minimized fatigue of a surgeon due to ergonomic operating environment.

The Computer Motion company, founded in 1989, offered its first product on the market: the robotic system "AESOP", used to hold endoscopic cameras in minimally invasive laparoscopic surgery. FDA (Food and Drug Administration) approved system "AESOP 1000" in December 1993. This system has become the first robotic surgical visually supported device. Foot pedals, although easy to manage for well-trained surgeons, presented a problem for new users because they had to look down at the pedals before they were able to adapt them. AESOP 2000, approved in 1996, used voice control, while AESOP 3000, approved in 1998, added another degree of freedom in hand. A combination of voice recognition technology with devices that hold the camera in the surgery is contained in the AESOP 3000 system in order to control a robotic arm with seven degrees of freedom of motion, providing further flexibility in the desired positioning of the endoscope. In recent years, thousands of surgical procedures have been performed using the AESOP robotic technology. AESOP manipulator is a manipulator designed to hold the endoscopic camera, enabling a surgeon to perform solo operations without the need for human assistants. The surgeon controls the manipulator using voice commands pre-recorded on a voice card inserted inside the controller. There are two reasons for its great application in orthopedic surgery. The first lies in the fact that a technology is well suited for operation on the bones, and the second is that a bone differs from soft tissues because it is less prone to deformation when pressed.

Fig. 9 The display of Computer Motion AESOP system [1]

Robotic surgeries increase the implementation accuracy because the current surgical technique often results in incorrect positioning and balancing in hip replacement. With computer navigation system and surgical robots, precision and accuracy are increased greatly (Fig. 9).

Neuro Arm was designed by Canadian scientists and engineers and performs risky operations at the highest level by operating within MRI magnetic resonance, providing a clear 3-D display of even the smallest nerve. Magnetic resonance imaging (MRI) is the name of the medical device which serves to display layers of the human body. NeuroArm is an MRI, compact, image-guided and computer-assisted robotic system designed for neurosurgery, which performs microsurgical as well as biopsy and stereotaxic surgery. A stereotaxic biopsy is an accurate method of sampling small areas of brain tissue, using image guidance and minimally invasive techniques.

NeuroArm surgical robot presented at Fig. 10 is 914.4 mm high, 609.6 mm wide and adaptable to the necessary height of the operating table. It weighs 226.8 kg and has two arms at whose ends suitable instruments are placed. Microsurgery is a general term for an operation that requires an operating microscope. It is a delicate operation that requires the use of precision instruments and is performed by means of miniature precision instruments, including scalpels, needles and specially designed optical microscopes. Although mostly used in plastic surgery, microsurgical techniques are often used in reconstructive surgery such as general surgery, orthopedic surgery, gynecological surgery, pediatric surgery, etc.

The System incorporates:

- Workstation,
- System control cabinet, and
- Two remote manipulators placed on a mobile base.

The workstation is a link between the surgeon and the NeuroArm surgical system. Figure 11 shows the layout of the workstation where the surgeon sits and

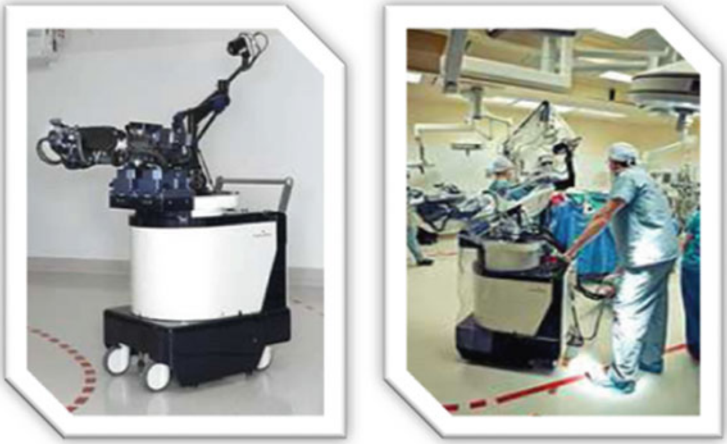


Fig. 10 The appearance of NeuroArm surgical system in the operating room [1, 31]

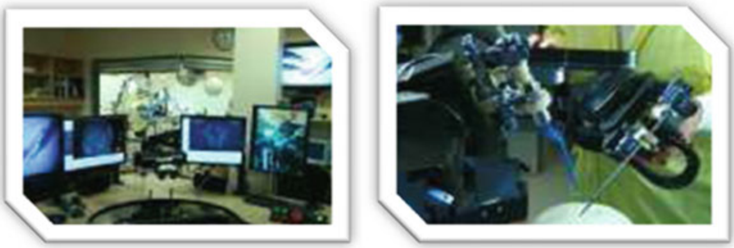


Fig. 11 The appearance of WorkStation and the manipulator of NeuroArm a surgical system with an MR compatibility [1, 31]

controls the robot, i.e. the robot's manipulators, using the hand-held controllers with a stereoscopic display of the surgical site as one of its components, and performs complex surgical procedures such as microsurgery and stereotaxic surgery. In addition to the aforementioned hand-held controllers, its component parts include video monitors and touch-screen computers. The touch screen enables 3D graphics that can be manipulated in any direction. With the help of a microphone located near the surgical instruments, a surgeon can even hear the robot work. NeuroArm includes two MR (Magnetic Resonance) compatible manipulators with grippers that have seven degrees of freedom of movement and a third hand with two cameras offering 3D stereoscopic display, which connect with microsurgical tools. The surgical microscope offers a stereoscopic view of the brain, which provides depth perception, while MRI magnetic resonance imaging and robotic sensors generate three-dimensional map of the brain. It also contains filters to eliminate an

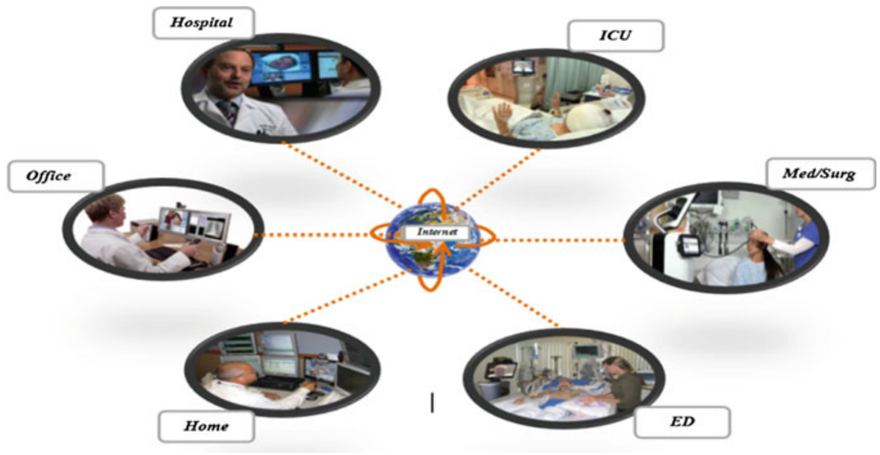


Fig. 12 A "many to many" system structure [1, 32]

unwanted tremor. Grippers are equipped with three-dimensional power sensors, providing a surgeon with a sense of touch while performing the surgery.

Innovation of the robot called Remote Presence-7 (RP 7) has marked the improved and better means of communication at a distance. The robot RP-7 has been produced by a private company InTouch Health located in Santa Barbara, California. The company was established in January 2002. with goal to develops, manufactures and distributes Remote Presence technology. Remote Presence (RP) is the ability to project oneself to another location (without leaving your current location) and the ability to see, hear, and talk as if you were actually there. This robot has a size comparable to the size of a man and allows individuals, as has been said, to project oneself from one location to another in order to be able to see, hear and speak, and thereby remain at the current location. Remote Presence is a new modality of interaction between a doctor and a patient. Wherever access to medical expertise is limited, Remote Presence can effectively extend a doctor's ability to provide care to patients. The system operates on a "many to many" system architecture (Fig. 12), allowing a doctor to connect from an office, hospital or home to the robot located at the intensive care unit or a patient's hospital room, and thus communicate with patients, their families, medical staff, etc. Using this technology, medical expertise can be made available to a patient at any time and at any place.

There are three main components of Remote Presence technology applied to the aforementioned type of a robot:

- RP 7 robot,
- Control Station,
- Connectivity service of RP (Remote Presence) technology.

RP (Remote Presence) Connectivity Service forms the basis of infrastructure, providing reliable connectivity between the robot and the control station. It delivers continuous monitoring of each robot, allowing direct quality control and maximal time of accuracy. Service, support, license fees and software improvement all together are involved in RP Connectivity Service and are essential components of Remote Presence Robot. The RP 7 robot is a wireless, mobile robot with the applied Remote Presence technology that allows us to “be in two places at the same time.” Under the direct control of a doctor, located in the control station, the robot can move without restriction, allowing the doctor to communicate freely with patients or members of the hospital staff.

The technology used by the RP 7 robot:

- Virtually There interactive technology,
- Holonomic Drive System,
- SenseArray 360 System, and
- RP System Core.

Although physical presence of a doctor near a patient cannot and must not be replaced, service robots for use in telemedicine have been developed because certain countries have very old population, a limited number of doctors, especially in rural areas where there are no doctors and where the application of these robots ideal. We refer to RP-7 service robot shown in Fig. 13.

This robot has a size that is comparable to the size of a man and allows an individual, as it has been said, to project oneself from one location to another to be able to see, hear and speak, and thereby remains in one’s current location. Examples of service robots application for treatment of patients at a distance are shown in Fig. 13.

Service robots are used in helping the disabled and rehabilitating patients in rehabilitation centres. An example of such service robots is shown in Fig. 14.

Rehabilitation robots help the disabled in activities that they cannot perform on their own, or are involved in therapies for people to improve their physical functions. Areas of rehabilitation robots are general divided into therapy and robot’s assistance. In addition, rehabilitation robots include prosthesis (prosthetics), nerve stimulation and devices for monitoring people during daily activities, as shown in Fig. 14.

Fig. 13 The robotic courier system used in medical institutions to serve patients [1, 32]

Fig. 14 Examples of service robots application for rehabilitation and helping the disabled [18, 20–30]

There are the following categories:

- robotic therapy for mobility (walking),
- personal rehabilitation robots,
- robotic therapy of the upper extremities,
- smart prostheses, and
- social service robots for personal care, autism and care of the elderly.

Giving back mobility to a patient is particularly tiresome and hard work for therapists, and this is the primary target for automation. Dozens of mobile robotic systems for training, i.e. rehabilitation is already in use in clinics around the world.

Service robots in medicine can, among other things, help in obtaining or distributing medications, while robots that help patients can assist in raising and positioning of patients who find it difficult to relate to. A Large part of activities related to providing professional medical assistance is logistical. It includes meeting the daily needs of patients (delivery of mail or personal care products, cleaning tasks), as well as supplying patients with medicaments and food. An example of such a system is the TUG system—an autonomous mobile robotic system also known as automated robotic system for delivery. This system automates the delivery and tracking of most hospital equipment and supplies such as medicaments, linen, blood samples, medical records, etc. It helps the circulation of the internal supply chain inventories in the hospital. TUG system requires wireless network access for communication with the base computer, lifts, and elevators at a ground floor, as well as areas where more TUG systems may encounter one another. The system contains a computer with an advanced TUG operating system, which uses its detailed map of a hospital and sophisticated navigation software in order to plan routes, avoid obstacles (it has sensors) and monitor its location constantly. The system may use carts connected in one column for transport, so that it can be used for virtually any application: patients' care, pharmacy, laboratory, primary supply, medical records delivery, etc. (Fig. 15).

Autonomous service robots working as a team (group) in order to complete the delivery of blood samples and courier tasks in hospitals and laboratories are controlled using computers. It is expected the service robots application in the field of human care and social assistance will increase. The strategic goal is to develop

Fig. 15 The robotic courier system used in medical institutions to serve patients [1]

service robots that meet real needs in the areas of social assistance as well as in areas of human care which demand an advanced technology. The application of such next-generation robots will be promoted in areas where robots have more physical contact with people, provided that it guarantees man safety.

4 Conclusion

Robotics technology is very attractive, challenging and imaginative discipline. Robotics as a science has a task, i.e. a noble objective—for example, to replace a man in performing tiresome, monotonous or dangerous and health-endangering jobs. A major breakthrough in robotics is that robots and humans work closely together, as servants or helpers in everyday life. Robotics is a relatively young technical branch, but it already has a rich tradition. It turned out that robots, just like people, passed generation cycles. Each new generation of robots received the more advanced features than the previous one, which is primarily related to the actual degree of intelligence, supporting computing power, enhanced dynamic indicators, and more advanced control algorithms. There are a number of facts that speak in favour of rapid long-term growth in the market for auxiliary robotic systems for the elderly and the disabled. The number of temporarily and permanently disabled persons is increasing, as well as the quota of the elderly in the world. This will increase the need for nursing and care of these people. Given the decline in the next 10–15 years in the number of people from active life who are interested in performing the role of a caregiver, there is a huge potential of demand for auxiliary robotic systems and service robots. For this reason, important scientific institutions working on service robots are developing new prototypes of service robots to assist the elderly and persons in need of rehabilitation.

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