Title of Research Proposal:

To Develop Intelligent Secure IoT Framework for Telesurgery

1. Introduction of research proposal

The technological development of the last decades resulted in the rise of entirely new paradigms in healthcare domain. The use of robots in medical procedures has been shown to result in better surgical outcomes and faster recovery, thus enhancing the delivery of medical services to the patients. It is envisioned these systems will be used to provide immediate medical relief in under-developed rural terrains, areas of natural and human-caused disasters, and in battlefield scenarios.

In this study, the interdisciplinary approach is proposed through telesurgery. This system consists of one or more arms of robot controlled by surgeon, a server which acts as a master controller, sensory system providing feedback to the user, communication technology such as high speed data connections and database management. Based on the gathered visual information, the surgeon guides the arm by moving the controller and closely watching its effect. Patient's historical data, reports and real time data are stored in database system. Wearable device capture real time data and send it to middleware for further filtering and processing. The Wearable biomedical device receives the biomedical signal and analyses the received signal with the reference signal and process the signal to get different types of information's that required to know the condition of the body. If any abnormalities found in patient or users health then it will alert or call to doctor in unconscious situations. The open and uncontrollable nature of the communication medium opens these systems to a variety of possible security vulnerabilities. Rapidly growing applications of teleoperated surgery raise the question; what if the computer systems for these robots are attacked. So system need security algorithm to have secure communication from device to master controller in wireless network.

2. Origin of research problem

In earlier days, Mechatronic devices were used by physicians for remote patients surgery. Soon after, many new set of instruments created for telesurgery. Recent development is robotic sugery have a profound impact in medicine. The surgeries in countries at war, victims of natural disasters or humanitarian crises have always been an obstacle to the appropriate surgical care and quality. Accordingly, telesurgery allows contact local surgical team who work with surgeons using advanced technology.

Patients has to travel long distance to receive surgical procedures that they require, but the majority of these patients, for various reasons, cannot travel long distances, which in consequence leads to the fact that patients in areas where there is a lack of medical personnel do not receive the medical care that they need[c].

3. Definition of the Problem

Remote surgery is essentially advanced telecommuting for surgeons, where the physical distance between the surgeon and the patient is less relevant. It promises to allow the expertise of specialized surgeons to be available to patients worldwide, without the need for patients to travel beyond their local hospital.

A controller system (Master sub-system), Robotic Arms (Slave sub-system) and a sensor system (reception of audio-visual data), these connected systems ensure the surgeon the ability to remote control the robotic arms and audio-visual feedback of the surgical field. The data transmission depends on the used technology: Digital Video Transporting System (DVTS), Integrated Service Digital Network (ISDN), Digital Subscriber Line (DSL),etc. Real-time images with the lowest possible delays capture through wearable devices and sends real time data either though mobile device or any other device. These communication technologies accelerate the development of telesurgical systems by providing affordable, high-speed, high-bandwidth Internet access. Security over communication medium and patient privacy issues have become more complex, as a great proportion of medical records are stored and transmitted in electronic form. . In order to perform telesurgery privately, the encryption of information and data authentication must be introduced, and advanced security technology is required in telesurgical communication.

4. Objectives

1. To provide and develop Support for data collection in surgical robotics using information system that store patients historical as well as real time data.
2. To provide Low encoding and decoding total latency by analyzing biomedical signals obtained from sensory system.
3. To develop Superior visualization including 3-dimensional imaging of the operative field and Stabilization of instruments within the surgical field
4. To develop the GUI for user (doctors, trainers) at the opposite side.
5. To develop Robustness to network characteristics including guarantee of quality-of-service parameters by implementing IoT framework for secure communication in wireless network.
6. To provide Low cost and availability of the codecs and applications.
7. To support healthcare domain which uses the idea of Internet of Things (IoT)
8. To provide intensified healthcare support to remote patients.

This system comprises the following aspects:

1. Provides high-quality surgery to medically underserved locations such as rural areas, battlefields, and spacecraft.
2. Eliminates the need for long-distance travels, along with travel-related financial burden and dangers.
3. Allows for surgical collaboration amongst surgeons at different medical centers in real-time.
4. Secured and Improved surgical accuracy and healthcare domain.

5. International status

First telesurgery systems were funded by the DoD. First prototype of telesurgery robot was developed at Stanford Research International (SRI). It was assembled by 1991, primarily aimed for open surgery. Based on the experience at SRI and NASA, the Defense Advanced Research Projects Agency (DARPA) of DoD initiated the Trauma Pod project in 1994. The main goal was to enhance battlefield casualty care by developing autonomous and semi-autonomous mobile platforms through the integration of tele-robotic and robotic medical systems. Surgical robotics at the turn of the twenty- first century has produced the technology to disrupt paradigm of surgeon-patient proximity[d]. Robotics entered the operating room in 1985 with the PUMA 200 industrial robot adapted for CT-guided brain biopsy. The first commercially available medical robot came in 1992 with the ROBODOC (Integrated Surgical Systems, Sacramento, CA).

The development of telesurgery arose in the 1970s with the aim to replace the surgeon physical presence in situations of mass casualties in hostile environments such as war or natural catastrophes[d]. While the foundation of telemanipulation surgical systems can be traced back to the United States National Aeronautics and Space Administration (NASA), their major development was funded by DARPA (Defense Advanced Research Project Administration) as a potential military tool for remote surgical care of the injured soldier. Two main teleoperator surgical robots were developed from the research: the da Vinci Surgical System and the ZEUS system Intuitive Surgical and Computer Motion merged in 2003, resulting in a single FDA-approved robotic platform on the market today that carries the name da Vinci.

The first transatlantic telesurgery was done in 2001 in which the surgeon Marescaux performed a cholecystectomy in a patient located in Strasbourg, France[e].

In the military context there is interest in the advancement of research and testing to extend health care to war field (2007) performed 22 laparoscopic telesurgeries, the biggest and most expensive experiment in the area so far. In this study they created a surgical service between two hospitals separated by 400Km in Ontario, Canada.

6. National status

First time Tele-robotic surgery is performed at a distance from the patient from a remote location using robotically controlled instruments in India. It is enabled by computer technology and advanced robotics. Dr Patel, who is the chief interventional cardiologist at Ahmedabad-based Apex Heart Institute, guided the robot to perform the surgery on the patient from the Akshardham Temple in Gandhinagar, around 32 kilometers away.

According to study, very little Indian company is doing any major research or development in this field. General monitoring systems are available like recording signals and perform analysis on recorded vital signals.

7. Methodology

1. Survey of Related work

To understand problem domain, we propose extensive survey to collect information about available telesurgery hospitals/industry. Wealth of data will be accumulated globally over the past decades in the areas of health and health care. The survey will include

a. Survey to collect and understand different research under the given research Topic

b. Survey to collect and understand diseases where telesurgery is possible

c. Survey of other approaches available for remote surgery

d. Survey of techniques used for effective telesurgery

e. Survey on number of patients availed telesurgery facility in India

f. Survey on existing security approaches in wireless network

g. Survey on pricing of equipments.

h. Mathematical theories

2. Comparative analysis and Experimentation

a. Perform Comparative analysis of algorithms and methods used in existing systems considering parameters such as accuracy, complexity in time and space domain etc., to select best algorithm and method for proposed system.

b .Perform analysis on the wearable sensor devices available, data logging on the on the wearable device and upload Services and equipment available for telesurgery.

c. Comparative analysis of security algorithms and techniques used in existing system.

d. Understand methods, hardware or algorithms required for implementing proposed system.

e. Understand the applicability of methods or algorithms for effective remote surgery.

3. Development and testing of selected hardware, algorithms and methods

Finally the tested methods for formulating the proposed system will be selected based on their comparative analysis. The design of architecture will be decided and will be implemented using wearable devices and other equipments.

The work of this stage will be focused on

a. Design the architecture for the system and justify its suitability.

b. Identify the Hardware, methods or algorithms based on their benefit analysis.

c. Generate the test data and provide methodology for testing the system.

d. Verify for test data, hardware, methods or algorithms to understand implementation requirements and relevant technologies.

e. Design security algorithm architecture for secure communication between wireless devices.

f. Verify and test results with existing experimental survey

g. Justify the results of the implementation through case studies.

8. Bibliography

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9. Importance of Project

Teleoperated surgical robots use a combination of existing publicly available networks and temporary ad-hoc wireless and satellite networks to send video, audio and other sensory information between surgeons and remote robots. Advancement of the technology enabled surgeons to control robots from remote sites. Robotic instruments, such as the grasper, scissors, cautery, and so on that can be controlled remotely. These robots function as a master-slave system, in which the device transmits the movement of the hand of the surgeon to the surgical instrument by remote manipulation. Telephones and modems, Ethernet, ISDN, ADSL, and ATM are currently used for the transmission of information.

The system consists of Surgeon Site Software (SSS). SSS contains of two pieces of software: the surgeon's graphical user interface (SGUI) and a Haptic Device Client (HDC) that communicates with the two haptic devices through their API, and with the remote surgical robot using network. The SGUI allows the surgeon to execute high-level commands during medical procedures. The Surgeon window provides options and information relevant to the surgeon. The HDC connects with the Haptic Interface Devices (HIDs) that control the robot. It also transmits commands to the robot. Once user options are selected, the HDC begins communication with the robot[i]. The video feedback from the surgical robot operating either locally or at a remote location is completely decoupled from the rest of the SSS.

Patient privacy issues have become more complex, as a great proportion of medical records are stored and transmitted network. In telesurgery, if patient information is leaked or patient privacy is infringed, the medical institution and the telecommunications industry may be unduly exposed to legal ramifications. In order to perform telesurgery privately, the encryption of information and data authentication must be introduced, and advanced security technology is required in telesurgical communication. In such operating conditions, attack vectors are feasible. First attack is Endpoint compromise attack, where either a surgeon's control console or a robot can be compromised, and second is network and communication-based attacks, where an attacker may intercept the existing network traffic; inject new malicious traffic, or both. By encrypting , authenticating data streams between the surgeon's terminal and the robot and providing authorization and access control, make the ability of an attacker to initiate an attack that comprises an intention modification, manipulation, or hijack .

In implementing such systems, following attributes and quality of service parameters are considered:

Attributes

1. Communication security
2. System reliability
3. Redundant communication channels
4. High quality video

Quality of Service parameter

1. Network Latency
2. Efficiency
3. Accuracy and Reliability

Time schedule of research work

Sr. No.	Year	Duration	Task to be accomplished
1	First Year	04 months	Survey to collect and understand patients needs and diseases operated through telesurgery
2		02 Months	Investigate various tools and techniques. Data collection and analysis
3		02 Months	Problem Solving and Analysis of the required input and output
4		04 Months	Design the system (module design and various use cases)
5	Second Year	06 months	Implementation of modules using basic hardware required in system, Implementation of security module
6		06 Months	Connectivity of all modules and implementation of algorithm
7	Third Year	04 Months	Personalization of the proposed system
8		04 Months	Hardware and software Modules Integration and source code testing,
9		04 Months	Complete Project Testing : Apply testing strategies and methods for real time users, Results compilation

10. Financial Assistance/ Budgeting

Sr. No.	Budget Head	Year I Estimate (in Thousands)	Year II Estimate (in Thousands)	Year III Estimate (in Thousands)	Total Estimate (in Thousands)
1	Equipments	3,50,000.00	4,93,750.00	3,00,000.00	11,43,750.00
2	Software	4000.00	8000.00	8000.00	20,000.00
3	Books	5000.00	6000.00	3000.00	14,000.00
4	Field Work and Travel	5000.00	5000.00	5000.00	15,000.00
5	Contingency (including special needs)	7000.00	8000.00	2000.00	17,000.00
6	Hiring Services	1,50,000.00	1,50,000.00	1,50,000.00	4,50,000.00
Annual Total		5,21,000.00	6,70,750.00	4,68,000.00	**16,59,750.00**

Equipments:

1. Wearble sensor devices or cyber gloves ($13,750)- 8,93,750
2. Server-2,00,000
3. Cost of network:= 50000

Total= 1143750

Latest article

Rachel V. Thomas 21st Nov 2017

With the aim of installing 200 more robots and reaching over 20,000 robotic-assisted surgeries per year by 2020, US-based Vattikuti Foundation is set to make India the second largest market for robotic surgery in the world after the US, said the non-profit's top executive in Panaji.

"Today, India has tremendous potential and much talent, across all domains specially in the medical field," Raj Vattikuti, Founder and President of Vattikuti Foundation — a non-profit promoting robotic surgeries across the world, including in India — told *IANS* on Saturday.

"Thus, it can soon become the second largest robotic market in the world in terms of sale of robots as well as surgeries."

He was speaking at the two-day bi-annual "Robotic Surgeons Council", organised by the foundation, which began in Panaji on Saturday.

At present, India has over 50 surgical robots and a pool of over 300 trained robotic surgeons. An estimated 700 robotic-assisted surgeries a month are conducted in the country.

"In late 2011, we entered Indian market with only eight to nine robots and with hardly any procedures. The market perceived the systems to be very expensive and surgeons felt that it can take a lot of effort for them to learn and master it," Vattikuti said.

"Now, we have seen a tremendous progress in the status of robotic surgery in the country as well as a change of perception in the market. Lot of surgeons are really fascinated about the technology and have come forward to learn it."

The foundation, which is expected to install nearly 70 robotic systems, helping in over 7,000 robotic-assisted surgeries till December this year across India, aims to install 100 robots across India by 2018.

Till now, it has trained 360 surgeons and hopes to train another 100 in 2018.

"We aspire to bring the count to 600 surgeons in the coming two to three years as well as install 100 robots across India in the next year," Vattikuti said.

Robotic surgery is a method to perform surgery using very small tools attached to a robotic arm.

With the four-armed "Da Vinci Surgical Robot" developed by the US-based Intuitive Surgical, tiny instruments are sent in and controlled by an accomplished surgeon sitting at a nearby console.

Robotic Surgery offers immense possibilities in thoracic, urology, gynaecological, colorectal, paediatric and general surgical disciplines.

Importantly, Vattikuti Foundation has also spread its wings to tier-2 cities such as Coimbatore, Nagpur, Vizag, Indore, and Mohali.

Government hospitals such as Army Hospital Delhi, AIIMS Delhi, Delhi Cancer Institute, PGI Chandigarh, have already bought the robots. Others such as AIIMS Jodhpur and Rishikesh as well as Safdarjung Hospital in Delhi are in talks to buy the innovative systems, said Vattikuti.

"We have such immense talent in India in terms of number of surgeons, expertise, government institutes like AIIMS, PGI, Tata Memorial, that we can also be the world leaders in building clinical aspects of the robotic surgery," he added.

Mahendra Bhandari, CEO of the foundation, told *IANS*: "With robotic surgeries, our mission was not to segregate the poor and rich. We are happy that the government has shown interest, and are buying robots, which can help the marginalised sections to avail its benefits."

In a surgery conducted by surgical robots, the incision is small, the loss of blood is very minimal, the patient has quick recovery, shorter hospital stays and a faster return to normal life.

The surgeon has a magnified, high-definition, three-dimensional (3-D) view as if sitting inside the patient's body and, with a joy stick, he or she can manipulate tiny surgical instruments that enjoy better flexibility than human hands.

These surgeries range from the removal of cancerous tissues to the reconstruction of organs damaged by cancer as well as the removal of organs such as the kidney, liver, pancreas, thyroid, prostate, and uterus.

It is best for getting under soft tissue to reach organs that otherwise require opening up, involve long and painful recovery periods, and leave behind scars.