GrippyBot

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BONAFIDE CERTIFICATE

Certified that this project report entitled "**GrippyBot**" is a Bonafide work of Devika Rajasekar (20BRS1214), Ramya T (20BRS1109), Swaathy K (20BRS1083) who carried out the Project work under my supervision and guidance for **CSE1022 – Foundations of Robotics: Kinematics, Dynamics and motion control.**

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TABLE OF CONTENTS

ABSTRACT

A robot is an intelligent embedded machine that is capable of performing tasks that are monotonous or beyond the capability of us human beings. Robots are perfect for doing work that human beings either cannot or will not do, such as working in a harmful or aggressive environment. The grippy bot, which stands for grip and copy, is basically a robotic arm that is controlled by another arm by mimicking its motions. It can also record these actions and repeat them as long as we want it to. Introducing human interaction with the robotic arm in the real-time scenario creates new opportunities for innovations and applications. In places or situations related to nuclear operations, rescue operations, hazardous environments etc, the movement of humans are completely restricted. In such cases, a manually controlled miniature arm which in turn gives instructions to the robotic arm remotely will be extremely useful. This setup also needs very few components for its implementation. This technology can also be used in place of a typical pick and place mechanism. For instance, when the pick and place robots need to handle some hazardous substances and cannot be left without human supervision. Another example is where the miniature arm can act as a wearable one that can be worn by a therapist and the main arm can be an exoskeleton robotic arm that can be worn by a patient.

***Keywords*:** Robotic arm, master-slave, Arduino, servo motor, potentiometer

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1 Introduction

Robotic arms in general are very versatile and are involved in many operations in various fields like medical, disaster management, industrial applications, etc. Usually, a robotic arm is controlled using a terminal in the computer wherein the exact coordinates need to be mentioned to make the robotic arms move, which would be a herculean task for the user. On the other hand, controlling the robotic arm using switches and joysticks is a tough task and it needs good experience for the individual operating the mechanism. In most factories the bots are pre-programmed to do the tasks, there's a line of code for every movement done. But in cases where the task is unpredictable and keeps changing it becomes tedious to re-program the movements as required by the tasks. To tackle this, we plan to make and test an actual robotic arm that can be controlled by a miniature prototype controller arm using Arduino technology. The bot follows a master-slave methodology where the main robotic arm acts as a slave and the miniature arm acts as the master.

2 Literature Review

According to Latombe (1991), "The creation of autonomous robots is one of robotics' ultimate ambitions. These robots will accept high-level task descriptions and carry them out without the need for further human participation. Instead of describing how to do something, the input descriptions will describe what the users desire. The robots will be any type of adaptable mechanical device with actuators and sensors that is controlled by a computer." [1]
Over the last two decades, a significant portion of robotics and automation research has been devoted to the development of such autonomous systems.

Humans have always used robots as a means to overcome their limitations or do tasks with ease. Robotic arms are widely used in industries, medical fields, nuclear operations, manufacturing factories etc and are rapidly growing in importance.
Plenty of advancements in robotics technology has led to the development of various robotic arm mechanisms. One of these many mechanisms is the master slave methodology which sees its implementation in numerous applications. For instance, underwater exploration with remotely operated vehicles are mounted with robotic arms that are controlled by the master slave methodology. Although this reduces the bill of materials it involves a lot of development in software technology. [2]

Another instance for the collaboration of robotic arms and master slave methodology is their application in medical surgeries. Robotic manipulators consisting of positioning arm, forceps manipulator and bending forceps are being programmed with high preciseness which acts as a compact slave in the master slave system. [3]

The use of master slave methodology in the medical industries carries along with it various hazards which might lead to fatal mistakes. Torabi, Khadem, Zareinia, Sutherland, & Tavakoli, in their research paper, state “The performance of a master-slave robotic system depends significantly on the capability of its master device to appropriately interface the user with the slave robot. However, master robots currently used in the clinic present several drawbacks such as the mismatch between the slave and master workspaces and the inability to intuitively transfer the slave robot's dexterity and joint limits to the user.” They also introduce a new measure called teleoperation manipulability index (TMI) which can be used to measure the manipulability in a master slave methodology.[4]

The master slave methodology need not always involve another robotic arm or just programs and codes. With the advancements in technology, the slave arm can also be controlled by a mechanism which acts as an exoskeleton to the human hand. The slave arm is able to mimic the motions made by a human hand with high accuracy and preciseness which is achieved wirelessly with the help of image processing and MATLAB codes.[5]

3 Proposed Work

We plan to make and test an actual robotic arm that can be controlled by a miniature prototype controller arm using Arduino technology. The bot follows a master-slave methodology where the main robotic arm acts as a slave and the potentiometers act as the master.

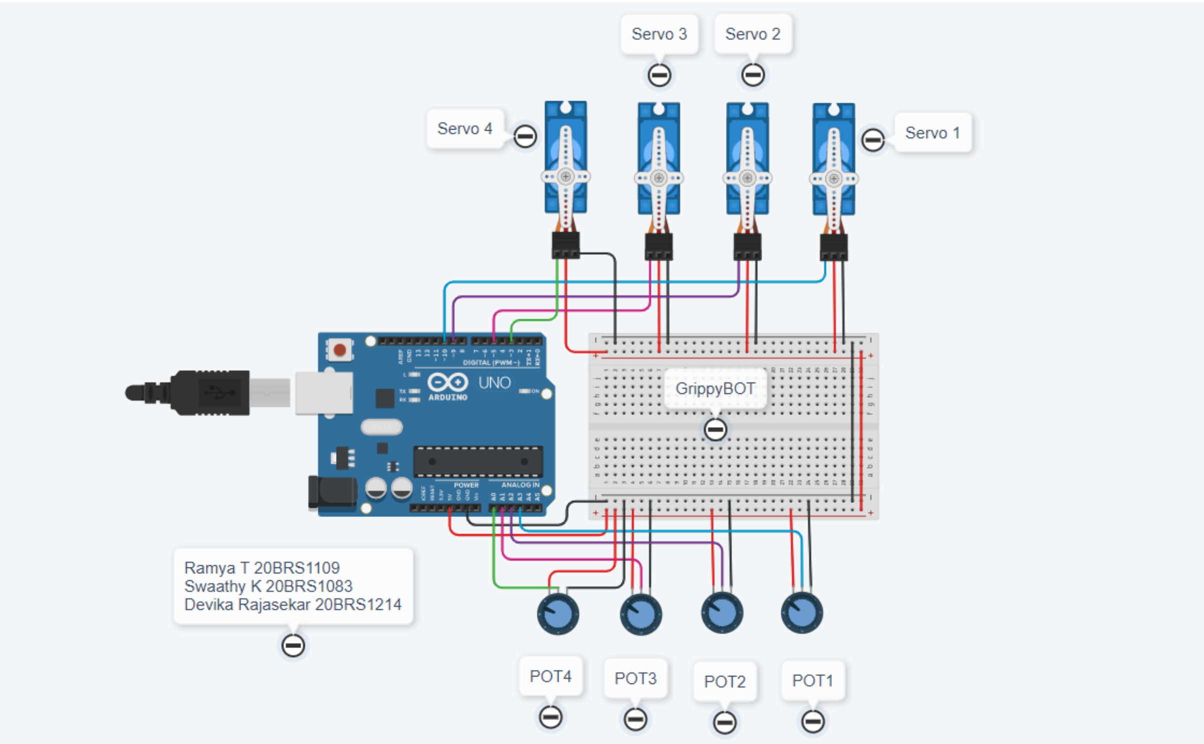
The grippy bot’s main functionality would be to pick and place. It can use its gripper powered by a servo motor to pick and place objects from one place to another. It can mimic the master arm and repeat its actions until it is reprogrammed. Reprogramming the bot could be done with just a simple push of a button, making it user-friendly for those who have little to no coding knowledge.

After upscaling the bot, it can be used in different industries and for a wide variety of tasks. For example, in manufacturing industries, for rescue operations, for performing medical surgeries, doing tasks in hazardous environment etc.

4 Results

4.1. Circuit Setup

Circuit Diagram:



Components used:

In our circuit, the main components that are used are:

- An Arduino Uno board
- 4 10k ohm rotary Potentiometers
- 4 SG90 Micro-servo motors
- Lego Mindstorms NXT kit.
- LINECRAFT DESIGNS Robotic Arm With Gripper(plastic parts only) with All Nuts & Bolts Included, Servos and controller Not Included.

TINKER CAD LINK: Mimic Robot

(Kindly mail us at swaathy.k2020@vitstudent.ac.in if the Tinker cad link expires)

4.2. Working

We have implemented the circuit for the slave arm which can be controlled by a master controller using the potentiometers. We also worked on the formation of the slave arm and experimented with various structures and materials such as the Lego Mindstorms NXT which is a programmable robotics kit, wooden sticks etc. Finally, we bought a premade robotic arm structure with a gripper for the slave arm and attached the servo motors to it.

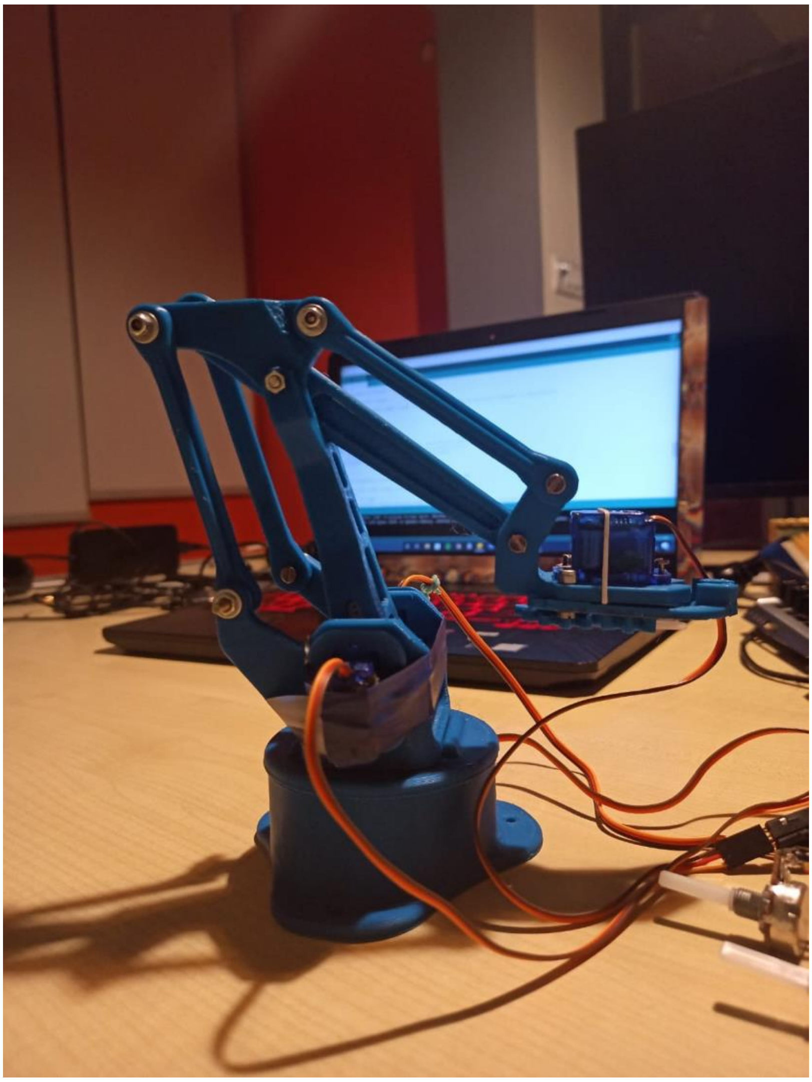
The data is exchanged between the master and the slave robotic arm with the help of Arduino interfacing. While using the master robotic mechanism, the only crucial parameter that has to be read is the angle made by the joints. This can be achieved with the help of simple potentiometers at the joints of the master arm. The slave robotic arm consists of servo motors which enables the links to move.

The code is written in such a way that the actions of the arm will be *recorded* and stored in an array, once we press the button designated to Record attached to the breadboard and interfaced with the Arduino board. The servo motors move with respect to the change in the resistance (angle) measured by their respective potentiometer. This process of saving information is done until a button designated to Play is pressed as input. Once the button is pressed, the *play mode* is enabled and the servo motors move in the recorded sequence. These actions can be modified later by re-running the code and pressing Record and Play buttons. This feature is specifically useful as it does not consume a lot of time and energy that will go into re-programming the tasks of a simple robotic arm i.e., a simple mimic and repeat is enough to reprogram the tasks.

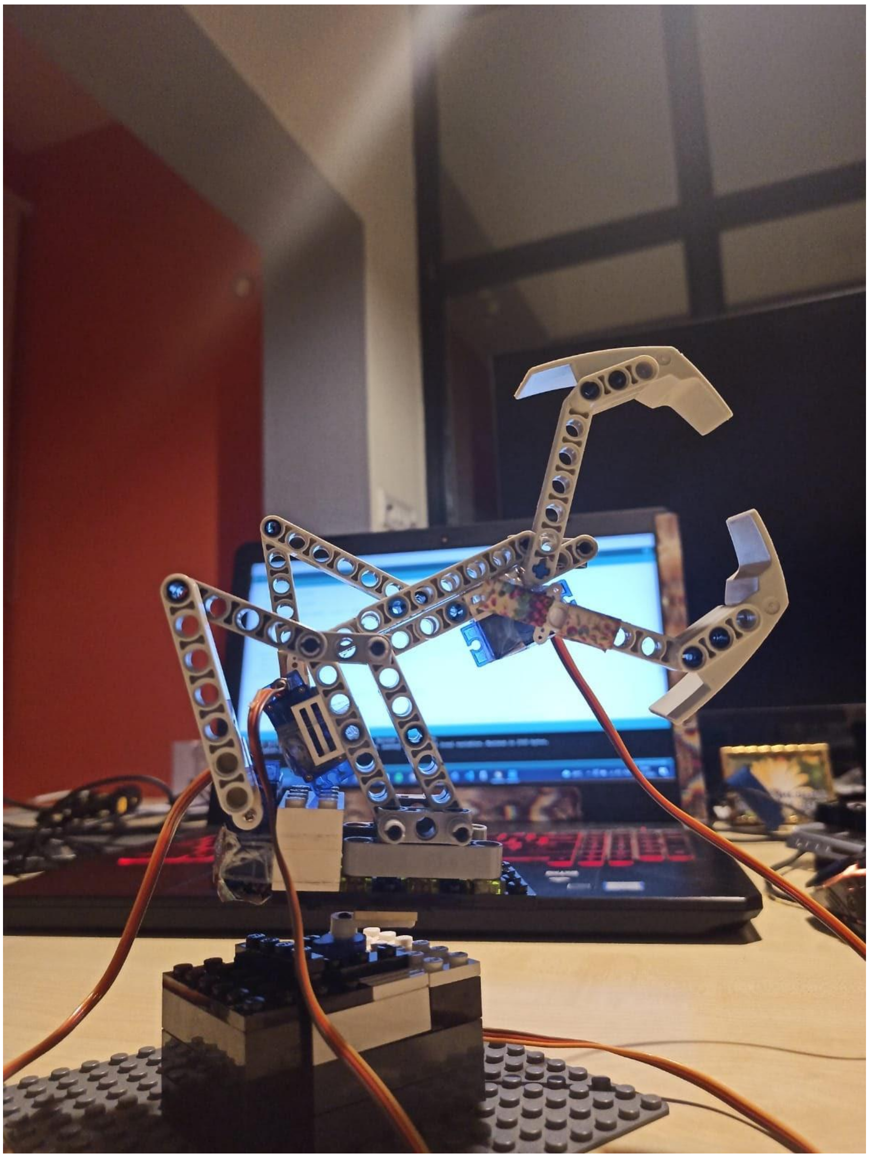
Click to view the video demonstration of the bot constructed with Lego kit and 3D printed structure

5. Discussions

5.1. Output



GrippyBot made with a pre-made Robotic Arm with a Gripper from Linekraft.



GrippyBot made with Lego Mindstorms NXT kit.

5.2. Problems Faced

Creating and implementing a working model definitely involves a lot of trial and error. We faced quite a few challenges when we were executing our circuit. Some of the obstacles that we faced are:

1. *Space Complexity:* Our current code requires a lot of space as we are storing the mapped values in an array during the recording mode. The Arduino IDE displays a warning that the execution might not be smooth as a lot of space has been used up by the code.

2. *Inaccurate readings read by the potentiometer:* Our potentiometers did not have connection wires pre-attached to them. This cost us some time as we took a while to figure out why our servo motors were not moving accurately with respect to the mapping of the potentiometers.
3. *Structural integrity:* We spent a good amount of time trying to build the links of the slave arm using the Lego robotics kit and attached them directly to the servo motor only to realise later that the links are too heavy for the servo motors to move or lift.

5.3. Our Solutions

To tackle our space complexity problem, we optimized our code and utilized the Arduino's built-in EEPROM feature for storing our array values instead of storing it dynamically in the program itself. The Electronically Erasable Programmable Read-Only Memory allows for values to be written and stored for long periods of time while consuming very little power.

In order to overcome the inaccurate potentiometer readings caused by our poor connection of wires to the potentiometers, we decided to solder the wires onto the potentiometer. This resolved the issue and the potentiometers started reading the accurate values.

To solve the structural difficulties, we decided to create a mechanism where the servo motor in the first link does not have to carry the entire weight of the other links and the servomotors. The new mechanism works in such a way that the motor has to handle only one link and a joint which in turn will move the other links. In this way, we reduced the weight imposed on the servo motor which made it impossible to move. But the disadvantage of this new mechanism is that the degrees of freedom of the arm is limited.

Finally, we decided to use a pre-made Robotic Arm with a Gripper, and assembled the final structure according to our methodology. This has 3 degrees of freedom, opposed to our previous system made with Lego Mindstorms kit with limited degrees of freedom.

5.4. Future Enhancements

A good invention is known for its ability to rapidly adapt to the changing times and as such ensuring provisions for the same becomes a matter of utmost importance. In our project, we have made provisions for future enhancements as well, and therefore it proves to be highly accommodative.

Instead of the master-slave mechanism, we could use a mobile app and Bluetooth/Wi-Fi module to control the bot remotely. A 3D model of the arm can be made using MATLAB software and the user can change the values to the joint angle to control the arm. Furthermore, a 3D printed arm or metal robotic arm can help increase the robot's payload.
The project will be highly accommodative of all new technologies, giving greater customization and control options to the user.

Here are some of the features that can be implemented in the future:

1. Establishing a wireless connection between the master and the slave arm with the help of Bluetooth or Wi-Fi module can replace the wires connecting them.
2. Instead of using a master arm to control the slave arm, we can create a mobile app which lets the user directly communicate and control the Grippybot.
3. Upscaling the Grippybot by improving its structure and material will make it suitable for industrial tasks and extreme environmental conditions.

6. Conclusion

In this project, our goal was to create a robotic arm that follows a master-slave methodology where the main robotic arm acts as a slave and the miniature arm acts as the master. The user can record a sequence of actions and repeat them endlessly till the task is completed and can just restart the device to record a new set of actions. Our system aims to be helpful in scenarios where the task to be automated is repetitive and keeps changing. Through this project we were able to understand the importance of space complexity, structural integrity etc. We hope to implement the features discussed in the future enhancements as we learn more about robotics in our upcoming semesters and possibly present this paper at conferences.

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