Current Medical Digital Applications-
Telesurgery

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Abstract
Last years many efforts have been made for developing “smart” biomedical devices, which can change in high level the way of the healthcare provision for a large amount of population. For instance, people who suffer from chronic diseases such as diabetes or neurological disorders, the elderly and some groups of people with special needs can easily check repeatedly many times per day their health status. This check up could happen without any removal of the patient’s home or work thanks to the advances in communication technology and suitable devices or sensors which can derive information from patient body and his environment. These electronic devices can be either mobile, or even wearable devices. It depends on which technology supports the functions of each device and also on the types of operations which these devices can control.

Once a test is completed, a suitable digital device is able to evaluate the results if the required criteria have been satisfied and the values are normal. However in case of a problem even if the device can evaluate the test results, data have to be transmitted to the specialists of the medical facility in real-time via telephone or wireless internet connection expediting personal healthcare that might be needed.

Surgical procedures carried out at a distance thanks to advances in robotic and computer technology and their applications to surgery are referred as telesurgery. In a modern integrated Telesurgery model, the surgeon uses the patient information derived by sensors (health data, image, sound, touch), evaluates directly them and through a special console which operates, as interface to a remote system feels present in surgical theatre. Many metres or Km fixed or wireless network connect patient and surgeon as one or more robotic arms perform the surgical operation on the patient under the control and direct supervision of the surgeon.

Index Terms
Digital applications, sensors, robots, telecare, telemonitoring, telesurgery, robotic surgery, telementoring, telepresence.

I. INTRODUCTION

The recent evolution in healthcare and health services delivery is mainly driven by societal changes, progress in science and technology but also the rapid increase of medical knowledge. Citizens are more informed and consequently they are asking for better quality healthcare and life style management. Ageing population and the proportion of chronic diseases increases steadily, while prevention, fast and accurate diagnosis, better and cost-efficient disease management and rehabilitation as well as minimally-invasive treatment become broadly urgent requirements. The significant progress in sciences and technologies, like the advances in communication and information technology, microsystems and nanotechnologies, robotics and artificial intelligence offer new possibilities and technological solutions bringing ambient intelligence and instrument miniaturization.

The rapid progress of information and communication technology in combination to amazing speed of development and embedding of new technologies in daily life, makes eminent need of application of these technologies to healthcare specifically in areas, such as telemonitoring, telementoring and telecare.

The last decade has brought an explosive growth in our capabilities to collect, storage, process and manage data. Beyond the traditional mode, health data can be collected by novel equipment, such as portable digital appliances, hand-held devices, health cards and many kinds of sensors in a variety of storage media types. Administrative, clinical, laboratory, imaging and genetic data can be stored in distributed, open-architecture Electronic Health Records and heterogeneous information systems, in order to support the fast and easy access to health care facilities, the quality and continuity of healthcare.

Last years many efforts have been made for developing “smart” biomedical devices, which
can change in high level the way of the healthcare provision for a large amount of population. For instance, people who suffer from chronic diseases such as diabetes or neurological disorders, the elderly and some groups of people with special needs can easily check repeatedly many times per day their health status. This check up could happen without any removal of the patient’s home or work thanks to the advances in communication technology and suitable digital devices or sensors, which can derive information from patient body and his environment. These electronic devices can be either mobile, or even wearable devices and they are able to detect deviations from normal values, such as vital signs measurements, when people work, move, travel, exercise or stay at home.

Intelligent personal systems and individualized electronic services are currently under development world-wide to enhance healthcare provision through cost-effective, continuous monitoring of physiological and physical data from the inner body. The research is focused on the integration of different biomedical sensors and other digital devices, into a unified user-friendly wearable material as also on issues of ambient intelligence. More efforts have to be done on this research field.

II. DIGITAL TELEMEDICINE APPLICATIONS

Telemonitoring, Telementoring, Telepresence and Telecare are some of the most important telemedicine applications in the new digital era. In a modern, integrated Telesurgery model, the surgeon uses the patient information (health data, image, sound, touch), derived by sensors and specific imaging devices and systems evaluates directly them and through a special console which operates as interface to a remote system, feels present in surgical theatre. As the technology is evolving, more medical procedures can be operated remotely and more electronic health services become part of reality.

A. TELECARE

Telecare means the healthcare services can be delivered to a citizen home remotely using the new telematics technologies. Fundamentally, a telecare system aims to offer remotely care services in real time based on the application of telemonitoring systems and telealarm technologies. The basic technologies of telecare include wireless and mobile communication, digital cameras and remote control systems, many types of sensors and actuators, different purpose digital medical devices, hand-held devices, health cards and technologies of electronic health records as well. These technologies are capable to support the activities of remote monitoring and delivery of care at the point of need, as also they are able to support teleconsultation services, in respect to privacy and security, automated control and maintenance services to all the medical devices and home electronic equipment remotely.

1) Telemonitoring

Telemonitoring means the use of telematics technology in monitoring of objects, actions, and human daily activities or his environment. Telemonitoring strongly depends on data types have to be transmitted. Health telemonitoring refers especially to remote monitoring of physiological parameters of a human and transmission of health data to a control central system for data interpretation, evaluation, and storage in health databases. Continuous measurements, such as ECG, heart rate, respiration rate or discrete values (oximetry, blood pressure, temperature, spirometry etc.) as also events and alarms signals are transmitted over communication networks. The design and development of new technological devices for telemonitoring, specifically of those monitoring physiological parameters in real time is unique challenge for the engineering.
2) **Telealarm systems**

A telealarm system as a basic component of a complicated monitoring system has the responsibility to monitor the events and manage the risks from every threat of human life, such as physical threat (fire), terroristic threat, and health events in automated mode and in direct link to emergency and health services providers. A contemporary, telealarm system ensure full mobility feedback, and also integration to the whole telecare system. Moreover, it ensures compatibility to all fixed or wireless communication protocols in order to transmit securely health data over public or virtual private networks.

A central, fully automated telematics center located at the healthcare facility, which hosts integrated information and communication systems, is the core of a telecare network. This central unit controls remotely 24 hours per day and synchronizes all network nodes activities through home-based communication systems and alarm actuators. Such a telecare system, is able to check repeatedly and evaluate the health status of a patient, deliver telemedicine services, and ensure the collaboration with many health professionals of different specialties, assuring cost-effective and high quality health services. Agents software technology and intelligent applications complicate the technological core of a telecare system and more research has to be done on integration all new technologies to delivery smart e-health services.

3) **Smart biomedical devices.**

Intelligent Biomedical clothing and wearable or embeddable electronics are very promising research and development areas, which extend monitoring of physiological signals. The development of intelligent biomedical clothing is based on multidisciplinary research and requires a strong cooperation between scientists and engineers of different scientific fields such as mobile and wireless communication, microsystems and nanotechnologies, biomedical engineering, telemedicine as well as public health and healthcare.

There are many possible applications of intelligent biomedical clothing spanning from the citizen’s health watch to patient’s disease and life management, including rehabilitation, diabetes management, cardiovascular diseases prevention and emergency intervention, drug delivery and stress management.

Recently scientists have developed wearable, wireless monitoring systems that can warn patients with underlying health problems in order to assist clinicians in the diagnosis and monitoring at patients at risk and automatically alert emergency services in the case of an acute health event. Based on dry-electrode technology, that can be built into common items of clothing, wireless monitoring technology continuously monitors the body signals to detect abnormal health conditions. The new technology enables the development of a new category of electronic products in the personal healthcare area.

The integration of the technologies involved like biomedical sensors, actuators, computing, power source, and communication into a smart cloth is at present stage on the threshold of developing prototypes and pilot projects e.g. Smart Shirt (Sensatex, USA), Medical Assistance Suit (VTAMN, French National Project). Several issues remain to be solved before large scale trials and clinical validation such as higher conductivity textile material, cleaning and washing, signal processing and data interpretation. Further research is required also in user interface, user acceptance, and business models. Finally, a number of ethical issues as misuse of data collected as well as social issues have to be investigated by the scientists.

B. **TELEMENTORING – TELEPRESENCE – TELESURGERY**

With the advent of computer technology and the availability of magnified video images it has become possible to incorporate computer and robotic technologies into surgical procedures. Computer and new communication technology permits to capture, enhance, compress, and transmit video signals and other types of health information over long distances. These technical advances have had a profound effect on surgical procedures and also on the surgeons education and practice.

Telementoring means the real time interactive teaching of techniques by an expert to a student
not at the same site. It was first reported in 1965 by Dr De Bakey who transmitted guidance on open heart surgery from the USA over broadband satellite to surgeons in Europe. After that, many other telementoring surgeries have been operated around the world successfully.

The technological advances of robots now permit telepresence surgery from remote locations, even locations thousands kilometres away. Telepresence permits the telementoring of novice surgeons who are educating or performing new procedures by experts in remote locations. Studies reviewed indicate that robotics and telerobotics offer potential solutions to the inherent problems of traditional surgery as well as new possibilities for telesurgery.

Surgical procedures carried out at a distance thanks to advances in robotic and computer technology and their applications to surgery are referred as telesurgery. Many telesurgery systems are under development but only two are currently available for clinical use. The first telesurgery system was developed by Green and colleagues at the Stanford Research Institute, California, USA, 1992. It consisted of a surgeon’s workstation with a high resolution colour three-dimensional image with adjustable magnification. The system included conventional surgical instrument handles for the surgeon to use placed underneath the viewing screen, stereo and audio input and force-feedback grasping, whereby motors in the surgeon’s console instruments recreated the amount of resistance being encountered at the remote surgical site. This system was commercially Known as MONA telesurgery system and was later improved and renamed as da Vinci telesurgery system.

The da Vinci system is currently the most technologically advanced surgical robotic system in the world and is designed to perform complex operations through incisior that are much smaller and less traumatic than those used with traditional surgical approaches. The da Vinci robotic system has successfully performed minimally invasive cardiac surgical procedures to patients desiring a minimally invasive approach. This system is comprised of four principal components: a surgeon console, a computerized control system, two instrument robotic arms and a fiberoptic camera. The surgeon sits at the console and views 3-D images of the human body through the digital, stereoscopic camera system, while manipulating the instinctive operating controls. The surgeon’s hands motions are relayed to a computer processor which digitizes and relays them to the fine instrument tips placed into body through small 1 cm port incisions. This computerized robotic system enhances the surgeon’s ability to perform minimally invasive surgery in several ways. First, the computer interface permits the accurate translation of the surgeon’s hand motions to a dexterous endoscopic wrist placed conferring much higher degree of freedom and precision that could be achieved with traditional hand-operated instruments. Second, da Vinci’s advanced two-camera stereoscopic optics provides unprecedented magnified, high definition, full-color images in three dimensions. This visualization provides much greater detail than is generally possible with the surgeon’s eyes. Since the first da Vinci operation was performed in 1999, more than 300 robotic mitral valve repair procedures, 300 robotic neurosurgical procedures and 150 atrial septal defect closures have been performed successfully in the United States and in Europe.

The ZEUS system, (Computer Motion, California, USA), is similar in design to the da Vinci system. It has robotic arms on the patient side that attach directly to the operating table, and the surgical site is viewed on a screen by theatre staff.

In 2001 the first international telesurgery was performed on a patient in France while the operating surgeon was 6500 Km away in New York. A remote laparoscopic cholecystectomy procedure was completed successfully using the ZEUS system connected to the remote site by a dedicated high bandwidth fibre-optic ATM service (10Megabits/sec) in 54 minutes with no intraoperative complications. Using the telesurgery techniques and systems available with the main aims of evaluating the equipment for clinical use and proving the concept many surgical procedures have been performed such as laparoscopic cholecystectomy, gastroplasty, coronary artery by pass, radical prostatectomy, mitral valve repair, nephrectomy, pyeloplasty,
pelvic lymph node dissection fallopian tube reanastomosis.

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Medical robotics and computer-assisted surgery is an emerging area of research on the applications of computers and robotic technology to surgery, in planning, execution of surgical operations and also in training of surgeons. With the robotic telesurgery, the goal is to apply robotic tools to augment or replace hand instruments used in surgery. The robotic tools are not automated robots but teleoperated systems under direct control of the surgeon, therefore giving the name telesurgery. Surgical simulation aims to develop an alternate training medium for surgery in the form of a virtual environment based surgical training simulator.

Laparoscopic surgery is a revolutionary surgical technique, minimally invasive and fundamentally telemanipulative. Minimally invasive operations including laparoscopy, thoracoscopy, arthroscopy, pelviscopy and angioscopy, are performed with instruments and viewing equipment inserted through small incisions to the body and have successfully implemented the last decade. The main advantage of these techniques is the reduced trauma to healthy tissue, which is the leading cause of patient’s post-operative pain and long hospital stay. Telerobotics offers the technical tools to extend surgeons capabilities or complement them. The surgical tools can be replaced with robotic instruments which are under direct control of the surgeon through teleoperation.

Issues of surgeon training and qualification, system instrument range, maintenance and certification, communication availability and reliability, and legal matters of liability, jurisdiction and informed consent must be
addressed before telesurgery can become common place.

III. CONCLUSION

The design and development of new technological solutions and products for the health telemonitoring specifically of human physiological parameters is a real challenge for scientists and engineers. Basic targets of research are full integration of sensing, processing, actuating, and communicating functions in a woven structure which will mostly affect the health status and human lifestyle.

The telesurgery systems provide opportunities to improve and expand range of procedures possible owing to their enhanced visualization and manipulation features, even where remote surgery is not currently feasible. Telesurgery may facilitate surgical decision making and avoid complications by allowing rehearsal of surgical procedures on a patient specific simulator. The robotics systems used in telesurgery need to be refined and new instrumentation is required. In addition, wireless and visual displays may form the next generation of display devices. Telesurgery systems will need to be designed for specific surgical subspecialties. Nonetheless, these technologies are still in early stages of development and applications and each device entails its own set of challenges and limitations for actual use in clinical settings.

IV. REFERENCES.