Development of a Pick and Place Mechanism to Deliver Surgical Tools During Surgery

ME420 Mechanical Engineering Individual Research Project

A project report submitted to the
Department of Mechanical Engineering,
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In partial fulfillment of the requirements for the degree
Bachelor of the Science of Engineering,

by

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Declaration

I confirm that I have written this report without any external help and not using sources other than those I have listed in the report. I also confirm that this report or a similar version of it has not been submitted to any other examination board and has not been previously accepted as part of an exam for a qualification. Each direct quotation or paraphrase of an author is clearly referenced.

Place, 19th Nov 2023 [LIYANAARACHCHI.L.A.S.D.]

Name of the project supervisor:

Dr. Indrani Kularatna

Preface

I am privileged to present this comprehensive report on the development of a Voice-Activated Pick and Place Mechanism to Deliver Surgical Tools During Surgery, a project that marks a significant milestone in my journey as a mechanical engineering undergraduate. This endeavor integrates advanced robotics with voice recognition technology to revolutionize the way surgical tools are managed in the operating room.

The core of this report is centered on the design and implementation of a robotic system that responds to voice commands to deliver surgical tools. This innovation is critical in enhancing surgical efficiency, reducing human error, and maintaining sterility in the operating room. The project encompasses the development of a robotic arm capable of precise movements along specific axes and a tool tray system designed for efficient tool handling and delivery.

Throughout the development process, the project faced numerous challenges, particularly in integrating mechanical design, electronic controls, and software development. These challenges were met with innovative solutions, rigorous testing, and continuous refinement, culminating in the creation of a robotic system that stands as a testament to the potential of technology in healthcare.

As a final-year undergraduate, I believe this project represents a significant contribution to the field of surgical robotics. The detailed exploration of the system's design, functionality, and potential impact, as presented in this report, reflects a comprehensive understanding of the complexities involved in such an innovative undertaking. I invite readers to delve into this report, confident that it will offer valuable insights into the integration of robotics in medical applications and inspire further exploration in this dynamic field.

Summary

In this project, a voice-activated robotic system was developed to enhance the efficiency and accuracy of surgical tool delivery in operating rooms. The primary goal was to create a system that could respond to voice commands from surgeons and precisely deliver the requested surgical tools, thereby reducing manual handling and potential errors.

The project commenced with the design and development of a robotic arm capable of multi-directional movements and a rotating tool tray system. The robotic arm was engineered to move along specific axes and rotate around the Y-axis, aligning itself with the selected surgical tools. The tool tray, designed as a rotating carousel, was equipped with tool holders for organized and accessible placement of surgical instruments.

A critical component of the system was the integration of a voice recognition module, developed using Python and implemented on a laptop. This module was designed to accurately process verbal commands and communicate with the Arduino microcontroller to initiate the appropriate movements of the robotic arm and tool tray.

To ensure the system's accuracy and reliability, extensive testing and calibration were conducted. The robotic system's performance was evaluated in simulated surgical environments, assessing its functionality, responsiveness, and impact on surgical procedures.

The project's focus was to demonstrate the feasibility and benefits of integrating advanced robotic and voice recognition technologies into surgical environments. It aimed to alleviate the workload on surgical staff, enhance patient safety by maintaining sterility, and streamline the surgical process.

A significant aspect of the project was its educational value, providing insights into the application of robotics and automation in healthcare. The project lays the groundwork for future enhancements, such as incorporating more advanced AI algorithms and expanding the range of tools and functionalities.

Acknowledgment

I wish to extend my heartfelt thanks to several key individuals and organizations whose significant contributions were pivotal in the fruition of this research project.

Foremost, my profound appreciation is directed towards Dr. Indrani Kularatna. Her steadfast mentorship, profound knowledge, and constant encouragement have been fundamental throughout the various phases of this research. Her valuable critiques and insightful suggestions have greatly shaped and enhanced the quality of this work.

I am also immensely grateful to my colleagues for their spirit of cooperation and engaging discussions. Their varied viewpoints and readiness to delve into deep conversations have substantially enriched this research's scope and depth.

My acknowledgment extends to the University of Peradeniya for its supportive academic atmosphere, the provision of comprehensive library resources, and the availability of necessary experimental facilities. The university's support has been a cornerstone in the successful execution of this project.

A special note of gratitude goes to my family and friends for their steadfast support and motivation. Their patience, understanding, and encouragement have been the backbone that supported me throughout the demanding phases of this research.

I also express my gratitude to the technical staff for their expertise and invaluable assistance. Their readiness to impart knowledge and address technical issues was crucial in the practical application of the methodologies in this research.

The collaboration and backing of these remarkable individuals and institutions have been indispensable in bringing this project to completion. I am deeply thankful to each one for being an essential part of this endeavor.

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Abbreviations

OR	Operating Room
NEMA	National Electrical Manufacturers Association
HIPAA	Health Insurance Portability and Accountability Act
RGB	Red Green Blue
PWM	Pulse with Modulation

1. Introduction

In recent decades, significant advancements have been made in global health, leading to substantial improvements in medical practices and patient outcomes. With approximately 313 million surgeries performed annually worldwide, the scope and complexity of surgical procedures have evolved dramatically. However, this increase in surgical interventions has not been without challenges. Recent studies indicate a concerning 7% to 37% probability of patient harm due to healthcare management errors, rather than the disease being treated . These errors range from wrong patient or procedure incidents to issues with anesthesia equipment, the unavailability of necessary instruments, unexpected blood loss, usage of non-sterile materials, and, alarmingly, surgical items like sponges and gauzes inadvertently left inside patients.

The operating room is a dynamic and complex environment, necessitating a highly coordinated team effort to ensure the successful execution of surgical procedures. This team typically comprises a surgeon, assistant surgeon, anesthesiologist, certified registered nurse anesthetist, operating room nurse or circulating nurse, residents or medical students, and a physician assistant. Each member plays a vital role in the surgery, with nurses being particularly crucial. Their responsibilities encompass preparing and sterilizing surgical tools, assisting the surgeon by handing over the necessary tools promptly, and ensuring that all surgical items are accounted for both before and after the procedure to prevent inadvertent retention in surgical wounds.

Despite these protocols, the reality of a high-pressure surgical environment often includes distractions and immense workloads, increasing the risk of errors. The task of passing surgical tools and equipment, primarily the responsibility of nurses, is pivotal. The efficiency and safety of a surgery can be significantly impacted by how seamlessly instruments are handed to the surgeon, in the correct order and at the right time.

In response to these challenges, technological innovations have emerged as potential solutions to enhance efficiency and reduce human error in surgical settings. This report introduces a novel voice-activated robotic system designed to automate the delivery of surgical tools, thereby aiding the surgical team and enhancing the overall safety and effectiveness of surgical procedures. The system aims to alleviate the workload on nurses and reduce the risk of errors associated with manual tool handling, marking a significant step towards integrating advanced technology in the operating room for better patient outcomes and streamlined surgical processes.

2. Aims and Objectives

2.1 Aims

The primary aim of this project is centered on enhancing surgical efficiency. By automating the delivery of surgical tools, we have developed a voice-activated robotic system designed to streamline the operative process. This system aids the surgical team by ensuring the precise and timely provision of necessary instruments to the surgeon, thereby optimizing the flow of surgical procedures.

Another significant aim is to reduce human error, which is particularly prevalent in the manual handling and passing of surgical tools. The automation provided by the robotic system minimizes such risks, contributing to the overall reliability of surgical operations.
In line with alleviating the burden on surgical staff, the project aims to lessen the physical and cognitive load on nurses and operating room personnel. This allows them to allocate more attention to other vital aspects of patient care during surgeries, enhancing the quality and efficiency of the medical care provided.

Patient safety is a paramount concern in any surgical intervention. The project addresses this by ensuring that surgical tools are handled in a sterile and controlled manner by the robotic system, significantly reducing the risk of postoperative complications, such as infections or unintentional retention of surgical items.

Lastly, the project endeavors to integrate advanced technologies into surgical procedures. Through the incorporation of sophisticated robotic mechanics and voice recognition capabilities, we aim to set a new standard for technological innovation within the realm of surgery. This initiative not only showcases the potential of such technologies in improving surgical outcomes but also paves the way for their broader adoption in future medical applications.

2.2 Objectives

The project is focused on several key objectives that drive its development and implementation. The foremost objective is to design and construct a voice-activated robotic arm. This arm is engineered to maneuver along designated axes and execute precise rotations, ensuring alignment with the specific surgical tools required during procedures.

In tandem with the robotic arm, the project aimed to create a specialized tool tray system. This system is characterized by a circular, rotating tray that houses tool holders, all of which are strategically arranged for optimal accessibility by the robotic arm.

A pivotal objective was the integration of a voice recognition system. This advanced system is adept at accurately processing verbal requests for surgical tools made by surgeons, translating these requests into precise commands for the robotic arm.

Ensuring the system's accuracy and reliability was also a critical objective. Through rigorous testing and calibration, the project guarantees the robotic system's precise and dependable delivery of surgical tools, which is crucial during the high-stakes scenarios of surgical operations.

To validate the system's performance, the project involved extensive evaluation within simulated surgical environments. This testing phase was crucial to ascertain the system's functionality, efficiency, and overall impact on surgical procedures, providing valuable insights into its operational effectiveness.

Finally, the project was designed with an eye towards future advancements. Objectives included identifying potential enhancements such as expanding the number of tool holders and refining the system's user interface, thereby improving its usability and functionality. These objectives encapsulate the project's commitment to innovation, ensuring that the robotic system can evolve to meet the growing and changing demands of surgical care.

3. Literature Review

3.1 Operating Room Environment

The operating room (OR) environment is a fundamental and complex aspect of modern healthcare, serving as the epicenter for surgical procedures. ORs are meticulously designed and equipped to cater to a wide spectrum of medical interventions. These environments can be tailored for general medical needs or specialized to handle particular types of surgeries, depending on the healthcare facility's capabilities and patient requirements.

Key to the operation of an OR is its stringent maintenance of sterility and organization. This aspect is critical not only for patient safety but also for the efficiency and effectiveness of surgical procedures. The environment within an OR is controlled and regulated, adhering to strict protocols to prevent infection and ensure optimal conditions for surgery.

The composition of the surgical team in an OR is diverse and includes a surgeon, assistant surgeon, anesthesiologist, certified registered nurse anesthetist, OR nurse or circulating nurse, residents, medical students, and physician assistants. Each team member plays a vital role, with specific tasks and responsibilities that contribute to the overall success of surgical procedures. The synchronization and collaboration of these professionals are essential for patient care and the smooth operation of the OR.

In the midst of this complex environment, scrub nurses emerge as pivotal figures. They are tasked with anticipating the surgeon's needs, ensuring the timely and accurate delivery of surgical tools, and maintaining the count of sponges and instruments. This role is crucial in preventing the inadvertent retention of surgical items, a significant concern in patient safety. Scrub nurses' responsibilities are multifaceted, extending from the preparation and sterilization of tools to critical decision-making and patient monitoring during surgery.

Communication within the OR is a critical factor influencing the efficacy and safety of surgical procedures. Effective communication ensures smooth workflow and coordination among team members. However, studies have highlighted that communication failures are a common issue in the OR, leading to potential risks and errors. These failures are often categorized based on occasion, content, audience, or purpose, affecting various aspects of the surgery, such as equipment usage, procedural updates, and medication management. The impact of these communication errors can be substantial, leading to delays, inefficiencies, increased tension among team members, workarounds, patient inconvenience, resource wastage, and even procedural errors. For example, miscommunication about the availability of specific instruments can disrupt the surgical process significantly, highlighting the need for effective and clear communication protocols.

Addressing these challenges, some healthcare institutions have adopted specialized team training programs focusing on enhancing communication skills, particularly concerning equipment requirements and procedural updates. Such initiatives have shown promising results in minimizing communication errors, thus improving the overall safety and efficiency of the OR.

The OR is also defined by the variety of surgical tools and instruments it houses. These tools, including scalpels, scissors, forceps, retractors, and hemostats, are essential for carrying out surgical tasks ranging from incisions to tissue manipulation and hemostasis. The management and handling of these instruments involve a high degree of coordination, often facilitated through verbal instructions, gestures, and an understanding of spatial dynamics. The interaction between the surgeon and the scrub nurse in this context is a delicate dance of precision and timing, where direct hand contact is typically avoided to maintain sterility.

In conclusion, the operating room environment is a delicate balance of technical precision, effective communication, and coordinated teamwork. The challenges posed by this environment, particularly in terms of communication and instrument management, highlight the potential value of integrating innovative technologies like robotic systems and advanced voice recognition. Such technological interventions could revolutionize the way surgical procedures are conducted, enhancing safety, efficiency, and overall patient outcomes. This evolution underscores the importance of continuous improvement and adaptation in surgical practices, aligning with the ever-advancing landscape of medical technology.

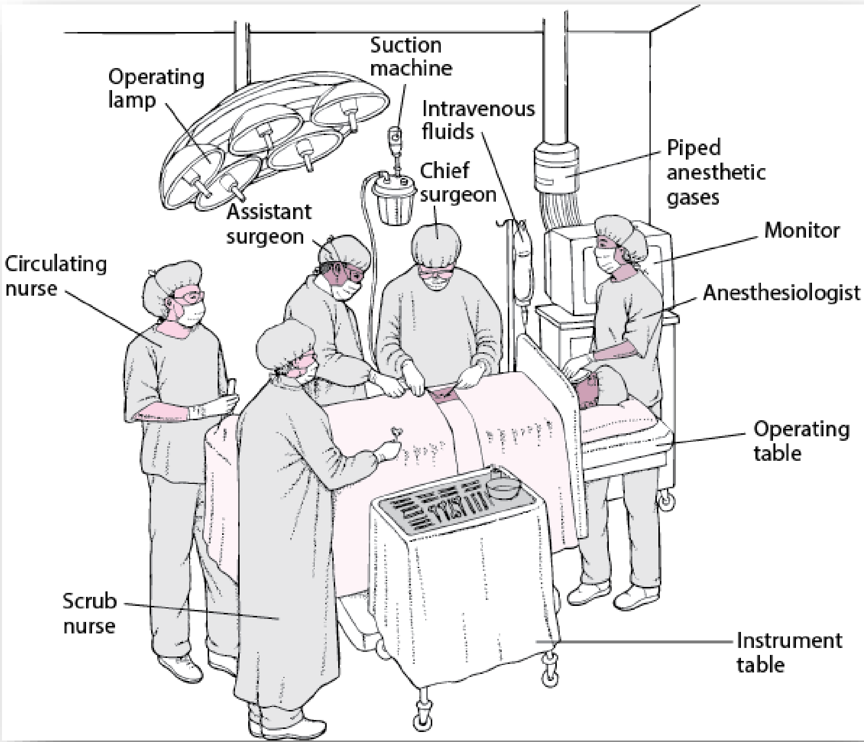

Figure 3.1 - Operating Room

3.2 Voice Recognition Technology

Voice recognition technology, a rapidly evolving field, has transformed numerous industries, including healthcare. This technology involves the identification and understanding of spoken language by a computer, enabling it to respond, transcribe, or take action based on voice commands. Recent advancements have significantly improved its accuracy, speed, and adaptability, making it a promising tool in various applications.

Historically, voice recognition systems struggled with issues like low accuracy and limited vocabulary. However, with the advent of machine learning and artificial intelligence, these systems have become more sophisticated. They now offer improved speech recognition capabilities, even in environments with background noise or among speakers with diverse accents.

In healthcare, particularly in surgical settings, voice recognition technology offers numerous potential benefits. It allows for hands-free operation, which is crucial for maintaining sterility in the operating room. Surgeons can issue commands without the need to physically interact with devices or interfaces, reducing the risk of contamination and improving efficiency.

One of the key areas of application for voice recognition in surgery is in controlling equipment and accessing patient information. Surgeons can use voice commands to adjust surgical tools, view different angles from a surgical camera, or retrieve patient data without breaking focus from the procedure. This level of interaction enhances the surgeon's control over the procedure and reduces reliance on assistance for menial tasks.

Despite its benefits, voice recognition technology in surgical environments faces challenges. The accuracy of voice recognition can be affected by the operating room's acoustics, the presence of background noise, and the use of surgical masks, which can muffle speech. Moreover, the technology must be highly reliable and responsive, as any delay or error in recognizing commands can have critical implications during surgery.

Recent developments in voice recognition technology have focused on machine learning algorithms that can adapt to different voices and accents, learn from corrections, and improve over time. These systems are also being trained to understand context, which is crucial for accurately interpreting commands in the complex environment of an operating room.

Data security and patient privacy are additional concerns with voice recognition technology in healthcare. Ensuring that voice-activated systems are secure and compliant with regulations like the Health Insurance Portability and Accountability Act (HIPAA) is essential to protect sensitive patient information.

In conclusion, voice recognition technology holds significant potential for enhancing surgical procedures by providing a hands-free interface that can improve efficiency and reduce errors. However, its implementation in the operating room must overcome challenges related to accuracy, noise interference, and data security. As the technology continues to advance, it is likely to become an increasingly integral part of modern surgical practices, offering improved outcomes and greater ease of operation for healthcare professionals.

3.3 Main Components of Surgeon Assistance Robot

Surgeon assistance robots, which are becoming increasingly integral to modern surgical procedures, are complex systems composed of various critical components. These components include actuators, sensors, and control systems, each playing a pivotal role in the functionality and efficiency of the robot.

3.3.1 Actuators

Actuators are the "muscles" of robotic systems, responsible for the movement and control of the robotic arm or tool. In surgeon assistance robots, precision, reliability, and controllability are of utmost importance. Stepper motors are commonly employed as actuators due to their precision in control and positioning. They can move to a known position without the need for feedback from sensors, making them ideal for repeatable tasks where precision is crucial, such as in surgical applications.

Stepper motors are typically utilized in conjunction with gear systems to enhance their torque and precision. The gear model, electrical and mechanical stiffness, friction, and resistance are significant considerations in the design of these actuator systems to ensure smooth and accurate motion.

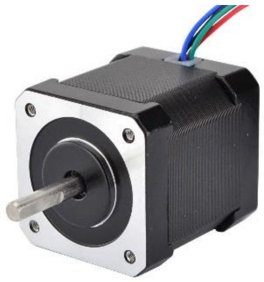

Figure 3.2 - Stepper Motor

3.3.2 Sensors

Sensors serve as the "senses" of robotic systems, providing vital feedback on the robot's environment and its interactions. In surgical robots, sensors must be highly accurate, reliable, and often sterilizable to function in the OR environment. Cameras and robotic skin sensors are two common types of sensors used in these applications.

Vision-based sensors, such as cameras providing RGB (Red, Green, and Blue) and depth information, are crucial for guiding the robot's movements with precision. They help in recognizing the surgical field and tools, assisting in navigation and manipulation tasks. However, challenges with these sensors include their susceptibility to occlusion and the variable lighting conditions of the OR.

Robotic skin sensors, equipped with tactile and visual feedback capabilities, allow the robot to detect and respond to contact with various surfaces and pressures. This feedback is essential for tasks that require a delicate touch, such as manipulating soft tissues or handling surgical instruments.

3.3.3 Control Systems

Control systems are the "brains" of the robot, processing input from various sensors and determining the actions of the actuators. In surgical robots, control systems must be highly sophisticated to enable precise and smooth operation. They use algorithms and models to interpret sensor data and convert it into precise movements. Two primary strategies in control systems are process control and goal selection.

Process control involves direct command of the robot's actuators based on real-time feedback, allowing for fine-tuned movements and adjustments. Goal selection, on the other hand, allows the robot to operate semi-autonomously by recognizing the intent of the user and performing a sequence of actions to achieve a desired outcome.

The integration and synchronization of actuators, sensors, and control systems result in a robotic system capable of assisting or augmenting the surgeon's capabilities. These systems can improve precision, reduce fatigue, and potentially lower the risk of complications.

As these technologies evolve, the implementation of surgeon assistance robots is set to become more widespread, bringing the potential for significant improvements in patient outcomes and surgical practices. Advances in materials science, robotics, and computer technology will continue to push the boundaries of what these robots can do, ensuring their place as a vital component of the surgical team.

3.4 Existing surgery assistant robots

The domain of surgeon assistance robots has experienced significant expansion in recent years, primarily due to the robots' ability to enhance the precision and outcomes of surgical procedures. These robotic systems have been pivotal in advancing minimally invasive surgery, leading to reduced pain, decreased analgesic use, faster recovery, improved cosmetic outcomes, and reduced wound complications.

3.4.1 Da Vinci Surgical Robot

The Da Vinci Surgical Robot stands at the forefront of this technological evolution, offering a teleoperated system that enables surgeons to perform complex surgeries with increased dexterity and precision. The system employs a master-slave configuration that translates the surgeon's hand movements into finer actions by robotic instruments. This high level of control is achieved through immersive 3D visualization, providing the surgeon with a depth of perception that closely mimics natural hand-eye coordination. The system's design also minimizes tremors, allowing for steadier instrument manipulation than traditional methods.

Figure 3.3 - Da Vinci Surgical Robot

3.4.2 CyberKnife

The CyberKnife represents another leap forward, particularly in the field of radiosurgery. This system combines robotics and image guidance to deliver radiotherapy with extreme accuracy. Its ability to target tumors with sub-millimeter precision minimizes damage to surrounding healthy tissues, which is a critical consideration in oncological surgeries.

Figure 3.4 - CyberKnife

3.4.3 Xenex Germ-Zapping Robot

In the sphere of surgical environment sanitation, the Xenex Germ-Zapping Robot leverages ultraviolet light to disinfect ORs, reducing the risk of post-operative infections. This technology illustrates the broader scope of surgical assistance, extending beyond the operating table to encompass the entire surgical environment.

Figure 3.5 - Xenex Germ-Zapping Robot

3.4.4 PARO Therapeutic Robot

The PARO Therapeutic Robot, while not used directly in surgery, demonstrates the expanding role of robots in patient care. As a socially assistive robot, PARO has been shown to improve patient mood and reduce stress levels, which can indirectly support recovery post-surgery.

Figure 3.6 - PARO Therapeutic Robot

3.4.5 Continuum Robot Manipulators

Emerging technologies in robotic surgery include continuum robot manipulators, designed for greater flexibility and reach within the body. These robots mimic the movement of natural structures like tentacles or trunks, allowing surgeons to navigate complex anatomical pathways with ease.

The advancements in surgeon assistance robots have not only improved the technical execution of surgeries but have also revolutionized the patient experience and post-operative care. As these technologies continue to evolve, they promise to further enhance the capabilities of surgeons and improve surgical outcomes. However, the integration of these systems into routine surgical practice requires consideration of cost, training, and the adaptation of current surgical workflows to fully realize their benefits. The future of robotic surgery lies in the development of systems that are not only technically proficient but also accessible and beneficial across all facets of patient care.

Figure 3.7 - Continuum Robot Manipulator

4. Developed Prototype

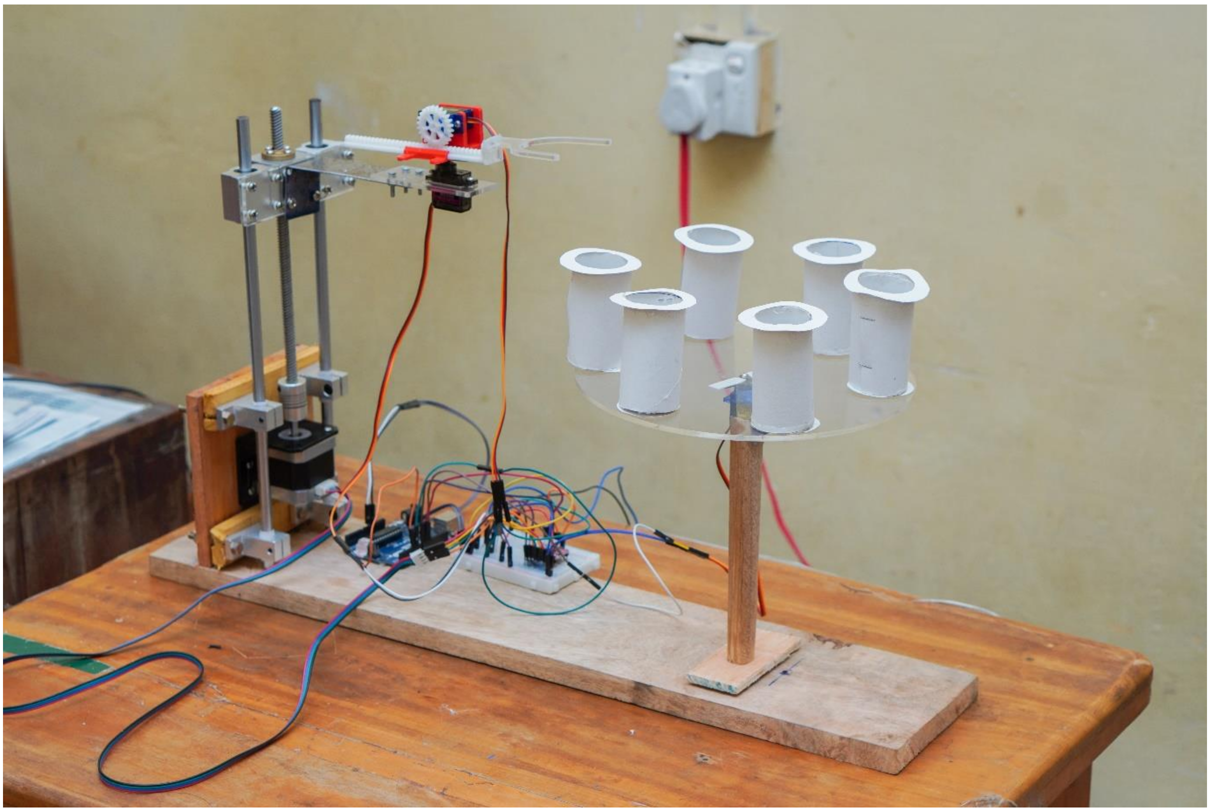

Figure 4.1 - Prototype

5. Components

5.1 Stepper motor

The NEMA 17 stepper motor is a key electronic component in this project. This motor is categorized under the National Electrical Manufacturers Association (NEMA) standard, with "17" referring to its faceplate dimensions of 1.7 inches by 1.7 inches. It is known for its precise control, reliability, and compact size, making it an ideal choice for applications where accuracy and space efficiency are paramount.

The NEMA 17 stepper motor operates by accurately moving in fixed angular increments, known as steps. This characteristic allows for exceptional control over the motor's position, speed, and torque. In our project, the NEMA 17 stepper motor is utilized for the Y-axis movement of the robotic arm. This motor's precision is crucial for the vertical maneuvering of the arm, ensuring that surgical tools can be positioned at specific heights with a high degree of accuracy.

One of the advantages of using a stepper motor, particularly in medical applications like ours, is its ability to hold its position when not moving. This feature is essential for maintaining the stability of the robotic arm during surgery. Moreover, the NEMA 17's relatively simple control mechanism makes it easier to integrate and synchronize with the robotic arm's control system.

Its compact size does not compromise its performance, as the NEMA 17 motor provides sufficient torque to handle the demands of moving and positioning the robotic arm. This balance between size, power, and precision makes the NEMA 17 stepper motor an indispensable component in our project, contributing significantly to the overall functionality and effectiveness of the robotic surgery assistant.

Figure 5.1 - NEMA 17 Stepper Motor

5.2 A4988 Stepper Motor Driver

The A4988 stepper motor driver plays a pivotal role in our robotic surgery assistant project, acting as a crucial interface between the NEMA 17 stepper motor and the control system. This compact module is highly regarded for its efficiency in driving stepper motors, particularly in precision-demanding applications like robotic surgery assistants.

The A4988 driver allows for the control of both the speed and direction of the stepper motor. It achieves this by converting the digital signals, sent from the microcontroller, into the motor's necessary physical movements. One of the key features of the A4988 is its ability to perform microstepping, a technique that divides each full step of the motor into smaller steps. This function significantly enhances the resolution of the motor's movement, allowing for smoother and more precise control – a critical requirement in surgical settings where exact positioning is essential.

The driver's current-sensing and adjustable current limiting capabilities are also noteworthy. These features prevent the stepper motor from drawing too much current, which could lead to overheating and potential damage. This aspect of the A4988 ensures the longevity and reliability of the motor, particularly important in the high-stakes environment of an operating room.

Additionally, the A4988 is appreciated for its simplicity in terms of connectivity. It requires minimal external components to operate, making it a user-friendly choice for integrating into the robotic system. Its small form factor is also a significant advantage, allowing it to be incorporated into the design without adding considerable bulk or complexity.

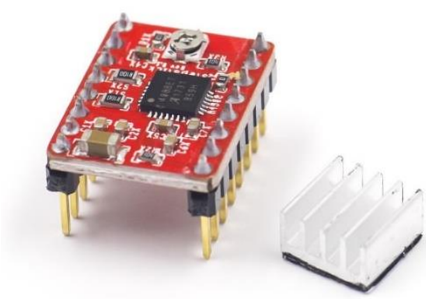

Figure 5.2 - A4988 Stepper Motor Driver

5.3 Servo motor micro SG90 – 360 model

The SG90 servo motor, modified for 360-degree rotation, is an integral component in the development of robotic surgery assistants. This micro servo motor is recognized for its affordability and effectiveness in various technical projects, and its adaptation for full rotational movement is essential for tasks requiring a comprehensive range of motion.

In contrast to the standard SG90 servo, which is typically limited to around 180 degrees of motion, this modified version allows for continuous rotation. This feature is vital for applications such as aligning a robotic arm or tool tray, where complete circular movement is necessary.

The precision control of the SG90 servo motor is a standout feature. Servo motors are designed to move to and maintain a specific position with high accuracy, a function critical in surgical environments where precise positioning and stability are mandatory. The ability of the SG90 to respond accurately to control signals ensures meticulous orientation of surgical tools, aligning with the exacting demands of surgical procedures.

Despite its small size, the SG90 delivers sufficient torque for tasks within its operational scope, striking a balance between compactness, power, and control. This makes it particularly suitable for space-constrained applications like medical devices and robotic systems.

The SG90 servo motor is also notable for its ease of interfacing and programming. It operates on standard PWM (Pulse Width Modulation) signals, making it highly compatible with various microcontrollers and simplifying its integration into complex systems.

Figure 5.3 - Servo motor micro SG90 – 360

5.4 Servo motor micro SG90 - 180 model

The Servo SG90 9g 180 Degree is a widely utilized component in precision-focused projects, including robotic applications where controlled and limited-range rotational movement is required. This micro servo is particularly renowned for its lightweight design, affordability, and reliable performance, making it a popular choice in the development of compact yet sophisticated devices.

The SG90 is characterized by its capability to rotate up to 180 degrees, providing a semi-circular range of motion. This range is particularly useful in applications where precise angular positioning is necessary, such as in the controlled movement of a robotic arm or the adjustment of tool orientation in robotic surgical assistants. Its design for a specific range of motion allows for precise control and accuracy, crucial in applications where fine adjustments are paramount.

Despite its small size, typically weighing around 9 grams, the SG90 servo motor delivers adequate torque for its operational range. This makes it an ideal choice for projects that demand a balance between size, power, and precision. Its compactness is a significant advantage in applications with limited space, such as in certain medical devices or miniature robotic systems.

In terms of interfacing, the SG90 is user-friendly and easily programmable. It operates on standard PWM (Pulse Width Modulation) signals, which are commonly used in microcontroller-based projects. This compatibility facilitates its integration into various systems without requiring complex programming or interface modifications.

Figure 5.4 - Servo motor micro SG90 - 180

5.5 Arduino Uno

The Arduino Uno is a fundamental microcontroller board widely used in robotics and electronic projects, including those in the field of robotic surgery assistance. Renowned for its user-friendly interface and open-source platform, the Arduino Uno serves as the heart of many interactive projects, bridging the gap between software and hardware components.

At its core, the Arduino Uno features an ATmega328P microcontroller, providing a robust and versatile framework for programming and executing a wide range of tasks. The board includes a set of digital and analog input/output (I/O) pins, which can be interfaced with various sensors, motors, and other peripheral devices. This flexibility allows the Arduino Uno to control systems like robotic arms or tool trays in surgical robotic assistants.

One of the key attributes of the Arduino Uno is its ease of use, especially for beginners. The Arduino Integrated Development Environment (IDE) enables users to write, test, and upload programs (known as sketches) to the Arduino board using a straightforward programming language based on Wiring and C++. This accessibility is crucial in educational environments and for prototyping, where rapid development and testing are required.

The Arduino Uno also offers a variety of shields - add-on modules that extend its capabilities without the need for complex wiring or advanced electrical knowledge. These shields can provide additional functionalities such as motor control, wireless communication, and power management, making the Arduino Uno a highly adaptable choice for diverse applications.

In the context of robotic surgery assistants, the Arduino Uno's reliable performance, ease of programming, and ability to interface with various components make it an ideal choice for controlling and coordinating the different elements of the system. Its widespread community support and abundance of resources further add to its suitability for such innovative and technical projects.

Figure 5.5 - Arduino Uno

6. Working mechanism

6.1 Y axis motion

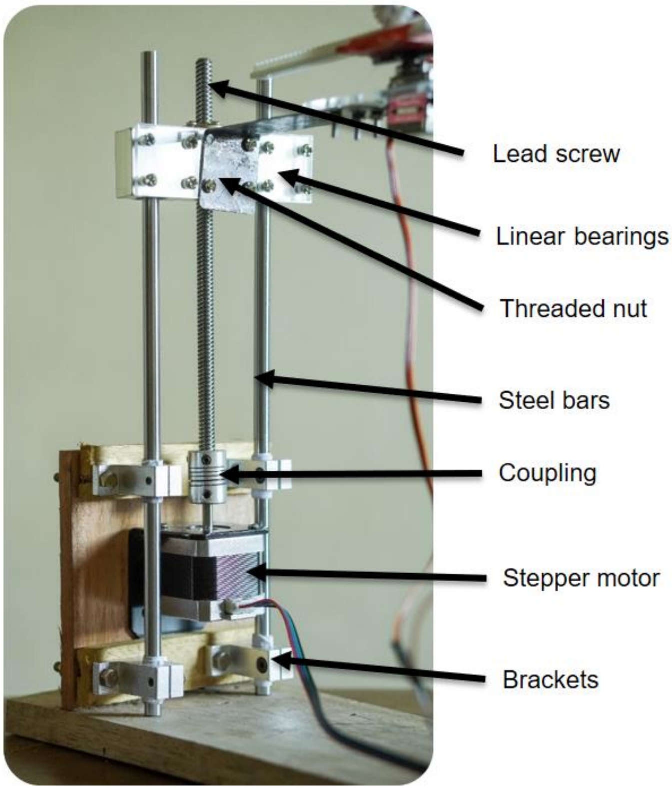

Figure 6.1 - Y axis motion

The Y-axis motion of the robotic system is a critical component enabling vertical maneuverability, which is essential for aligning the robotic gripper with the desired surgical tool. This motion is facilitated through a lead screw mechanism, powered by a stepper motor, which is renowned for its precision and reliability.

The stepper motor serves as the driving force behind the Y-axis movement. It is characterized by its ability to rotate in precise increments, known as steps. This attribute allows for meticulous control over the motor's position, ensuring that the robotic arm can be raised or lowered to exact heights as required during a surgical procedure.

Connected to the stepper motor is the lead screw, a finely threaded rod that converts the rotational movement of the motor into linear motion. As the motor turns, the lead screw rotates, causing the lead screw nut — which is in fixed attachment to the moving platform of the robotic arm — to travel up or down along the screw's threads. This conversion from rotational to linear movement is the cornerstone of the Y-axis motion system.

Stability during this motion is provided by a pair of smooth rods positioned parallel to the lead screw. These rods pass through linear bearings attached to the moving platform, ensuring that the motion is not only vertical but also free from lateral shifts that could affect the system's accuracy.

The entire assembly is supported by a framework that consists of metal brackets and a wooden base. The brackets secure the smooth rods and lead screw in place, forming a rigid structure that resists bending or misalignment under the dynamic forces of motion. The choice of materials and construction reflects a design optimized for stability and performance within the constraints of a prototype development process.

Wiring from the stepper motor connects to a microcontroller, which governs the Y-axis motion. This microcontroller receives input from the voice recognition system, translating spoken commands into electrical signals that precisely control the motor's steps. Consequently, the system allows for the vertical positioning of the robotic arm to be adjusted in response to the surgeon's vocal instructions, ensuring that the appropriate tool can be selected without manual intervention.

The integration of these components into the Y-axis motion mechanism results in a highly responsive and accurate system that enhances the robotic assistant's functionality within the surgical environment.

6.2 X axis motion

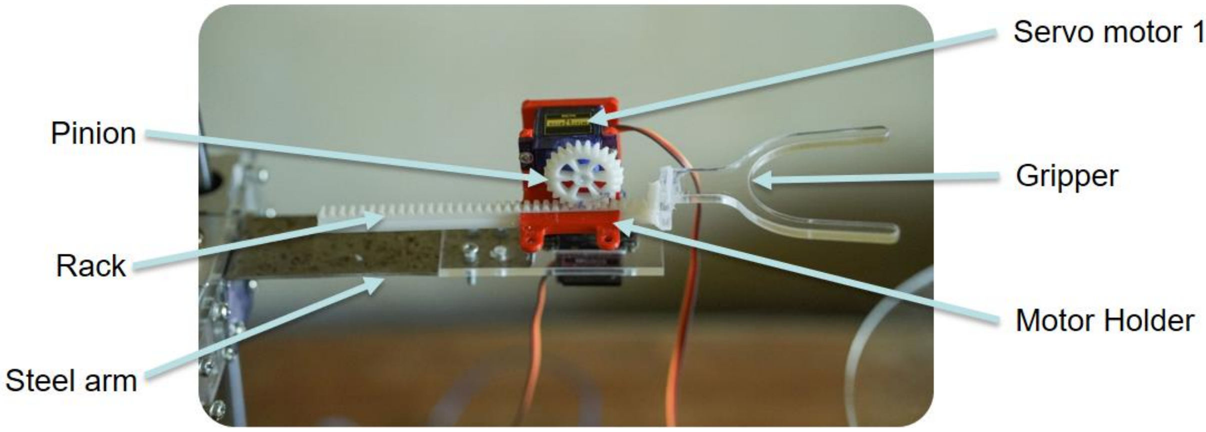

Figure 6.2 - X axis motion

The X-axis motion mechanism of the robotic system is engineered to facilitate the horizontal movement necessary to position the gripper in line with the selected surgical tool. This horizontal traversal is accomplished using a servo motor paired with a rack and pinion setup, providing the required linear motion that is both smooth and precise.

At the heart of the X-axis motion lies the servo motor, a rotary actuator known for its capability to control angular position, velocity, and acceleration with high accuracy. The servo motor is integral to the system as it dictates the movement of the gripper along the X-axis with a definitive control that is essential during intricate surgical procedures.

The pinion, a small gear wheel, is attached to the servo motor's output shaft. This pinion engages with a linear gear bar known as the rack. As the servo motor activates and rotates the pinion, this interaction drives the rack to move horizontally. This rack and pinion mechanism is a classic and efficient method to convert rotary motion into linear motion, which is exemplified in the movement of the gripper across the X-axis.

The gripper, which is fastened to the end of the rack, thus inherits the motion from the rack and pinion dynamics. It is through this mechanism that the gripper travels along the designed path to reach and retrieve the required surgical tools from the tool tray. The entire assembly is supported by a robust framework, which not only secures the components in place but also ensures their coordinated function without any misalignment that could hinder the system's performance.

6.3 Rotation around Y axis

The rotation around the Y-axis is a crucial function of the robotic arm, specifically designed to reorient the gripper for the seamless handover of surgical tools to the surgeon. This rotational capability is critical as it aligns the tools for an ergonomic transfer to the surgeon, thereby aiding in maintaining the flow of the surgical procedure.

The mechanism enabling this pivotal rotation is a servo motor, which is directly mounted onto the gripper assembly itself. The servo is chosen for its precise control and strong positional feedback, which are vital for the exact movements needed in a surgical context. Upon receiving a command, the servo motor activates and imparts rotation directly to the gripper assembly.

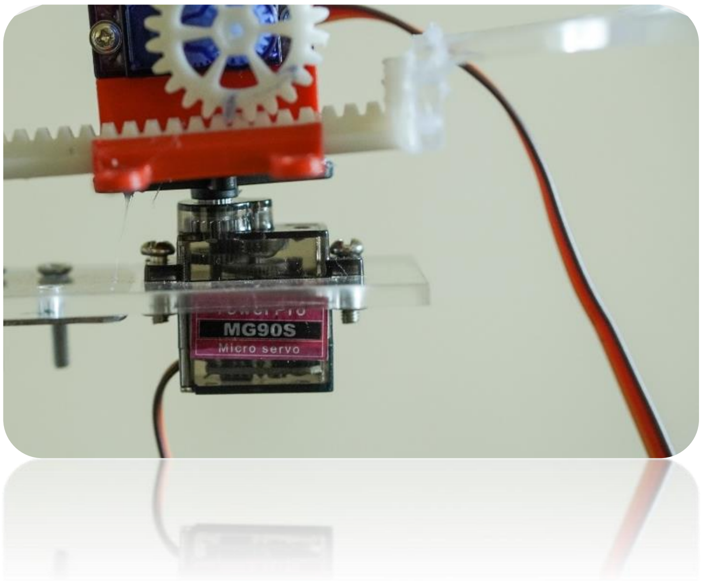

Figure 6.3 - Servo Motor Closer View

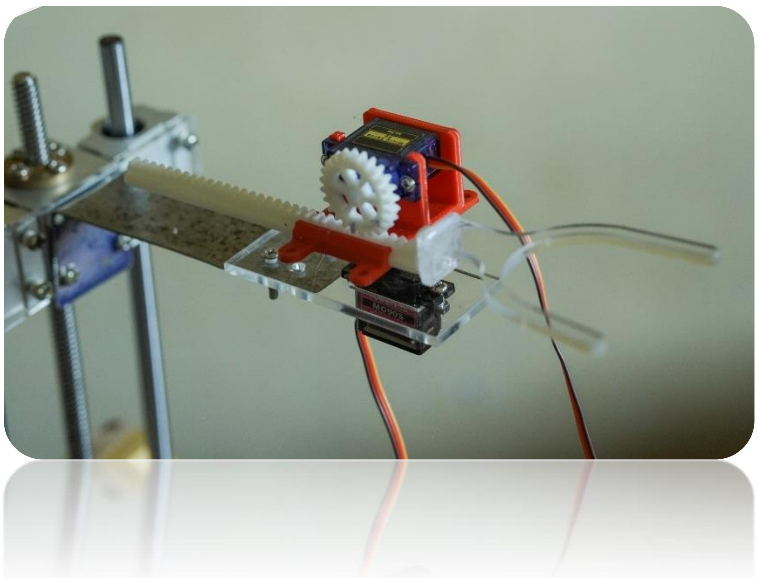

Figure 6.4 - Servo Motor

6.4 Rotational motion of the tool tray

The tool tray in our robotic surgery assistant works like a carousel, turning around to bring the right surgical tool to the robot arm's grabbing part. Here's a simple explanation of how this part works:

The tool tray is set on a base that can spin, and this spinning is controlled by a special motor. This motor turns the tray exactly how much is needed to line up a certain tool with the robot arm's grabbing part.

When a surgeon says out loud what tool they need, the system's voice recognition software hears this and understands which tool is being asked for. After hearing the command, the system figures out how much the tray needs to turn and sends a signal to the motor.

Then, the motor turns the tool tray to the position it calculated, making the tool the surgeon asked for line up with the grabbing part. Once the tool is in the right spot, the robot arm can move side to side and up and down to reach the tool and pick it up with its grabber.

This way of working allows the surgeon to quickly and accurately get surgical tools without having to do it by hand, which saves time in the operation and keeps everything clean and sterile.

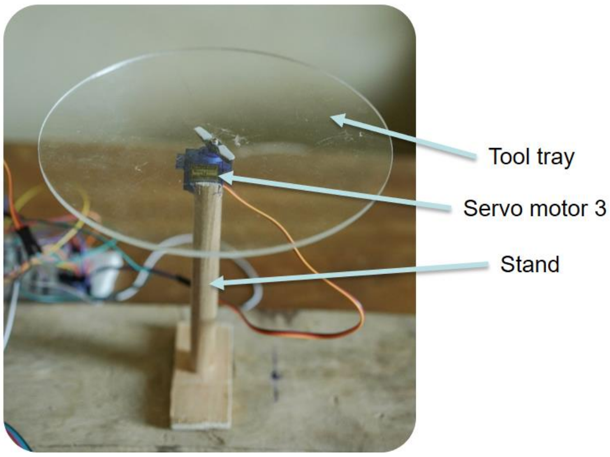

Figure 6.5 - Tool Tray

Figure 6.6 - Tool Tray

6.5 Tools mapping

The tool mapping strategy employed by the robotic system is designed to ensure that each surgical instrument is readily accessible in a predictable and organized manner. Utilizing a circular tool tray with a clearly defined segmentation, the system positions essential surgical tools at fixed locations around the circumference of the tray, each allotted its distinct holder.

The arrangement on the tool tray follows a systematic pattern, with tools placed at equal intervals of 60 degrees. This precise distribution permits the robotic arm to navigate to and from each instrument with accuracy. The layout is as follows:

- Scalpel: Positioned for initial incisions, the scalpel is a fundamental surgical instrument, placed for easy access by the robotic arm.

- Hemostat: Essential for controlling bleeding, the hemostat's placement ensures its prompt availability when required.

- Retractor: Necessary for holding back underlying organs or tissues, the retractor is positioned for quick retrieval.

- Scissor: Used for cutting tissue or sutures, the scissor is strategically located for efficient selection.

- Surgical Stapler: Utilized for closing wounds or connecting tissues, the stapler's location is marked for when suturing is necessary.

- Needle Holder: Critical for suturing during procedures, the needle holder's designated spot allows for its swift engagement by the robotic arm.

This tools mapping technique not only streamlines the process of tool selection and retrieval but also minimizes the time taken to identify and deliver the correct instrument during surgery. By integrating voice recognition technology, the surgeon can request an instrument verbally, and the robotic system responds by rotating the tool tray to align the specified tool with the robotic arm's gripper. Once aligned, the robotic arm extends to grasp the tool holder and retracts to present it to the surgeon or surgical assistant.

This systematic mapping, combined with the precision mechanics of the robotic system, enhances the efficiency of the surgical process, reduces the cognitive load on the surgical staff, and potentially decreases the duration of surgeries by minimizing delays in instrument handover.

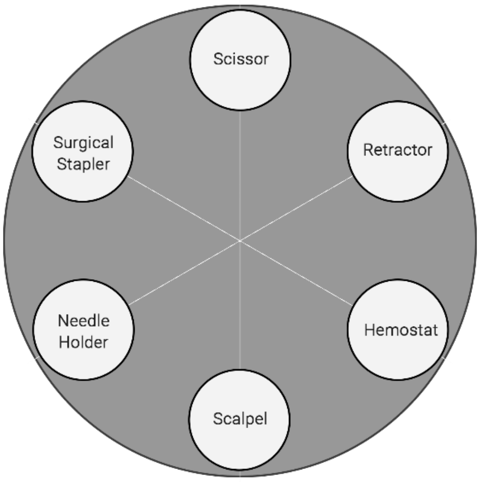

Figure 6.7 - Tool Map

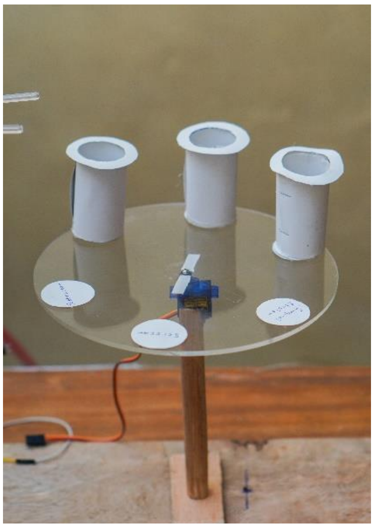

Figure 6.8 - Tool Tray

Figure 6.9 - Tool Holder

7. Circuit Diagram

Displayed is the circuit diagram that constitutes the electronic backbone of the robotic system. It incorporates three servo motors for precise rotational control and a Nema 17 stepper motor for linear movement, all managed by an Arduino Uno board.

The A4988 stepper motor driver module is a critical component, tasked with driving the stepper motor. This module ensures the accuracy and precision of the motor's steps, which is vital for the delicate operation of selecting surgical tools.

The servo motors are wired to receive signals from the Arduino, which directs their movement according to the programmed instructions. The Arduino Uno, functioning as the central controller, processes input commands and orchestrates the movements of each motor.

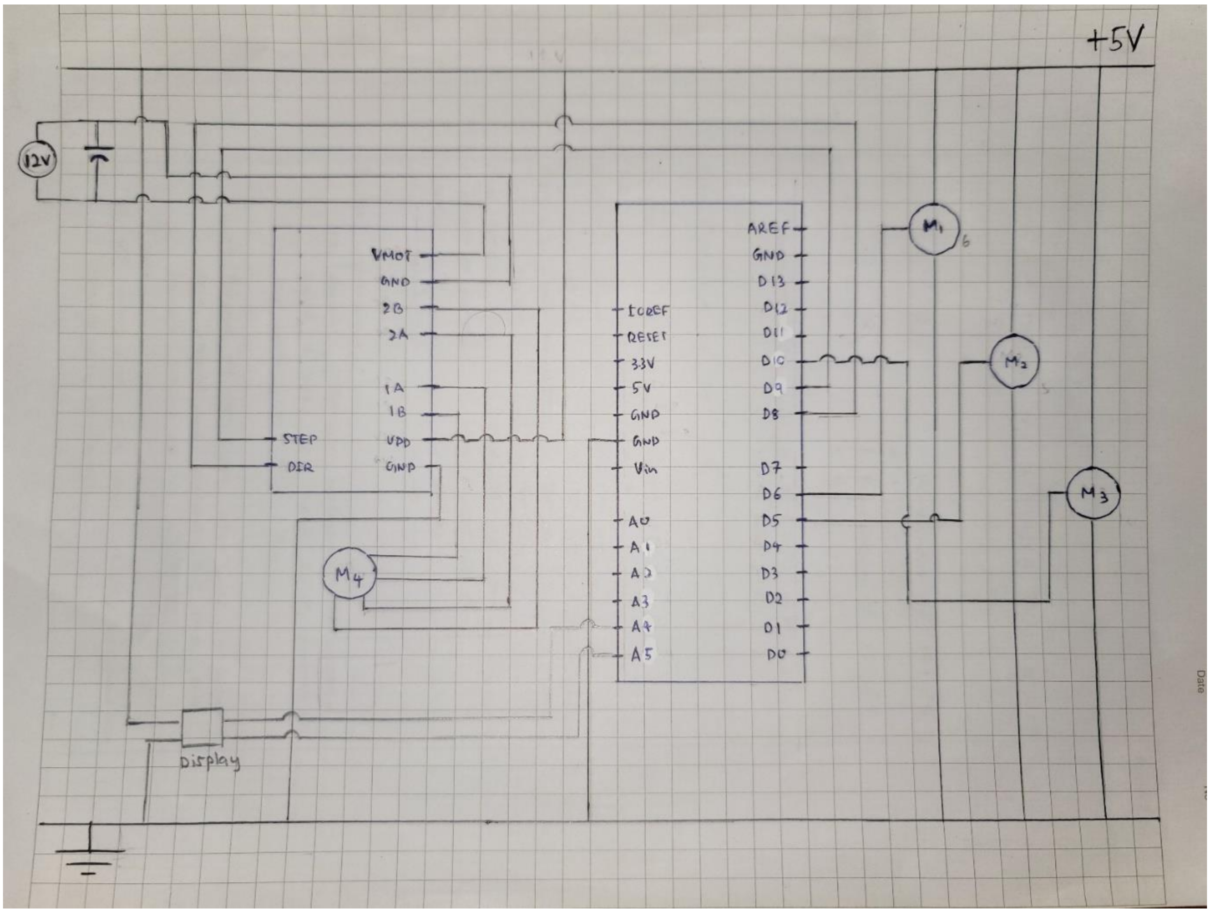

Figure 7.1 - Circuit Diagram

8. Algorithm

The primary algorithm for this mechanism is programmed using Arduino and comprises several distinct segments, each integral to the system's functionality. Below is a description of each segment,

- Setup
- Rotational motion of tool tray
- Y axis motion
- X axis motion
- Rotation around Y axis
- Main operational loop

Below is a description of each segment,

8.1 Setup

In the setup phase of the algorithm, three primary steps are undertaken to initialize the robotic system. First, control pins for the motors are defined and set as outputs. These pins will manage the direction and steps of the Nema 17 stepper motor, as well as signal the servo motors.

Next, the system establishes a home position for each servo. The gripper servo is set to 0 degrees, preparing it to pick up tools. The arm rotation servo is also set to 0 degrees, ensuring it starts from a known position. The tool tray servo is initialized at 90 degrees, ready to rotate to the desired tool location.

Finally, serial communication is established at 9600 bits per second. This allows the system to receive commands and provides a communication channel for operation status.

8.2 Rotational motion of tool tray

This segment of the algorithm governs the rotational motion of the tool tray. The function operateServoDisc is called with a target station number as its parameter. Its role is to rotate the tool tray to align the selected tool with the robotic arm's gripper.

The function calculates the rotation delay, which is the time required for the tool tray to move from its current position to the target position. It does this by determining the shortest path to the target tool station and assigns a delay time based on the number of stations it must pass. This ensures a smooth and timely rotation.

Once the delay time is calculated, the servo moves to an intermediate position and pauses for the computed delay, allowing the tray to rotate. After the pause, it returns to its initial position, completing the rotation cycle.

8.3 Y axis motion

This part of the algorithm addresses the vertical, or Y-axis, motion of the robotic arm. The functions moveUpward and moveDownward are responsible for translating the desired vertical movement into stepper motor steps.

For upward motion, the function moveUpward calculates the number of steps the stepper motor needs to take. It then energizes the motor in the appropriate direction, here assumed to be HIGH for upwards. Each step is carefully timed with microseconds delay to control the speed of the motor, ensuring smooth and precise movement.

Conversely, the moveDownward function operates similarly but in the reverse direction, indicated by setting the direction pin to LOW for downward movement. Again, the delay between steps is finely tuned for speed control.

These two functions are pivotal for the accurate placement and retrieval of surgical tools, providing controlled and precise Y-axis movement.

8.4 X axis motion

The gripper mechanism is controlled by two functions: extendServoGripper and retractServoGripper. These functions manage the opening and closing of the gripper arm.

extendServoGripper incrementally opens the gripper by rotating the servo from 0 to 180 degrees, with each degree movement followed by a short delay for smooth motion. After reaching full extension, the gripper holds position for a second to ensure a secure grip on the tool.

retractServoGripper does the reverse, closing the gripper by moving the servo back to 0 degrees using the same gradual approach. This precise control is crucial for handling surgical tools safely and accurately.

8.5 Rotation around Y axis

The algorithm facilitates rotation around the Y-axis through two functions: turnServo90 and returnServo90. These functions control the arm's rotation to position it for tool interaction.

turnServo90 rotates the arm 90 degrees from its starting position, moving the servo incrementally to ensure precision. The arm holds this position for a second, allowing for any necessary actions at this angle.

After the operation, returnServo90 brings the arm back to its original position, reversing the 90-degree rotation with the same incremental approach for accuracy.

8.6 Main loop

The main operational loop is the central process that governs the robotic system's actions. It begins by listening for new serial input when the system is idle. Upon receiving input, it parses the command to identify the target tool station, accepting values from 1 to 6.

Once a valid input is registered, the system enters a busy state to prevent overlapping commands. It then initiates a sequence of operations: rotating the tool tray for tool alignment, moving the arm upward, extending the gripper to pick the tool, and moving the arm further up to present the tool.

After the task, it reverses the sequence, retracting the gripper and returning the arm to the starting position. The system then sets the busy flag to false, indicating readiness for the next command.

9. Challenges faced and suggested solutions

The development of a surgical tool delivery system via a robotic arm presents numerous challenges that demand innovative solutions to ensure both the system's functionality and its seamless integration into the surgical environment.

Precision and reliability are paramount in surgical settings. To achieve this, the system can be equipped with advanced sensing and feedback mechanisms that continually adjust and calibrate the robotic arm's movements. Utilization of materials resistant to repeated sterilization processes is essential, and a modular design would allow for easy disassembly and reassembly, aiding in maintaining a sterile environment.

Voice recognition accuracy is critical in the noisy backdrop of an operating room. Solutions include integrating advanced noise-cancellation algorithms and diversifying the dataset on which the voice recognition software is trained to encompass a wide range of dialects and speech patterns. This would ensure clear and precise communication between the surgeon and the robotic system.

Ensuring the robotic system aligns with existing surgical protocols is also a challenge. A user-centric design approach, informed by direct input from surgical teams, and comprehensive training programs can help integrate the system into the surgical workflow. To counteract any potential delay in system response, optimizing the software for rapid processing and using high-speed communication protocols is necessary.

Safety is of the utmost concern, particularly in error handling. Implementing redundant safety checks, allowing for manual override, and employing predictive analytics can enhance the system's operational safety. Mechanical failures can be mitigated by using high-quality components and incorporating real-time diagnostics to alert technical staff of any impending issues.

The system must remain operational even during power outages, which calls for a robust uninterruptible power supply (UPS). As for the system's adaptability and scalability, a modular design that allows for easy updates and customization will enable the system to accommodate a wide range of surgical tools and procedures.

User training and acceptance are crucial for the system's adoption. Detailed training sessions, complemented by virtual or augmented reality simulations, can ensure that surgical staff are comfortable and proficient in using the new system. Engaging with regulatory bodies from the early stages and conducting extensive clinical testing will be essential to obtaining approval and ensuring compliance with medical standards.

Finally, a maintenance-friendly design, potentially with smart monitoring capabilities, will facilitate upkeep and prolong the system's lifespan. Offering a comprehensive maintenance schedule and responsive technical support can also minimize downtime and maintain operational readiness.

Addressing these challenges with the described solutions will help to create a surgical tool delivery system that enhances the efficiency and safety of surgical procedures, ultimately improving patient care.

10. Project Outcomes

The Robotic Surgery Assistant project has successfully achieved several key outcomes that mark significant advancements in surgical procedure efficiency and safety. The system has enhanced surgical efficiency by streamlining the selection and delivery of surgical tools. This automation reduces the time surgeons need to access necessary instruments, allowing for smoother and faster procedures.

A notable achievement is the substantial reduction in human error. The automation of tool delivery minimizes risks such as incorrect tool selection or the inadvertent retention of surgical items, which are prevalent in manual processes. This not only improves the accuracy of surgeries but also enhances patient outcomes.

Sterility in the operating room (OR) has seen improvement due to the robotic arm's design, which limits the number of human-tool interactions. This feature is instrumental in maintaining sterility and reducing the risks of contamination, a critical aspect of successful surgical procedures.

Safety and reliability have been central to the design and implementation of the robotic system. Adherence to medical standards and extensive testing ensures the system operates safely and dependably. The user-friendly voice command interface simplifies interaction with the robotic system, facilitating ease of adoption and integration into established surgical workflows.

This project serves as a testament to innovative engineering applications in healthcare. It combines mechanical design, electronic controls, and software development to address real-world challenges. The development process has been immensely educational, providing hands-on experience in robotics and automation while addressing the nuanced demands of surgical environments.

Looking to the future, the project establishes a foundation for subsequent advancements. There is vast potential for incorporating more sophisticated AI algorithms, enhancing the system's responsiveness, and expanding the scope to include a broader range of tools and functionalities. The Robotic Surgery Assistant project not only delivers immediate benefits to the surgical domain but also opens avenues for ongoing innovation and improvement.

11. Conclusion

In conclusion, the development of the Robotic Surgery Assistant represents a significant leap forward in the realm of surgical technology. This project has successfully demonstrated that through the integration of mechanical engineering, electronic systems, and software development, it is possible to enhance surgical efficiency, reduce human error, and maintain a higher level of sterility within the operating room.

The implementation of a laptop-based voice recognition system serves as a testament to the project's innovative approach to cost-effectiveness and resourcefulness. By leveraging existing technology in novel ways, we have established a model that could be replicated in other medical facilities seeking to adopt similar advancements.

The improved coordination among the surgical team, facilitated by the direct voice-command system, has underscored the importance of clear communication during procedures. Moreover, the intuitive interface of the system has proved to be user-friendly, ensuring a smooth integration into surgical workflows without a steep learning curve.

The safety and reliability embedded in the design of the Robotic Surgery Assistant set a precedent for future developments in surgical aids. With patient safety as the utmost priority, the project has adhered to stringent medical standards and undergone rigorous testing to ensure reliability in a high-stakes environment.

The educational value derived from this project cannot be overstated. It has provided an invaluable learning experience in the application of robotics and automation within the healthcare industry, highlighting the potential for further innovation in this field.

As we look to the future, this project lays the groundwork for continued enhancement and refinement. The potential to incorporate advanced AI, expand the range of tools, and further streamline the surgical process, presents an exciting frontier for research and development.

The Robotic Surgery Assistant stands as a prime example of the synergy between technology and healthcare, with the promise of contributing to the evolution of surgical practices and ultimately enhancing patient care.

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13. Appendix

13.1 Arduino Code

```
#include <Servo.h>

#define stepPin 8
#define dirPin 9
#define discStepPin1 10
#define discDirPin2 11

const int stepsPerRotation = 200;  // Number of steps for one rotation
const float leadOfScrew = 8.0;  // Distance the nut moves for one rotation in mm
bool moved = false;  // Flag to ensure the motor moves only once
bool busy = false;  // Flag to indicate if the system is busy

const int totalWorkstations = 5;
const int anglePerWorkstation = 72;  // 360 degrees / 6 workstations
int currentWorkstation = 1;  // Start at workstation 1

Servo servoGripper;
Servo servo90;
Servo servoDisc;
int currentStation = 1;  // Variable to keep track of the current station

void setup() {
  pinMode(stepPin, OUTPUT);
  pinMode(dirPin, OUTPUT);
  pinMode(discStepPin1, OUTPUT);
  pinMode(discDirPin2, OUTPUT);
  Serial.begin(9600);  // Initialize serial communication at 9600 baud rate
  Serial.println("Send a number (1-6) to rotate to the corresponding workstation.");
  servoGripper.attach(6); // Attach the servoGripper on digital pin 6
  servo90.attach(5);      // Attach the servo90 on digital pin 5

  // Home the servos by setting them to 0 degrees
  servoGripper.write(0);
  servo90.write(0);
  servoDisc.write(90);    // Initial position for servoDisc
  delay(10000); // Wait a bit to ensure servos have reached the home position
  Serial.println("Ready");
}
```

```
void operateServoDisc(int targetStation) {
  int delayTime = 0;

  if (targetStation == currentStation) {
    delayTime = 0;
  } else {
    int distance = targetStation - currentStation;
    if (distance < 0) {
      distance += 3; // Wrap around for negative distances
    }

    switch(distance) {
      case 1:
        delayTime = 350;
        break;
      case 2:
        delayTime = 700;
        break;
      case 0:
        delayTime = 1050;
        break;
    }
  }

  servoDisc.write(80);
  delay(delayTime);
  servoDisc.write(90); // Return to initial position after delay

  currentStation = targetStation;
}
```

```
int calculateAngle(int targetWorkstation) {
  int angleDifference = (targetWorkstation - currentWorkstation) * anglePerWorkstation;
  if (angleDifference > 180) {
    angleDifference -= 360; // Move in the opposite direction for a shorter path
  } else if (angleDifference < -180) {
    angleDifference += 360; // Move in the opposite direction for a shorter path
  }
  return angleDifference;
}

void rotateStepper(int stepPinNumber, int dirPinNumber, int angle, int stepDelay) {
  int steps = (int)(stepsPerRotation * abs(angle) / 360.0);
  digitalWrite(dirPinNumber, angle >= 0 ? HIGH : LOW);  // Set rotation direction

  for (int i = 0; i < steps; i++) {
    digitalWrite(stepPinNumber, HIGH);
    delayMicroseconds(stepDelay);
    digitalWrite(stepPinNumber, LOW);
    delayMicroseconds(stepDelay);
  }
}
```

```
void moveUpward(float distance_mm) {
  int steps = (int)((distance_mm / leadOfScrew) * stepsPerRotation);
  digitalWrite(dirPin, HIGH); // Assuming HIGH direction is upwards, change if necessary

  for(int i = 0; i < steps; i++) {
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(500); // Adjust delay for speed control
    digitalWrite(stepPin, LOW);
    delayMicroseconds(500); // Adjust delay for speed control
  }
}

void moveDownward(float distance_mm) {
  int steps = (int)((distance_mm / leadOfScrew) * stepsPerRotation);
  digitalWrite(dirPin, LOW); // Assuming LOW direction is downwards, change if necessary

  for(int i = 0; i < steps; i++) {
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(500); // Adjust delay for speed control
    digitalWrite(stepPin, LOW);
    delayMicroseconds(500); // Adjust delay for speed control
  }
}
void extendServoGripper() {
  for(int pos = 0; pos <= 180; pos++) {
    servoGripper.write(pos);
    delay(15);
  }

  delay(1000);
}

void retractServoGripper() {
  for(int pos = 180; pos >= 0; pos--) {
    servoGripper.write(pos);
    delay(15);
  }

  delay(1000);
}

void turnServo90() {
  for(int pos = 0; pos <= 90; pos++) {
    servo90.write(pos);
    delay(15);
  }

  delay(1000);  // Wait for 1 second at 90 degrees
}

void returnServo90() {
  for(int pos = 90; pos >= 0; pos--) {
    servo90.write(pos);
    delay(15);
  }
```

```
  delay(1000);  // Wait for 1 second at 90 degrees
}

void loop() {
  if (Serial.available() > 0) {
    int targetWorkstation = Serial.parseInt();
    clearSerialBuffer();

    if (targetWorkstation >= 1 && targetWorkstation <= totalWorkstations) {
      moveToWorkstation(targetWorkstation);

      // Execute the following sequence for any valid station
      delay(1000);
      //moveUpward(30.0);  // Move stepper motor 30 mm
      extendServoGripper();
      delay(500);
      moveUpward(90.0);
      delay(1000);
      turnServo90();     // Turn servo90 after servoGripper has retracted
      delay(1000);
      returnServo90();
      moveDownward(90.0);
      retractServoGripper();
      //moveDownward(30.0);

      busy = false;  // Operation complete, system is not busy anymore

      // Clear the Serial buffer to discard any input received during the operation
      while (Serial.available() > 0) {
        Serial.read();
      }

      Serial.println("Operation complete. Enter next position (1 - 6):");
    }
  }
}
```

13.2 Voice Recognition Code

```
main.py ×
D: > Project > Code > Full coe > main.py > ...
import speech_recognition as sr
from fuzzywuzzy import process
# import serial
import time
import serial

# Initialize the recognizer
reco
      (function) def identify_surgical_tool(command: Any) -> None
      Identifies if the spoken command matches any of the surgical tools.

def identify_surgical_tool(command):
    """
    Identifies if the spoken command matches any of the surgical tools.
    """
    tools = ["scalpel", "haemostat", "scissors", "retractor", "forceps",
             "needle holder", "surgical drapes", "suction devices",
             "curette", "trocar"]
```

```python
    best_match, score = process.extractOne(command, tools)
    if score > 50:  # Confidence threshold
        print(f"You might have mentioned the surgical tool: {best_match} (Confidence: {score}%)")
        if(best_match=="surgical drapes"):
            ser = serial.Serial('COM4', 9600)
            time.sleep(2)
            data_to_send = '1'
            ser.write(data_to_send.encode())
            ser.close()
            print("1 Done")
        elif(best_match=="haemostat"):
            ser = serial.Serial('COM4', 9600)
            time.sleep(2)
            data_to_send = '2'
            ser.write(data_to_send.encode())
            ser.close()
            print("2 Done")
        elif(best_match=="scissors"):
            ser = serial.Serial('COM4', 9600)
            time.sleep(2)
            data_to_send = '3'
            ser.write(data_to_send.encode())
            ser.close()
            print("3 Done")
        elif(best_match=="retractor"):
            ser = serial.Serial('COM4', 9600)
            time.sleep(2)
            data_to_send = '4'
            ser.write(data_to_send.encode())
            ser.close()
            print("4 Done")
        elif(best_match=="needle holder"):
            ser = serial.Serial('COM4', 9600)
            time.sleep(2)
            data_to_send = '5'
            ser.write(data_to_send.encode())
            ser.close()
            print("5 Done")
        elif(best_match=="forceps"):
            ser = serial.Serial('COM4', 9600)
            time.sleep(2)
            data_to_send = '6'
            ser.write(data_to_send.encode())
            ser.close()
            print("6 Done")

    else:
        print("Tool not recognized.")
```

```python
def main():
    """
    Main loop to listen for voice commands and identify surgical tools.
    """
    while True:
        print("Say the name of a surgical tool.")
        with sr.Microphone() as source:
            # Adjust for ambient noise for better voice recognition accuracy
            recognizer.adjust_for_ambient_noise(source, duration=2)
            audio = recognizer.listen(source)

            try:
                command = recognizer.recognize_google(audio)
                # Directly identify if the spoken command is a surgical tool
                identify_surgical_tool(command)
            except:
                pass


if __name__ == '__main__':
    main()
```