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Robots and Robotically Assisted Surgeries

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ABSTRACT
Today we all live in an age of technology and science. The use of technology and science has revolutionized our way of life. The use of the computer has been on the increase for some time in many fields like medicine and surgery. Due to advent of robotics smaller incisions with minimal scarring surgeries are possible. This paper reveals the aspects of use of an electronic device with computer controlled programs in it, assisting the doctors during surgeries of various kinds. The first part of it explains a robot and its related basics. The second part throws light on the basic construction facts of a robot. It also discuss about the tools and languages required to build a robot. It later explains the working of robots in medical domain and explains the most widely used surgery method: The da Vinci Surgical System where robots are widely used for assistance to doctors.

Keywords*: Robotics, ROS, Medical Robots, Da Vinci Systems.*

1. INTRODUCTION
At its most basic a robot is a machine that senses the world, processes the sensor information with a computer and then does something in response to that information (such as moving or turning). Robotics is a multi-disciplinary field; it takes a lot of different expertise to design, build and program a robot. Often mechanical engineers, electrical engineers, computer scientists, industrial engineers and industrial designers are all involved. Mechanical engineers design all of the physical parts of the robot – parts like the chassis, motors, arms and hands, wheels, tracks or legs. Electrical engineers design all of the circuits and wiring that the internal computer will use to control the robot. Computer scientists program the robot; they write the software that takes the information from the robot's sensors, processes it and then tells the robot how to act.

In the future robots may be used to help doctors examine patients who are far away, to help carry injured people out of disaster areas, to assist senior citizens or people with disabilities or even to inspect bridges for signs of wear. Scientists and engineers all over the world are developing robots that can help people in homes or outside, on land, in the water and in the air. Several special robots are used in medical field to help surgeons during various treatments and surgeries. Section 2 and Section 3 describes the way robots are created. Section 4 and Section 5 explains the history and working of medical robots. Section 6 explains the most widely used surgery method: The da Vinci Surgical System. Section 7 describes the benefits adopted by the medical system.

2. COMPOSITION OF A ROBOT
A typical robot has a movable physical structure, a motor of some sort, a sensor system, a power supply and a computer 'brain' that controls all of these elements. They have a reprogrammable brain (a computer) that moves a body. A robot is distinct from ordinary computers in their physical nature -- normal computers don't have a physical body attached to them. On the most basic level, human beings are made up of five major components [1]:

- A body structure.
- A muscle system to move the body structure.
- A sensory system that receives information about the body and the surrounding environment.
- A power source to activate the muscles and sensors.
- A brain system that processes sensory information and tells the muscles what to do.

A robot is made up of the very same components. The computer-enhanced robotic system consists of three components, including [1]:

- **A three-dimensional view of the surgical field**, including depth of field, magnification and high resolution.
- **Instruments on thin robotic arms** that are designed to mimic the movement of the human hands, wrists and fingers, allowing an extensive range of motion and more precision.

- **Master controls** that allow the surgeon to manipulate the instruments, translating the surgeon's natural hand and wrist movements into corresponding, precise and scaled movements.

3. THE PROCESS OF BUILDING A ROBOT

By following the following steps a robot can be formularized to functionality.

3.1. Robot Planning

Planning is the first step to start off with any new work. In order to build a robot one should start out making a list of all the things that we want our robot to do. This might include running around on its own, talking, understanding the human voice, picking up objects, following lines, avoiding crashing into things, etc.. Budget planning is also necessary as to invest in physical components for the robot.

3.2. Robot Micro-Controllers

Robot micro-controllers are little tiny computers that robots use for brains. Some widely used microcontrollers today are VEX, Arduino, Basic Stamp, BasicAtom, Parallax, and several others. These robot "brains" have their own features and pros and cons, but basically they all coordinate the flow of information and power on the robot. All other electronic system components must then interface to the microcontroller and function as a cohesive unit.

3.3. Programming the Robot in a Language

A robot will require a programming language for describing the operations that are to be done. Recently, there are plenty of robot programming languages available [2]. Among them, six robot languages are commonly and basically used. They are:

1) RAIL: It is a best language for controlling two major tasks such as the manipulation and vision system. It is a high – level robot language based on Pascal, and it will implement a Motorola–68000 central processor, teach pendant, and terminal. This language was designed by Automatix.[3]
2) AML: It is A Manufacturing Language , a high level language based on sub routine, which is mainly implemented to manage RS / 1 Assembly Robot, End Effectors Active Force Feedback, and Cartesian Arm with hydraulic motors. It was developed by IBM Corporation for robot programming.[3]
3) VAL: It is Variable Assembly Language adopted mainly for Unimation Robots i.e. to monitor commands that are used to execute the user written programs.[3]
4) AL: It was developed in Artificial Intelligence Lab at Stanford University. It is the second generation language based on simultaneous Pascal. The programs are written and executed on PDP – 10.[3]
5) RPL: This language makes the improvement, checking, and correction of control algorithms very easy. It can be done even by an unskilled programmer like line foreman, production engineers, etc. The RPL programs are translated to interpretable code with the help of a compiler in SRI Robot Programming System. The programs are typically written in BLISS – 11 and run in RT – 11. The DECPDP – 10 is cross compiled into the LSI – 11 or PDP – 11. This robot language was designed in SRI International. [3]
6) Arduino C: For easy simulation of robots Arduino C is used. It has most C constructs with added robotic constructs such as routines to run a servo motor. The arduino microcontroller has thousands of open sources that can be used and modified as per the needs [4].

3.4. Robot Sensors

Sensors are to robots what senses are to people. They allow a robot to be aware of his environment. There are sensors that can allow a robot to see, smell, hear, touch, and even taste, and more. There are plenty of sensors used in the robots, and some of the important types are listed below:

1) Proximity Sensor: This type of sensor is capable of pointing out the availability of a component. It is also used to find the presence of a human being in the work volume so that the accidents can be reduced.
2) Range Sensor: Range Sensor is implemented in the end effectors of a robot to calculate the distance between the sensor and a work part. The range is measured using the Sonar receivers & transmitters or two TV cameras.
3) Tactile Sensors: A sensing device that specifies the contact between an object and a sensor. This sensor can be sorted into two key types namely:

- Touch Sensor, and
- Force Sensor.

The touch sensor has got the ability to sense and detect the touching of a sensor and object. The force sensor is included for calculating the forces of several functions

like the machine loading & unloading, material handling, and so on that are performed by a robot.

3.5. Robot End Effectors

Robot end effectors are claws, grippers or even hands, are what a robot uses to more easily interact with the world. End effectors can be as simple as a screwdriver or stylus attached to a robot or as complicated as a human-like hand. Most often end effectors are like a human's "end effectors" put at the end of robot arms. The above mentioned sensors are used at end effectors to interact with the outside world.

3.6. ROS (Robot Operating System)

Robot Operating System is a framework for robot software development, providing operating system-like functionality. ROS was originally developed in 2007 under the name 'switchyard' by the Stanford Artificial Intelligence Laboratory in support of the Stanford AI Robot. It provides libraries and tools to help software developers create robot applications. It provides hardware abstraction, device drivers, libraries, visualizes, message-passing, package management, and more. ROS is licensed under an open source, BSD license.

4. MEDICAL ROBOTS

Researchers believe that some routine medical procedures such as biopsies and surgeries could be performed in the future with minimal human guidance at less cost and greater convenience to patients. They along with the medical professionals follow the following steps and perform surgery:

Step 1: Three small incisions or "ports" are made in the spaces between the ribs.

Step 2: The surgical instruments (attached to the robotic arms), and one camera are placed through these ports.

Step 3: Motion sensors are attached to the robotic "wrist" so the surgeon can control the movement of the surgical instruments.

Step 4: The surgeon sits at a computer console and looks through two lenses (one for each eye) that display images from the specialized camera with two optical outputs.

Step 5: From the two optical outputs, the computer generates a clear three-dimensional image of the surgical site for the surgeon to view from the two optical outputs. And Foot pedals provide precise camera control, so the surgeon can instantly zoom in and out to change the surgical view.

Step 6: The surgeon's hands control the movement and placement of the endoscopic instruments. The robotic "arm and wrist" movements mimic those of the surgeon. And the Surgery is performed successfully.

5. A BRIEF HISTORY OF SOME MEDICAL ROBOTS

The table underneath throws some light on existent medical robots.

Puma [5]	The first known medical robot utilized by the medical industry in 1985, when the robot PUMA 560 placed a needle for a brain biopsy using CT guidance.
ViRob Miniature [6]	In Israel, a miniature robot called ViRob was developed in order to crawl through the human body, locate a tumor, and treat it with drugs. Measuring only one millimeter long and four millimeters from end to end, the bot uses tiny arms controlled by an electromagnetic field to propel its way through different cavities of the human body, looking for deadly tumors to treat.
IV Robots[4]	It is used to mix and measure medications, specifically those used in chemotherapy. Using a robot thus removes the need for manual calculation and greatly reduces the possibility of human error.
The PillCam Robot[7][8]	It is a tiny capsule equipped with a tiny camera for recording images (via computer) of the digestive tract and intestines. It is only1.1 cm in diameter and 2.6 cm in length, and transmits pictures of the human insides at a rate of two images per second, and in an 8-hour period, could generate more than 50,000 pictures. Used to detect cancerous growths in the colon.
Mr. Gower[4]	At a medical center in Maryland, a robot named Mr. Gower navigates the hallways, riding elevators, opening doors and delivering patient medications to the nurses station all on its own. Mr. Gower can pull up to 500 lbs and can work for 12 hours after charging its batteries for only two hours. Aside from filling the gap created by staff shortages, the robot helps them deliver medications to their patients faster.
Robot Nurse Cody[9]	It performs bed bath for patient hygiene. It consists of a Segway omnidirectional mobile base, two anthropomorphic arms with seven

	degrees of freedom and wrists equipped with 6-axis force/torque sensors. The end of the robot's right arm is fitted with a specialized 'bath mitt' and the robot gathers laser range data and images from a laser range finder and camera mounted above the robot's torso.[2010 IEEE International Conference on Intelligent Robots and Systems (IROS) in Taipei, Taiwan, Cody, the robot nurse was developed by a team led by Dr. Charles Kemp]
IntelliFill i.v.[10]	A robot that can fill up to 60 drug-filled, patient-specific syringes per hour, also designed to ensure that the right medicine in the right dose gets to the right patient.
PROBOT[11]	A surgical robot has the ability to remove soft tissue from a human body during an open surgery.

6. COMMONLY USED ROBOTIC SURGERY APPARATUS-DA VINCI SURGICAL SYSTEM

It is a telesurgical product in which human directs the motions of the robot. It was approved by FDA(Food and Drug Administration) on July 11, 2000, for laparoscopic procedures. It consists of two primary components:

- A viewing and control console.
- A surgical arm unit that includes three or four arms, depending on the model.

In using da Vinci for surgery, a human surgeon makes three or four incisions (depending on the number of arms the model has) -- no larger than the diameter of a pencil -- in the patient's abdomen, which allows the surgeons to insert three or four stainless-steel rods. The robotic arms hold the rods in place. One of the rods has two endoscopic cameras inside it that provide a stereoscopic image, while the other rods have surgical instruments that are able to dissect the tissue. Sitting at the control console a few feet from the operating table, the surgeon looks into a viewfinder to examine the 3-D images being sent by the camera inside the patient. The surgeon uses joystick-like controls located underneath the screen to manipulate the surgical instruments. Each time the surgeon moves one of the joysticks, a computer sends an electronic signal to one of the instruments, which moves in sync with the movements of the surgeon's hands. Once the surgery is complete, the surgeons remove the rods from the patient's body and close the incisions. [12][13][14]

7. BENEFITS OF ROBOTICALLY-ASSISTED SURGERY

Compared with traditional surgery, the benefits of robotically-assisted surgery may include:

- Smaller incisions with minimal scarring and less bleeding.
- Less trauma to the patient, including less pain
- Decreased use of pain medications and risk of infection
- Shorter recovery and quicker return to daily and professional activities.

Most patients can resume normal activities, drive and return to work as soon as they feel up to it -- usually within a few days to one week after surgery.

8. CONCLUSION

In this paper, a vivid view of Robots, their make and their working in the field of medicine is shown. Techniques like da Vinci system is shown for various cardio vascular surgeries. Tools and languages description is also given so that more such kind of systems to be made for various means in medical field. By integrating various fields of engineering efficient surgical robots can be built in future.

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