International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 834-840 www.ijaem.net ISSN: 2395-5252

Robotics in Medical Field

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Date of Submission: 09-03-2023 Date of Acceptance: 18-03-2023

ABSTRACT
Robotics has revolutionized the medical field by enabling the development of advanced technologies and tools that assist medical professionals in patientcare. Medical robots are used in a variety of settings, including surgical procedures, rehabilitation, and diagnostic testing. Robotic systems offer several advantages over traditional medical procedures, such as improved precision, reduced invasiveness, and faster recovery times. In addition, robots can be used to perform tasks that are too dangerous or difficult for humans to undertake, such as working in hazardous environments or manipulating small structures in the body. This abstract provides an overview of the role of robotics in the medical field, highlighting its potential benefits and limitations, and exploring emerging trends and technologies in the field.

I. INTRODUCTION

Over the past few decades, robotics has been rapidly growing in popularity in the medical field, and it has been showing promising results in helping improve patient outcomes and healthcare delivery. Healthcare professionals are using robots in a variety of ways to assist them with diagnosis, treatment, and care of their patients. These robots range from surgical robots to telepresence robots. In recent years, the integration of robotics and artificial intelligence (AI) has led to even more advanced and sophisticated applications in the medical field. Through the implementation of this technology, healthcare delivery has become more efficient and accurate.

A key objective of this paper is to explore the various applications of robotic technology in the medical field, including surgical robots, rehabilitation robots, and telepresence robots [1]. In addition to analyzing the ethical and social implications of these technologies, we will also analyze their benefits and limitations. Furthermore, this paper will discuss the current state of research and development in robotics and AI for healthcare, and the potential for future advancements in this field [2]. It will highlight the challenges and opportunities of integrating these technologies into healthcare systems, and the impact they may have on the healthcare industry and society as a whole.

Robots have the potential to play a significant role in preventing the spread of diseases, including infectious diseases like COVID-19 [3]. Here are some examples of how robots can be used to prevent the spread of diseases:

1. Disinfection robots: Robots equipped with UV lights or other disinfecting technologies can be used to clean and disinfect surfaces in public spaces, hospitals, and other high-traffic areas. These robots can help reduce the risk of transmission of infectious diseases by killing bacteria and viruses on surfaces.
2. Autonomous cleaning robots: Robots can be programmed to clean public spaces and high-traffic areas autonomously, reducing the need for human cleaning staff to enter these areas and risk exposure to infectious diseases.
3. Temperature screening robots: Robots equipped with thermal cameras can be used to screen people for signs of fever, a common symptom of many infectious diseases. These robots can identify individuals with elevated temperatures and alert healthcare professionals to take appropriate measures to prevent the spread of disease.
4. Delivery robots: Robots can be used to deliver supplies and medications to individuals in quarantine or isolation, reducing the need for human contact and the risk of transmission of infectious diseases.
5. Social distancing robots: Robots can be used to encourage social distancing in public spaces and workplaces, reminding individuals to maintain a safe distance from one another and reducing the risk of transmission of infectious diseases.
6. Testing and diagnosis: Robots have been used to perform COVID-19 tests and to assist with

diagnosis in areas where healthcare resources are limited. These robots can be equipped with AI and other technologies to analyze test results and provide feedback to healthcare professionals.

7. Remote patient monitoring: Robots have been used to remotely monitor patients with COVID-19, reducing the risk of exposure for healthcare workers. These robots can be equipped with sensors and other monitoring tools to collect vital signs and other health data, which can be transmitted to healthcare professionals for analysis and treatment.
8. Telepresence robots: Telepresence robots have been used in hospitals and healthcare facilities to enable remote communication between patients, healthcare workers, and family members. These robots can be controlled remotely and are equipped with video conferencing and other communication tools that allow healthcare professionals to provide care and support to patients without the need for direct contact.

Overall, robots have the potential to be an effective tool in preventing the spread of diseases, particularly in high-traffic areas and healthcare settings where the risk of transmission is high. As robotic technologies continue to advance, it is likely that we will see increased use of robots to prevent the spread of diseases in the future.

Background Study

Robotics has been used in the medical industry since the 1980s, with the first robotic system, the PUMA 560, being utilized in neurosurgical biopsies in 1985. Since then, this technology has been increasingly employed in various medical fields, including surgery, rehabilitation, diagnosis, and more.

In the late 1990s, the development of the da Vinci Surgical System marked a significant milestone in the advancement of robotic surgery. The system was specifically designed to enable surgeons to carry out minimally invasive procedures with improved accuracy and control. By utilizing small instruments and a 3D camera, the da Vinci System provides a magnified view of the surgical site, while the system's robotic arms are remotely controlled by the surgeon sitting at a console.

The use of robotics in surgery has expanded to include a wide range of procedures, such as prostatectomies, hysterectomies, and heart surgeries. Robotic systems have also been used in other medical fields, such as rehabilitation, where robots can assist in the recovery of patients who have suffered strokes or other neurological injuries.

In addition to surgery and rehabilitation, robots have been used in other medical applications, such as diagnosis and treatment. For example, robots have been used to help identify cancer cells and to deliver drugs to specific areas of the body. They have also been used in research to develop new medical treatments and to study the human body and its functions.

Overall, the history of robotics in the medical field has been one of innovation and progress, with new technologies and applications continually being developed and refined. As robotic technology continues to advance, it is likely that robots will play an increasingly important role in medical care and treatment [4].

II. DATA ANALYSIS

Robotics has played an increasingly important role in the field of medicine, and there has been a growing interest in using data analysis to improve the performance of robotic systems. Here are some key points to consider when looking at data analysis of robotics in the medical field:

1. Performance Metrics: One of the key ways that data analysis can be used in robotics in the medical field is to measure the performance of robotic systems. This can include metrics such as accuracy, precision, and speed, which can be used to assess the effectiveness of the robotic system.
2. Predictive Analytics: Another way that data analysis can be used in robotics in the medical field is to make predictions about the future performance of the system. This can involve using data from past operations to make predictions about the success of future surgeries, for example.
3. Image Analysis: Data analysis can also be used to analyze medical images, such as CT scans or MRI scans, to help guide the movements of robotic systems during surgery. This can improve the accuracy and precision of surgical procedures, and can also reduce the risk of complications.
4. Machine Learning: Machine learning techniques can be used to analyze large amounts of data and identify patterns that can help improve the performance of robotic systems. For example, machine learning algorithms can be used to analyze data from previous surgeries and identify factors that contributed to successful outcomes.
5. Decision Support Systems: Data analysis can also be used to develop decision support

systems that help surgeons make better decisions during surgeries. By analyzing data from various sources, these systems can provide real-time feedback and recommendations to surgeons, helping them make more informed decisions.

In conclusion, data analysis plays a crucial role in the development and optimization of robotics in the medical field. It helps improve the performance of robotic systems and allows for more precise and accurate surgical procedures. With the increasing amount of data being generated by these systems, the importance of data analysis is only set to increase in the years to come.

Embedded System

Embedded systems are often used in robotics to control the behaviour and movements of the robot. An embedded system is a combination of hardware and software that is designed to perform a specific function or set of functions. In the case of robotics, embedded systems are used to control the robot's actuators, sensors, and other components [5].

Here are some examples of embedded systems used in robotics:

1. Microcontrollers: Microcontrollers are small, low-power computer systems that are used to control the behaviour of a robot. They are often used to read sensor data, control motors, and perform other functions that require precise timing and control.
2. Single-boardcomputers: Single-board computers, such as the Raspberry Pi or Beagle Bone, are small, low-cost computers that can be used to control a robot's behaviour. They are often used for more complex tasks, such as computer vision or machine learning.
3. Programmable logic controllers (PLCs): PLCs are industrial control systems that are often used in manufacturing and other industrial applications. They can be used to control the behaviour of a robot, particularly in applications that require high reliability and safety.
4. Field-programmable gate arrays (FPGAs): FPGAs are programmable integrated circuits that can be used to implement custom logic circuits. They are often used in robotics to implement real-time control systems or to perform high-speed signal processing.

The specific embedded system used in a robot will depend on the robot's application and the requirements of the task. Some robots may use a combination of different embedded systems to achieve the desired behaviour and performance.

Microcontroller

Microcontrollers are a common type of embedded system used in robotics. They are small, low-power computers that are designed to perform specific tasks and control the behaviour of a robot. Microcontrollers are often used to read sensor data, control motors, and implement control algorithms.

Fig. 1 - Arduino

Here are some of the ways microcontrollers are used in robotics:

1. Sensor reading and processing: Microcontrollers are often used to read sensor data, such as temperature, humidity, light, and motion. The microcontroller can then process this data to make decisions and control the robot's behaviour.
2. Motor control: Microcontrollers can be used to control the speed and direction of motors that drive the robot's movement. By controlling the motor, the microcontroller can regulate the robot's speed and make adjustments to maintain stability and avoid collisions.
3. Control algorithms: Microcontrollers are often used to implement control algorithms that regulate the behaviour of the robot. For example, a microcontroller can use sensor data to maintain a certain distance from an object, or to follow a specific path through an environment.
4. Human-robot interaction: Microcontrollers can also be used to implement user interfaces for human-robot interaction. For example, the microcontroller can interpret signals from buttons or touchscreens to control the robot's behaviour or display information to the user.

Overall, microcontrollers are a key component in the development of robotics. They provide a low-cost, low-power solution for controlling the behaviour of a robot, and can be

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customized to meet the specific requirements of the application.

Design

The design of a robot can vary greatly depending on its intended application and function. Here are some common aspects of robot design:

1. Mechanical design: The mechanical design of a robot involves the creation of a physical structure that can move and perform tasks. This includes selecting materials, designing joints and linkages, and creating the overall shape and size of the robot.

Fig. 2 – Robot Design

2. Electrical and electronics design: This involves designing the electrical and electronic components of the robot, such as motors, sensors, and microcontrollers. It also involves the creation of the circuitry and programming that controls the robot's movements and behaviours.
3. Control systems design: The control system is the brain of the robot and is responsible for managing the robot's movements and behaviours. This includes designing algorithms, software, and hardware to control the robot's movements and decision-making processes.
4. Human-robot interaction design: This involves designing the interface between the robot and the human user, such as the design of buttons, screens, and other user input/output devices. It also includes designing the robot's behaviour and responses to human input.
5. Safety and reliability design: Safety and reliability are critical aspects of robot design. This involves designing features that ensure the robot operates safely and reliably, such as emergency stop buttons, fail-safe mechanisms, and redundancy.

Overall, the design of a robot must take into account the specific application and task it will perform, as well as the environmental and social factors that will impact its use.

Calculations

There are various calculations involved in the field of robotics, depending on the specific application and task at hand. Here are some examples of calculations that may be used in robotics:

1. Kinematics: Kinematics is the study of the motion of objects, and is an important calculation in robotics. In order to program a robot to move and perform a specific task, it is necessary to understand the kinematics of the robot, including its position, velocity, and acceleration [6].
2. Trajectory planning: Trajectory planning involves calculating the path that a robot should follow in order to perform a specific task [7]. This may involve calculating the optimal trajectory based on the robot's kinematics, as well as accounting for any obstacles or constraints in the environment.
3. Force and torque calculations: In applications such as robot manipulators or grippers, it is important to calculate the force and torque required to move and manipulate objects. This involves understanding the physics of the system, including the weight and dimensions of the object being manipulated.
4. Power and energy calculations: Calculating the power and energy requirements of a robot is important in determining the size and capacity of the robot's power source. This may involve calculating the energy required to move the robot's joints or perform a specific task, as well as the power required to drive the robot's motors or sensors.
5. Control system calculations: In order to program a robot to perform a specific task, it is necessary to develop a control system that can regulate the robot's movements and actions [8]. This may involve calculating the optimal control parameters based on the robot's kinematics and dynamics, as well as developing feedback control algorithms to account for any disturbances or uncertainties in the system.

A robot's performance and efficiency are optimized through calculations. As robotic technologies advance, we are likely to see even more sophisticated and advanced calculations.

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Robot Interface

A robot interface refers to the means by which a human user can interact with a robot. The interface can include any physical or digital components that allow the user to provide input to the robot and receive feedback from it.

Robot interfaces can take many forms, including buttons, switches, touchscreens, voice commands, and gestures. The specific type of interface used will depend on the robot's purpose, its capabilities, and the user's needs [9].

For example, a robot designed to perform manufacturing tasks in a factory might have a physical interface with buttons or switches that allow workers to start and stop the robot, adjust its speed, and perform other functions [10]. A social robot designed to interact with people in a more human-like way might have a touchscreen interface that displays facial expressions and allows the user to select different options for interacting with the robot [11].

Fig. 3(a) – Web Interface

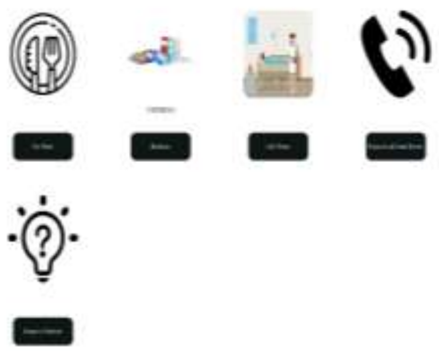

Fig. 3(b) – Web Interface

Overall, the robot interface is an important part of the robot's design, as it determines how easily and effectively users can interact with the robot to achieve their goals.

Sensors

Robots employ a diverse array of sensors to perceive and react to their surroundings. Below are several of the most prevalent sensor types utilized in robotics:

1. Proximity sensors: These sensors perceive the existence of objects in the immediate vicinity of the robot. Their applications include collision avoidance and obstacle detection.
2. Light sensors: Light sensors are used to detect light and dark areas. They can be used to follow lines or detect objects based on their brightness.
3. Infrared sensors: Infrared sensors are used to detect heat and can be used to track objects or detect the presence of people.

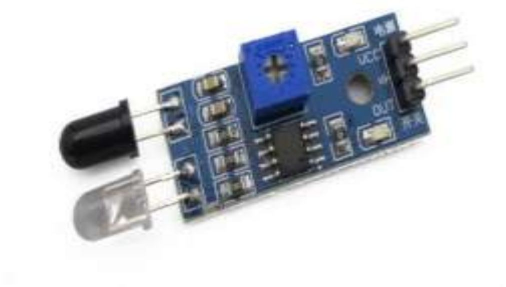

Fig. 4- Infrared Sensors

4. Ultrasonic sensors: Sound waves are utilized by ultrasonic sensors to identify objects and determine distances. These sensors are commonly employed for localization and obstacle detection purposes.

Fig. 5- Ultrasonic Sensor

5. Tactile sensors: Tactile sensors detect pressure and can be used to provide feedback on contact with objects. They are often used in grasping and manipulation tasks.
6. Vision sensors: Vision sensors, such as cameras, are used to provide visual feedback

on the robot's environment. They can be used for object recognition, tracking, and navigation.

7. Force sensors: Force sensors detect the amount of force applied to an object or surface. They are often used in force feedback and compliance control.
8. Gyroscopes and accelerometers: Gyroscopes and accelerometers are used to detect changes in orientation and acceleration. They can be used for motion control and stabilization.

The specific sensors used in a robot will depend on the application and the requirements of the task. Many robots use multiple sensors to provide a comprehensive view of their environment and respond to changes in real-time.

Material Selections

When selecting materials for a robot, several factors need to be considered, including mechanical properties, weight, cost, and environmental conditions. Here are some common materials used in robotics and their properties:

1. Metals: Metals such as aluminium, titanium, and steel are commonly used in robot construction due to their high strength and durability. They are also relatively lightweight, making them suitable for applications that require speed and agility.
2. Plastics: Plastics such as polycarbonate and ABS are commonly used in robot construction due to their low weight and resistance to impact. They are also cheaper than metals, making them suitable for low-cost applications.
3. Composites: Composites such as carbon fiber and fiberglass are becoming increasingly popular in robot construction due to their high strength-to-weight ratio. They are also resistant to corrosion and fatigue, making them suitable for applications in harsh environments.
4. Ceramics: Ceramics such as alumina and zirconia are used in robot construction for their high strength and stiffness. They are also resistant to high temperatures and wear, making them suitable for applications in extreme environments.

Ultimately, the material selection for a robot will depend on the specific application and its requirements. Factors such as weight, strength, durability, and cost will all need to be taken into consideration when selecting materials for a robot.

Fabrication

The fabrication of a robot involves the construction and assembly of the mechanical, electrical, and electronic components that make up the robot. Here are the steps involved in fabricating a robot:

1. Design: The first step in fabricating a robot is to design the robot's mechanical and electrical components. This can involve creating 3D models of the robot using computer-aided design (CAD) software, or sketching out the design on paper.

2. Component selection: Once the design is complete, the next step is to select the components that will make up the robot. This can involve selecting motors, sensors, microcontrollers, and other electronic components, as well as selecting materials for the mechanical components.
3. Mechanical fabrication: The mechanical components of the robot are typically fabricated using machining, cutting, and welding techniques. This can involve using a variety of tools, such as lathes, mills, saws, and grinders, to fabricate the components to the required specifications.
4. Electrical and electronic fabrication: The electrical and electronic components of the robot are typically fabricated using soldering and circuit board assembly techniques. This can involve assembling the microcontroller, sensors, and other electronic components into a circuit board, and then connecting the board to the motors and other mechanical components.
5. Assembly: Once all of the components have been fabricated, the final step is to assemble the robot. This can involve mounting the motors and sensors onto the mechanical components, connecting the electronic components, and testing the robot to ensure that it functions properly.

` Overall, the fabrication of a robot can be a complex and time-consuming process. It requires a range of skills, including mechanical and electrical engineering, and can involve a variety of tools and equipment. However, with careful planning and attention to detail, it is possible to fabricate a robot that meets the required specifications and performs the desired tasks.

III. CONCLUSION

In conclusion, robotics has the potential to revolutionize the field of medicine, improving the accuracy and precision of medical procedures and enhancing patient outcomes. Robotics has been used in various medical applications, including surgical procedures, rehabilitation, and medical imaging, among others[12].

Robotic surgery, in particular, has become increasingly popular in recent years, providing minimally invasive solutions for complex surgeries, reducing recovery time and improving outcomes. Other areas where robotics is making an impact in medicine include prosthetics, telemedicine, and drug delivery, among others.

Robots can also assist in handling hazardous materials and infectious diseases, reducing the risk of exposure to healthcare workers. Furthermore, robotics can help to address the shortage of healthcare professionals in remote and underserved areas.

Despite the potential benefits of robotics in the medical field, there remain challenges to overcome as with any emerging technology. Concerns about the safety and effectiveness of these systems exist, as well as the cost barrier to their implementation in certain contexts. Nonetheless, ongoing research and development are anticipated to drive further progress and advancements in the field of medical robotics.

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