



DEVELOPMENT OF GRAPHICAL USER INTERFACE (GUI) TO CONTROL ROBOTIC ARM FOR BIOMEDICAL APPLICATIONS

Ritesh G. Mahajan^{*1}, Girish L Allampallewar², Mohd. Imran Ansari³, Akshay Ramesh Kumar Shah⁴,
Om Mangesh Chandavale⁵, Mohammad Asaad Abrar Sayed⁶

^{1,3,4,5,6} Department of Robotic's & Automation Engineering ,Bharati Vidyapeeth (Deemed to be University) College of Engineering,
Pune 4110143, India.

² Marathwada Mitra Mandal's Institute of Technology, Lohgaon, Pune 411047, India.

¹<http://orcid.org/0000-0002-5911-987X> , ²<http://orcid.org/0000-0003-0386-2899> , ³<http://orcid.org/0000-0001-9477-6368> 

⁴<http://orcid.org/0009-0000-9403-7100> , ⁵<http://orcid.org/0009-0004-2116-4263> , ⁶<http://orcid.org/0009-0005-6990-0132> 

E-mail: *riteshmahajan103@gmail.com, girish.allampallewar@mmit.edu.in, imransarimech@gmail.com, arshah20-ra@bvucoep.edu.in,
omchandavale20-ra@bvucoep.edu.in, masayed20-ra@bvucoep.edu.in

ARTICLE INFO

Article History

Received: February 02, 2026

Reviewed: March 02, 2026

Accepted: April 01, 2026

Published: May 29, 2026

Keywords:

Graphical user interface,
Robotic arm,
Servo motors,
Arduino ,
Biomedical application

ABSTRACT

The article, Development of GUI to Control Robotic Arm for Biomedical Applications, is a trailblazer in biomedical robotics. It seeks to develop a graphical user interface (GUI) that is easy to use and intuitively applies to enhance the manipulation and accuracy of robotic arms in different areas of biomedical use. This research covers essential aspects such as goals, scope, phases of development, methodology and experimental accuracy with a focus on developing a GUI that enhances efficiency, safety, and user acceptance in medical procedures. Detailed descriptions of software development, hardware integration, safety measures, and usability testing demonstrate the research success in enhancing safety, performance and precision in biomedical applications. The research provide as a valuable resource for individuals and organizations interested in the convergence of robotics and biomedical applications, with the potential to positively impact healthcare providers and patients by driving innovation in biomedical robotics. The whole set up consist of five degrees of freedom robotic arm, capacitive touch screen display, Arduino UNO and Raspberry pi controller. For the accurate and precise control of Robotic arm joint motion five servo motors are used. The payload capacity of robotic arm is 0.5Kg.



Copyright ©2026 by authors and Galileo Institute of Technology and Education of the Amazon (ITEGAM). This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

1. INTRODUCTION

Biomedical use of Robotic arms have revolutionized and created precision and dexterity in biomedical practice, such as surgeries, rehabilitation, and diagnostics. The study by [1],[2] aims at developing a user-friendly interface to harness the capabilities of robotic arms in healthcare, specifically the development of GUI to control the robotic arm. The research will help to increase the precision, safety, and efficiency of different medical procedures by reducing the distance between the complex robotic functionalities and the medical requirements of these fields [3]. The hardware integration, safety, and usability testing of the GUI development process are the main aspects of this initiative [3]. Finally, this study provides the potential to transform healthcare by ensuring better patient care and patient outcomes through the further control of robotic arms in situations of pandemics such as Covid-19 [4]. In this study, integration of Robotic arm and HMI panel controller is built using python programming. The experimental set up developed was able to handle glass tube that was used in chemical reaction /sample testing in different biomedical labs with the help of graphical user interface that was developed in robotic arm. Besides biomedical use, developed integration is also positively utilized as pick and place application and service robot application.

II. LITERATURE REVIEW

The literature review explores the very essential information between user interfaces and robotic arms in the Biomedical application. It points to the changing environment of the graphical user interfaces (GUIs) to control robotic arms, and its central contribution to the improvements in accuracy, efficiency, and safety. According to the review, there are various gaps in research, including the urgent necessity of a flexible and more comprehensive interface design that would be applicable to a wide range of healthcare environments and further examination of the human factors, including user experience and error mitigation. Furthermore, the inclusion of the Internet of Things (IoT) as the global accessibility, standardization, scalability, and sustainability is listed among the fields that need additional research. The contemporary Human-Machine Interface (HMI) design is undergoing a paradigm shift away from inflexible, one-way control systems toward flexible, self-directed collaboration systems. In particular, the intelligent reflective panels based on facial recognition logic can be developed, which, in combination with a high level of personalization of the interface, will provide not only the maximum level of security but also the optimal user interaction [5]. The current domestic automation uses combined Raspberry and Arduino processing platforms to monitor different home appliances using one, integrated HMI [6]. The importance of MATLAB and Arduino integration lies in the fact that high-fidelity modelling is achieved and is the base towards low-latency, hardware-level precision when it comes to physical implementation [7].

Managing robotic systems in marine environments is uniquely difficult due to the constant environmental turbulence that threatens hardware stability. So, It is essential to develop graphical user based control to manage robotic system in marine application [8], [9]. Recent research emphasizes the utility of touch-responsive grids utilizing capacitive force sensing, which provide an accessible and "green" solution for intelligent HMI applications [10]. While these tactile keys are effective for routine tasks, academic research-focused manipulator systems often utilize specialized embedded control interfaces to investigate complex motion interactions [11]. For the most hazardous or unstructured zones, hybrid sensory multi-participant virtual environments offer a significant strategic lead. By delivering a spatial awareness that standard two-dimensional displays lack, these immersive systems allow several remote operators to collaborate effectively [12]. In Agriculture domain, Human Machine Interfaced 4 DoF robotic arm shown effective reduction in cycle time with 93% success rate [13]. Various methods of artificial intelligence used for control of robotic arm for industrial application conclude that deep learning for object recognition is most accurate [14]. Furthermore, the evolution of collaborative robots, or "cobots," has led to systems that employ colour-sensing technology for sorting [15]. The history of HMI has progressed from foundational studies at Sandia-based government research facilities to the current democratization of sophisticated hardware.

There are still early frameworks created by the first pioneers such as McDonald which we still use to organize the modern interactions of remote-controlling [16]. An essential strategic perspective of the diverse studies reveals that the trade-off of hardware between the distinct controllers: Arduinos appear well to be suited to produce base-tier engine signals at real time, whereas the Raspberry Pi units have advanced executive software operating environments that are suitable to perform network-centric workloads and intricate GUIs [17]. As an example, when equipped with PID-based control of Raspberry Pi, one can control servo motors carefully and at the same time run a sophisticated user-friendly display [18]. The sociotechnical design and assessment of HMIs in distributed architectures has been a major challenge because the conventional form of interface testing often does not consider the challenges of network delays or spatial context loss in the event that the operators are separated physically by the machine [19]. Finally, the introduction of six-axis robotic manipulators demands a balance between strict motion mathematics and easier-to-use feedback loops in order to make them operationally durable [20].

III. METHODOLOGY

For the development of graphical user interface with robotics arm following Figure 1 represent the methodology used to carry out experimentation.

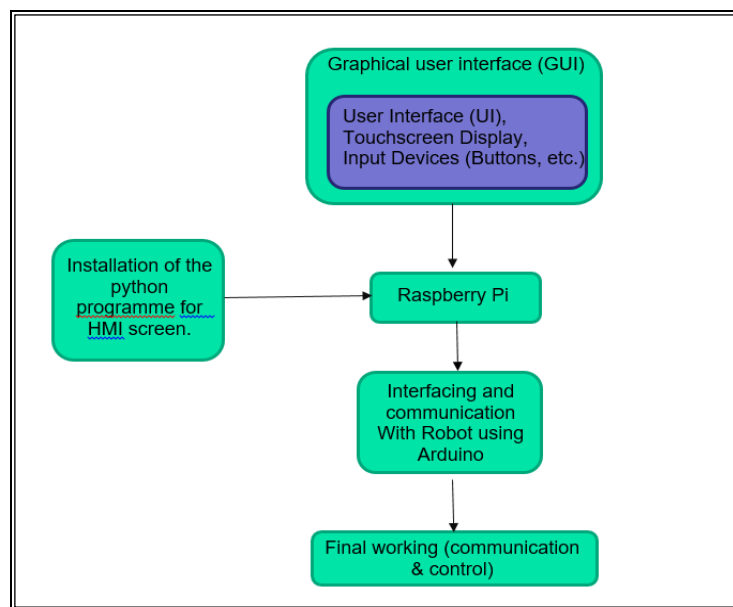


Figure 1: Block diagram of GUI Development.

Source: Authors, (2026).

III.1 DETAILED EXPLANATION OF EACH BLOCK IN THE BLOCK DIAGRAM:

- i. **Graphical user interface (GUI):** The GUI is the graphical representation of the HMI. It typically includes buttons, sliders, and other controls that the user can interact with to send commands to the robot.
- ii. **Touchscreen display:** The touchscreen display is the physical device that the user interacts with to interact with the GUI. It allows the user to select buttons and other controls by touching them with their finger.
- iii. **Input devices (buttons, etc.):** In addition to the touchscreen display, the HMI may also have other input devices, such as buttons and switches. These can be used to send additional instructions to the robot or to control the HMI itself.
- iv. **Raspberry Pi:** It is a single-board computer that acts as the brain of the HMI. It runs the Python program that controls the HMI screen and communicates with the Arduino.
- v. **Installation of the python programme for HMI screen:** The Python program for the HMI screen is installed on the Raspberry Pi. It is responsible for rendering the GUI, receiving commands from the user, and sending commands to the Arduino.
- vi. **Final working (communication & control):** Once the Python program is installed and running, the HMI is ready to be used to communicate and control the robot.
- vii. **Interfacing and communication with robot using Arduino:** The Arduino microcontroller board is used to interface the HMI with the robot. It receives commands from the HMI and controls the robot's actuators accordingly.

The HMI works as follows:

- a. The user interacts with the HMI UI to send commands to the robot.
- b. The HMI Python program receives the instructions and sends them to the Arduino.
- c. The Arduino interprets the commands and controls the robot's actuators accordingly.
- d. The Arduino sends feedback to the HMI Python program about the robot's state.
- e. The HMI Python program updates the HMI UI to display the robot's current state.
- f. This process is repeated continuously, allowing the user to control the robot in real time.

III.2 BLOCK DIAGRAM OF COMMUNICATION AND INTERFACING OF COMPONENTS

This is the block diagram of Communication and Interfacing of components. The user interface sends signals to the Python program, which can be keyboard inputs, mouse clicks, or other input devices. The Python program interprets the signals from the user interface and generates control signals for the Arduino UNO. These control signals are used to drive the servo motor. The following Figure 2 shows a simplified overview of the interfacing process.

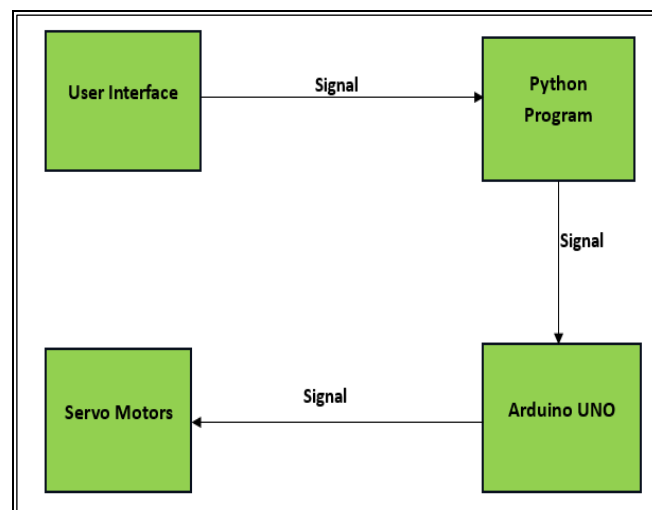


Figure 2: Communication of components.

Source: Authors, (2026).

Some examples of how this type of interfacing can be used:

- A 3D printer could use this type of interfacing to move the print head to specific coordinates.
- A CNC machine could use this type of interfacing to move the cutting tool to specific locations on a work piece.
- A robot arm could use this type of interfacing to move its joints to specific positions.

This type of interfacing is a powerful and versatile way to control servo motors using Python.

IV. EXPERIMENTAL SET UP

A Figure 3 shows the physical set up developed for graphical user interface for robotic arm. It consist of five degree of freedom robotic arm attached with 2 figure mechanical gripper, capacitive 7 inch HMI touch screen ,USB cable for interfacing ,servo motor used for precise movement of robotics arm, raspberry pie.

1. Robotic arm with two figure mechanical gripper 2. Arduino UNO. 3. Capacitive 7 inch HMI touch screen 4.USB cable for interfacing 5. servo motors 6. Raspberry pie

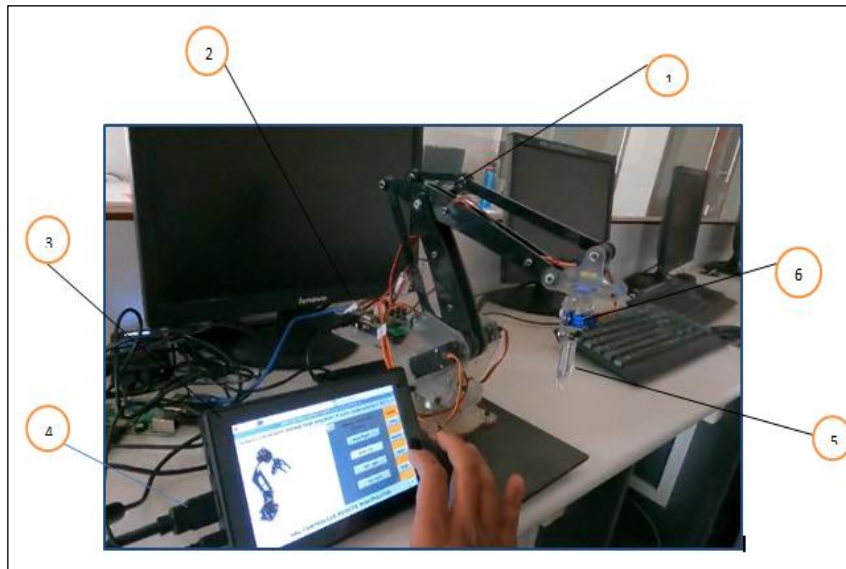


Figure 3: Experimental Set up for complete interface with Robotic Arm.
Source: Authors, (2026).

IV.1 COMPONENTS OF ROBOTIC ARM

IV.1.1 Robotic Arm:

The robotic arm used in this assemble has total five degrees of freedom as shown in Figure 4. First is rotation about base ,second is radial traverse of robotic arm about shoulder , third is upward and downward motion (elbow) in vertical direction, fourth is yaw motion of wrist and fifth is rolling about wrist. It is attached with 2 finger mechanical gripper for pick and place of part. The material used for robotic arm is acrylic material and all the parts are 3D printed. Robotic arm has payload capacity of 500 gm i.e.0.5kg.



Figure 4: Robotic Arm.
Source: Authors, (2026).

IV.1.2 Arduino Uno

It is a widely recognized and renowned for its user-friendly hardware and software also open source electronics platform It's designed to facilitate the reading of various inputs, such as the illumination level detected by a sensor, the touch of a finger on a button, or even a digital communication like a Twitter message. These inputs are then converted into outputs, which can range from initiating the movement of a motor, illuminating an LED, to interacting with the digital world, such as posting online. To program the Arduino board, one utilizes the Arduino programming language, which is inspired by Wiring, and the Arduino Software, known as the Integrated Development Environment (IDE), which is influenced by Processing. This combination allows users to craft a set of instructions that command the microcontroller on the board to perform a wide array of tasks, effectively bridging the gap between the physical and digital realms. The versatility of the Arduino UNO (Figure 5) makes it an ideal tool for a multitude of interactive projects, from simple DIY endeavour's to complex scientific instruments.



Figure 5: Arduino UNO.
Source: [21].

IV.1.3 Capacitive Hmi Screen :

A 7-inch capacitive HMI (Human-Machine Interface) display is widely used across industrial settings and DIY projects as shown in Figure 6. Key manufacturers in this space include DWIN, Nextion, and Waveshare. These screens are frequently bundled with integrated software to simplify user interface creation and ensure compatibility with development boards such as microcontrollers and single-board computers like the Raspberry Pi.



Figure 6: Capacitive HMI Screen (7 inch).
Source: [22].

IV.1.4 USB Cable for Interfacing:

Arduino cable and USB to USB cable as shown in Figure 7 used for communication and interfacing of controller, robotic arm and HMI screen. Use of jumper wires is required for solderless wire connection between components as shown in Figure 8.



Figure 7: Arduino and USB to USB Cable.
Source: [23].



Figure 8: Jumper wire.
Source: [23].

IV.1.5 Raspberry:

The Raspberry Pi Foundation created the Model B+ single-board computer. It has a small form factor, 40 GPIO pins, four USB ports, and enhanced power management, audio and video support, connection, and heat dissipation. It is backward compatible with original Model B software and accessories, giving it a viable platform for a variety of projects and applications. The Raspberry Pi B+, which was released in 2014, is a popular choice among hobbyists, educators, and manufacturers as shown in Figure 9.



Figure 9: Raspberry Pi b+.
Source: [23].

IV.1.6 Servo Motor

There are 5 servo motors used in the assembly out of which 3 are MG995 180 degree and 2 are SG 90 as shown in Figure 10. There are 3 wires in Servo motors. Red is for +5V supply, Brown is for Ground and yellow is for controlling the motor. So, in Robotic Arm total 5 motors are used. Power supply of all these motors will be connected externally as explained earlier and according to the specific motor.



Figure 10: Servo Motor.
Source: [23].

IV.2 COMPONENTS SPECIFICATION:

IV.2.1 Arduino UNO Specification

Table 1: Arduino UNO Specifications.

Sr. No.	Specification	Value
1	Microcontroller	ATmega328P
2	Operating voltage	5V
3	Input voltage range	6V to 20V
4	Digital I/O pins	14 (of which 6 provide PWM output)
5	Analog input pins	6
6	DC current per I/O pin	20mA
7	DC current for 3.3V pin	50mA
8	Flash memory	32 KB (0.5 KB used by bootloader)
9	SRAM (static random access memory)	2KB
10	EEPROM (Electrically Erasable Programmable Readonly Memory)	1KB
11	Clock speed	16MHz

Source: [21].

IV.2.2 Raspberry Pie:

Table 2: Raspberry Pi 4 Model B Specifications.

Sr.No.	Specification	Value
1	CPU	Broadcom BCM2711, Quad-core Cortex-A72 (64-bit)
2	CPU Clock Speed	1.5 GHz
3	GPU	VideoCore VI
4	RAM	2GB, 4GB, or 8GB LPDDR4-3200 SDRAM
5	USB Ports	2 × USB 3.0, 2 × USB 2.0
6	Video Outputs	2 × Micro HDMI (up to 4K 60Hz)
7	Audio Output	3.5mm audio jack, HDMI
8	Storage	microSD card slot
9	Networking	Gigabit Ethernet (RJ45), Wi-Fi 802.11ac, Bluetooth 5.0
10	GPIO Pins	40-pin GPIO header (backward-compatible with previous Raspberry Pi models)
11	Power Supply	5V via USB-C connector
12	Power Consumption	Varies depending on usage, typically around 2.5W to 7.6W
13	Operating System	Raspberry Pi OS (Raspbian) and various other Linux distributions
14	Supported Resolutions	Up to 4K (3840x2160) @ 60Hz via HDMI

Source: [24].

IV.2.3 Servo Motor MG995

Table 3: MG995 Servo Motor Specifications.

Sr. No.	Specification	Value
1	Operating Voltage	4.8V - 6.0V
2	Stall Torque (4.8V)	Approximately 10 kg/cm
3	Stall Torque (6.0V)	Approximately 12 kg/cm
4	Speed (4.8V)	Approximately 0.20 sec/60°
5	Speed (6.0V)	Approximately 0.16 sec/60°
6	Operating Angle	180 degrees
7	Weight	About 55 grams
8	Dimensions (L x W x H)	40.7mm x 19.7mm x 42.9mm
9	Gear Material	Metal and Plastic
10	Connector Type	JR Style
11	Rotation Range	180 degrees
12	Dead Band Width	4 µs
13	Operating Temperature	0°C - 55°C

Source [23].

IV.2.4 Servo SG 90

Table 4: Servo SG 90 Motor Specifications.

Sr.No.	Specification	Value
1	Operating Voltage	4.8V - 6.0V
2	Stall Torque (4.8V)	2.2 kg/cm (30.5 oz/in)
3	Stall Torque (6.0V)	2.5 kg/cm (34.7 oz/in)
4	No-Load Speed (4.8V)	0.12 sec/60°
5	No-Load Speed (6.0V)	0.10 sec/60°
6	Operating Temperature	-30°C to +60°C
7	Dead Band Width	10 microseconds
8	Gear Type	Plastic
9	Connector Type	JR/Futaba-style 3-pin
10	Dimensions	23 x 12.2 x 29mm
11	Weight	9g
12	Rotation Range	0° to 180° (90° each way)

Source:[21].

IV.2.5 Capacitive HMI Screen

Table 5: Capacitive HMI Screen Specifications.

Sr.No.	Specification	Value
1	Display Size (inch)	7
2	HDMI Port	Yes
3	Panel Type	IPS
4	View Angle	170°
5	Brand	Waveshare
6	Touch type	Capacitive
7	Touch Port	USB
8	Toughend Glass Panel	Yes
9	Touch-Points	5
10	Length (mm)	191
11	Height (mm)	112
12	Width (mm)	17
13	Weight (gm)	350
14	Shipment Weight	0.408 kg
15	Shipment Dimensions	12 × 5 cm

Source: [22].

IV.3 PROCEDURE FOR CONNECTION OF THE COMPONENT:

Step 1: First connect the Arduino to the PCB in the way that all pins are connected to each other. Plug-in the motors cable to the pcb. Keep in mind that you plugged-in the specific motor to the designated place on PCB. For Example:- Elbow motor to the Elbow male connector on PCB. Shoulder motor to the shoulder male connector on PCB and so on as shown in Figure 11.

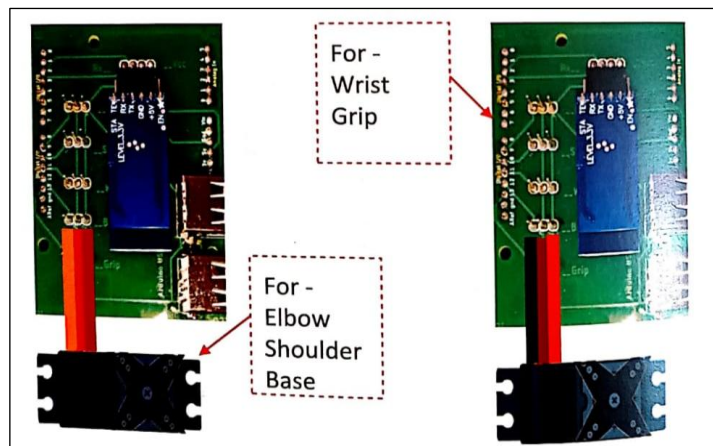


Figure 11: Customized PCB.

Source: [23].

NOTE: Make sure you connect the cable of motors color code wise as shown in figure. For Elbow, Shoulder and Base color code from left is orange, red and brown. For wrist & grip colour code is black, brown & red.

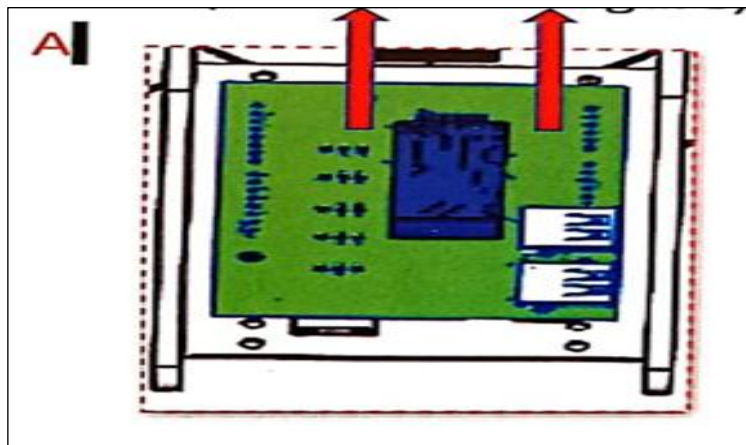


Figure 12: Top View of Customized PCB .

Source: Authors, (2026).

Step 2: Now, put the case above the PCB and tighten it with the screw.

Step 3: a) After connecting the arduino, connect the USB cable (type A/B) to the arduino and Arduino USB (on PCB). b) Male to Male cable to your charging adapter and Power USB (on PCB).

Step 4: Now, you are all set to run the Robotic Arm. Turn on the power supply and you can see that arduino LED is ON now.

Step 5:- Now whole code in Void Loop section is working on the same approach. In coding, we have defined at what time which motor is running from starting defined angle to the final defined angle. You can also change the servo angles between 0° to 180° for different location.

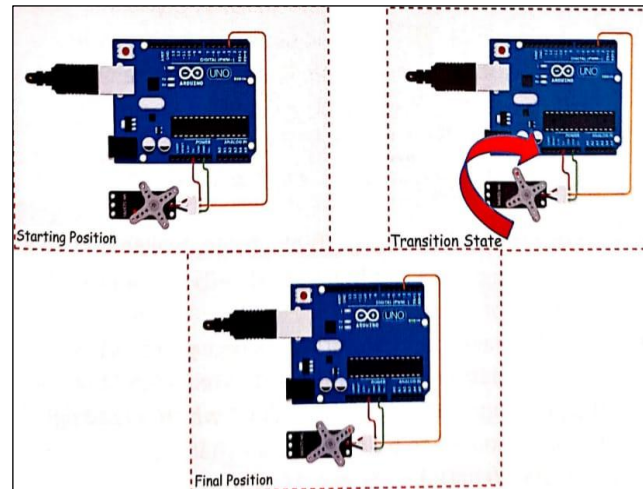


Figure 13: Arduino and Servo motor connections PCB.

Source: Authors (2026).

V. RESULTS AND DISCUSSION

This section explains about the results obtained for graphical user interface developed to control the robotic arm. It is explained in 2 parts. One is control of robotic arm by Arduino Uno code. Second is Python Arduino Integration for graphical user interface. The algorithm shown in figure 14 describes the code used for control of robotic arm by moving servo motor joints. The Second algorithm consist of control of robotic arm movement with graphical user interface i.e 7inch capacitive display programming as shown in figure15. This programing is integration of Python programing with arduino Uno code of robotic arm controller. On successful integration of graphical user interface it is observe that first we need to enter log in credential to execute control of robotic arm as shown in Figure 16. Once user logged in with required credential user interface winow enable the tab to control robot elbow, shoulder, base and wrist by servo motor 1,2,3and 4 respectively as shown in figure as per selection of individuals wish.

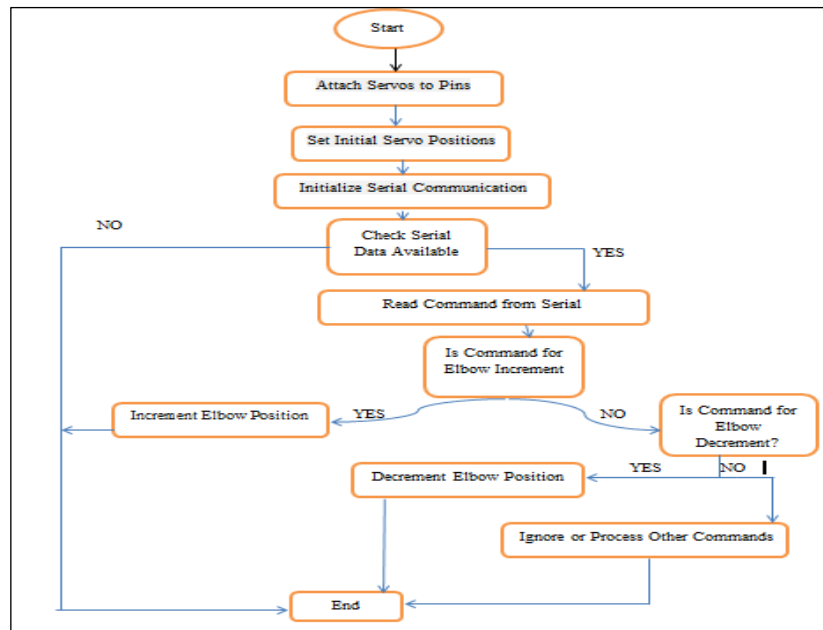


Figure 14: Algorithm for robotic arm servo motor program.

Source: Authors, (2026).

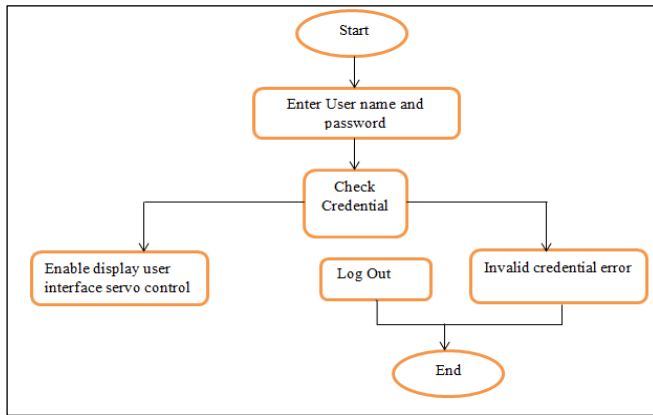


Figure 15: Algorithm to check log in credential.
Source: Authors (2026).

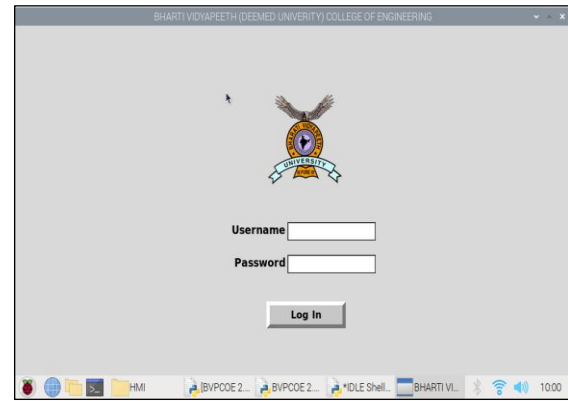


Figure 16: Initial security log in on display.
Source: Authors (2026).

The image depicts the login window of a program designed to control a robotic manipulator. This initial interface houses the college's name prominently at the top, signifying its potential use in an educational or research setting as shown in Figure 16. Below that lies the core functionality - username and password fields - essential for user authentication before accessing the control panel. Finally, a "Log In" button sits at the bottom, granting authorized users entry to the program's functionalities. Overall, this login window provides a clear and concise entry point for users to interact with the robotic manipulator.

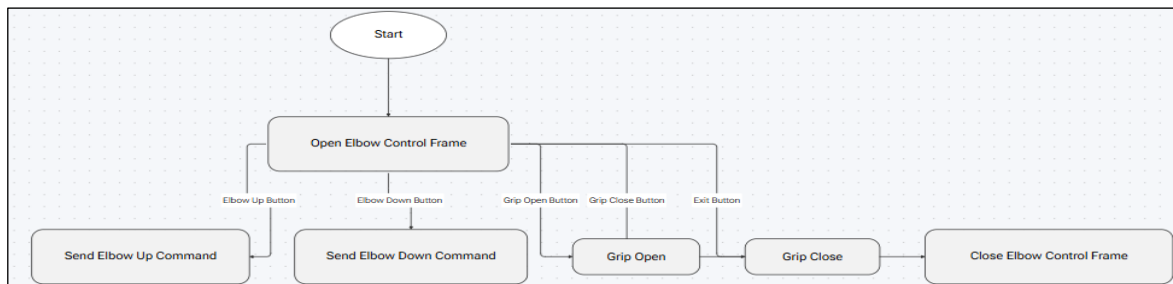


Figure 17 (a): Algorithm for elbow control from GUI.
Source: Authors, (2026).

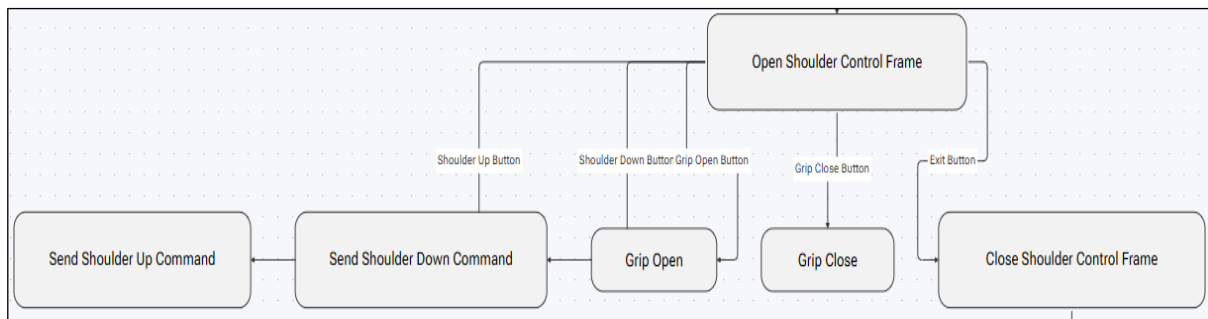


Figure 17 (b): Algorithm for shoulder control from GUI.
Source: Authors, (2026).

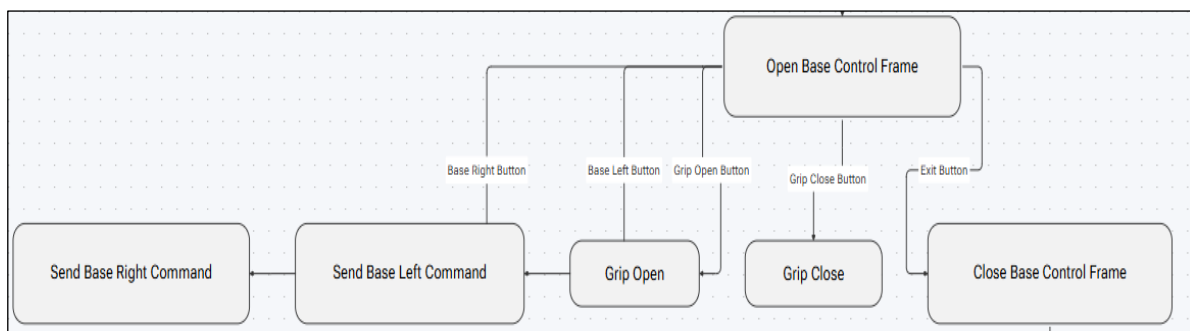


Figure 17 (c): Algorithm for Base control from GUI.
Source: Authors, (2026).

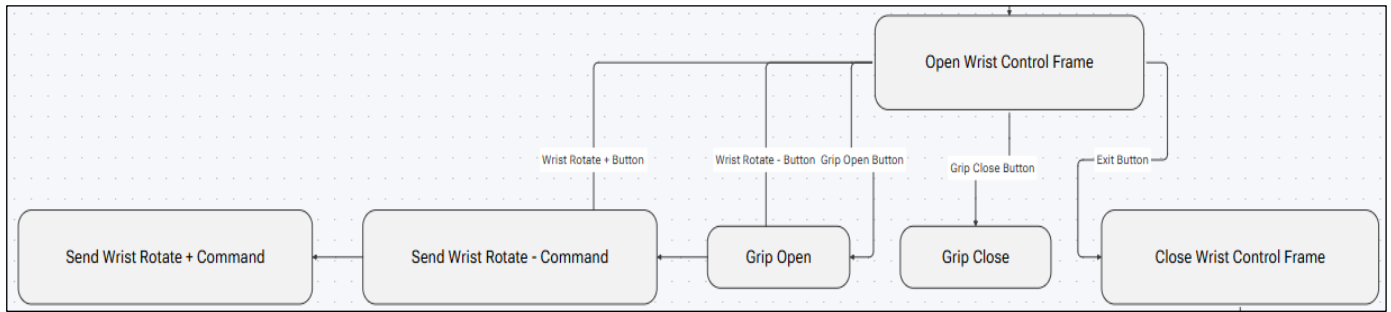


Figure 17(d): Algorithm for Wrist control from GUI.
Source: Authors, (2026).

The above algorithms are developed from the program code logic used for control of robotic arm with operating graphical user interface (GUI). For better visibility and understanding the algorithm is splitted in 4 parts i.e Figure 17(a) to Figure 17(d). The algorithm describes the movement of elbow, shoulder, base and wrist along with gripper of robotic arm is made by selecting respective tab on HMI screen.

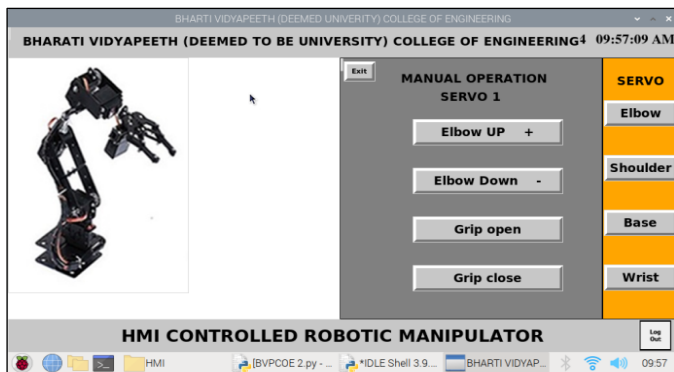


Figure 18(a): Elbow Joint Control.
Source: Authors, (2026).

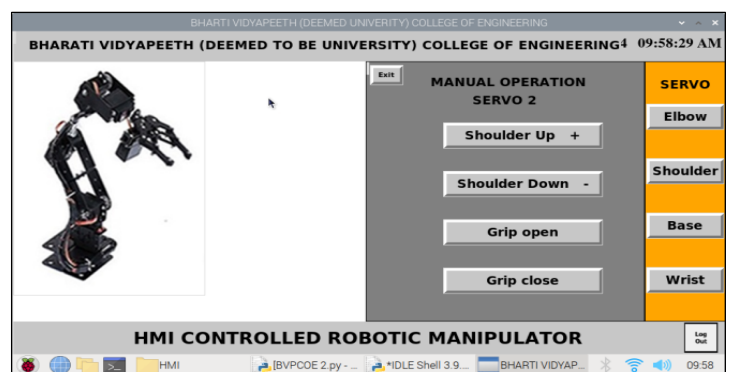


Figure 18(b): Shoulder Joint Control.
Source: Authors, (2026).

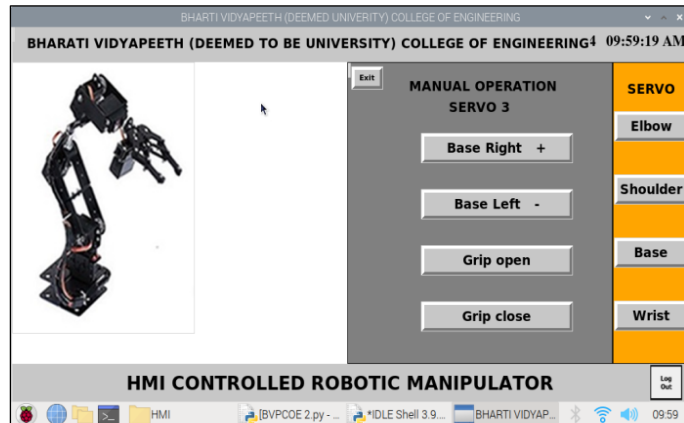


Figure 18 (c): Base Joint Control.
Source: Authors, (2026).

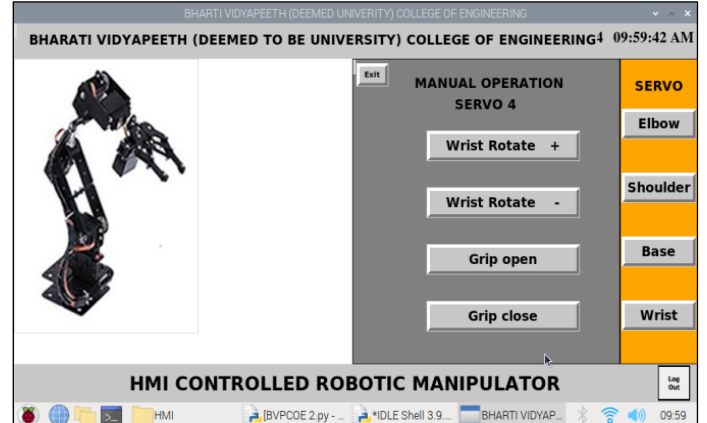


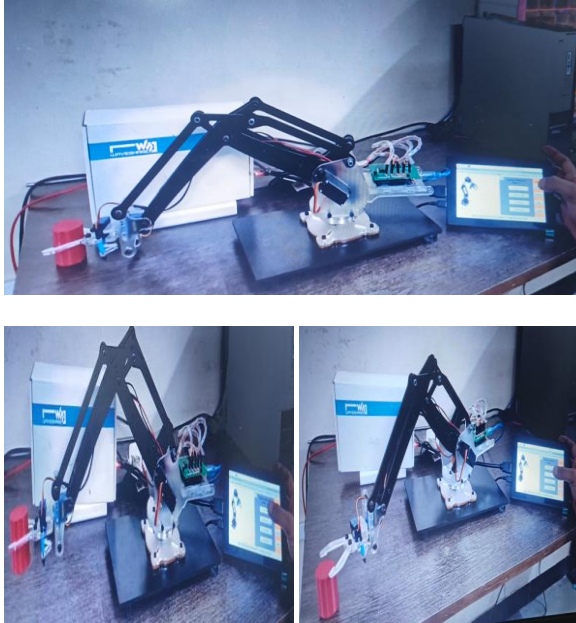
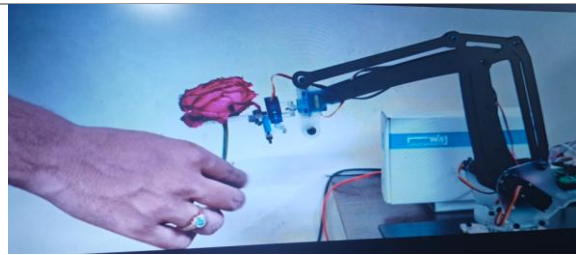
Figure 18(d): Wrist Joint Control.
Source: Authors, (2026).

The above figure depicts a graphical user interface (GUI) for a program that controls a robotic manipulator. HMI (Human-Machine Interface) refers to the interface that allows a human to interact with and control the machine i.e. here robotic arm. The main section of the user interface is the control panel. It consists of several buttons and a display area. Let's look at the elements within the control panel: Servo Controls: The panel appears to have four sections labelled "Elbow", "Shoulder", "Base", and "Wrist" as shown in Figure 18(a),(b),(c) and (d) respectively. Each section likely controls a corresponding servo motor on the robotic manipulator. Within each section, there are buttons labelled "Up +" and "Down -". These buttons are likely used to control the direction of the servo motor. Additionally, the "Elbow" and "Wrist" sections have buttons labelled "Grip Open" and "Grip Close," suggesting these sections might control a gripper attachment on the robotic manipulator.

VI. DEMONSTRATION OF APPLICATIONS DEVELOPED FROM EXPERIMENTAL SET UP

The following table shows the observation in the form of actual photographs captured to validate the application of experimental set up developed during experimentation and testing.

Table 6: Demonstration of application developed from experimental set up.

Sr. No.	Application category	Photograph of observation	Description
01	Biomedical (Health Sciences)		Here robotic arm and HMI panel is used to handle the test tube for chemical sample handling purpose in laboratories. The photograph observed during experimentation shows the successful integration of graphical user interface for biomedical application of robotic arm
Sr.No.	Application category	Photograph of observation	Description
02	Pick and Place Industrial application		Here it is observed that robotic arm operated by using HMI panel is doing pick and place activity with accuracy and precision. In the first photograph robotic arm doing picking activity of red block, second photograph shows that robotic arm successfully hold the block during motion and third photograph shows it is kept accurately to desired position.
03	Service Robot		Third observation shows that robotic arm and HMI integration is used for offering a flower to guest in cultural function as service type of robot.

Source: Authors, (2026).

VII. CONCLUSION

Finally, the "Development of GUI for Controlling Robotic Arm for Biomedical Applications" research is a game-changing endeavour that has the potential to transform the landscape of biomedical robotics. The research emphasis on developing an intuitive and user-friendly graphical user interface (GUI) shows a dedication to improving control and precision in a variety of biomedical applications. The detailed overview of the article including goals, scope, stages, methodology and conclusions gives a comprehensive understanding of the intricate aspects of the project. The rich content of the process of developing the GUI, hardware integration, safety measures, and successful testing of usability of the GUI indicate the success of the research in fulfilling its goals. It is important to note that the project has demonstrated tremendous improvements in precision, safety, and efficiency in a large scale of biological applications. Compared to its technical achievements, this study report is a valuable reference material to those and organizations that are keen to the interface between robotics and biomedical applications. The future and positive effect on healthcare providers and patients presented as projections indicate the innovation and progress of biomedical robots. This success of the research in essence is an indicator of a new era in the evolution of user-friendly interfaces of robotic arms which can advance the technology and healthcare industry.

VIII. AUTHOR'S CONTRIBUTION

Conceptualization: Ritesh G. Mahajan, Akshay Ramesh Kumar Shah, Mohammad Asaad Abrar Sayed.

Methodology: Om Mangesh Chandavle.

Investigation: Akshay Rameshkumar Shah, Mohammad Asaad Abrar Sayed.

Discussion of results: Akshay Rameshkumar Shah, Mohammad Asaad Abrar Sayed, Om Mangesh Chandavle.

Writing – Original Draft: Ritesh G. Mahajan.

Writing – Review and Editing: Akshay Rameshkumar Shah, Ritesh G Mahajan.

Resources: Mohd. Imran Ansari.

Supervision: Girish L. Allampallewar and Ritesh G Mahajan.

Approval of the final text: Ritesh G Mahajan.

IX. REFERENCES

- [1] Leonid Prokhorenko , Daniil Klimov, Denis Mishchenkov and Yuri Poduraev "Surgeon-robot interface development framework", Computers in Biology and Medicine volume 120, May 2020, 103717, Elsevier publication <https://doi.org/10.1016/j.combiomed.2020.103717>
- [2] Nurul Muthmainnah Mohd Noor, Muhamad Safwan Sabin and Rohidatun Mahmud@Wahab, "Performance Analysis of a 5-DOF Robotic Arm by Implementing a Graphical User Interface", Malaysian Journal of Science and Advanced Technology, e-ISSN: 2785-8901, 22 Aug. 2023, <https://doi.org/10.56532/mjsat.v3i3.170>
- [3] Meng Cuia, Wenqing Renb, Tengfei Cuic, Ruifeng Chena, Yi Shana, Xiaodong Ma "Design of intelligent human-machine collaborative robot-assisted craniotomy system", Heliyon a cell press journal, Volume 10, Issue 23e40364 December 15, 2024, 10.1016/j.heliyon.2024.e40364
- [4] Ernesto Iadanza, Giammarco Pasqua, Davide Piaggio, Corrado Caputo, Monica Gherardelli and Leandro Pecchia, "A robotic arm for safe and accurate control of biomedical equipment during COVID-19", Health and Technology (2023) Vol.13 page 285–300, 5 Jan. 2023, <https://doi.org/10.1007/s12553-022-00715-1>
- [5] Omkar Vaidya. "Development of Human Machine Interface using Smart Mirror and Face Recognition Algorithm." "IAEME Publication", "Volume 11", (October 10, 2020). <https://doi.org/10.34218/IJARET.11.10.2020.05>
- [6] Kumar, Praveen, and Umesh Chandra Pati. "Arduino and Raspberry Pi based smart communication and control of home appliance system." "ResearchGate" , November 1, 2016. <https://doi.org/10.1109/get.2016.7916808>.
- [7] Kanoria, Shubham & Anil, & Jeet, Pandya & Parikh, Priyam & Student, Ug & Professor, Assistant. "Design and Development of Universal Motor Control Unit using MATLAB and Arduino", "Researchgate" , April 1, 2017. http://ijsrd.com/C_Article.php?manuscript=ETCOP019.
- [8] M. Mirdanies, E. Yazid, R. A. Ardiansyah and Y. Sulaeman, "The Development of Human Machine Interface (HMI) Based Graphical User Interface (GUI) for Telecontrol System of a Ship Mounted Two-DoF Manipulator," "International Conference on Radar, Antenna, Microwave, Electronics, and Telecommunications (ICRAMET)" , Bandung, Indonesia, 2022, pp. 212-218, doi: 10.1109/ICRAMET56917.2022.9991234.
- [9] Farneland C, Harrysson M. Developing a Human-Machine-Interface with high usability. "KTH Publication". (2016). <http://www.diva-portal.org/smash/record.jsf?pid=diva2:935447>
- [10] Malik, Muhammad Shumail, Muhammad Hamza Zulfiqar, Muhammad Atif Khan, Muhammad Qasim Mehmood, and Yehia Massoud. "Facile Pressure-Sensitive Capacitive Touch Keypad for a Green Intelligent Human-Machine Interface" "MDIP PUBLICATION" Sensors 22, no. 21: 8113. (2022) <https://doi.org/10.3390/s22218113>.
- [11] Ing. Brayan Sneider Duran Bautista, MSc. Oscar Manuel Duque Suarez, & Msc. July Andrea Gomez Camperos. "Development of a manipulator and kinematic control system with embedded control hmi for academic purposes for tecnocademia cúcuta". "PalArch's Journal of Archaeology of Egypt / Egyptology", 19(4), 27-40 (2022). Retrieved from <https://archives.palarch.nl/index.php/jae/article/view/11415>
- [12] Szczurek, Krzysztof Adam, Raúl Marín, Eloise Matheson, Jose Rodriguez-Nogueira, and Mario Di Castro. "Multimodal Multi-User Mixed Reality Human-Robot Interface for Remote Operations in Hazardous Environments." "IEEE Access" 11 (January 1, 2023): 17305–33. <https://doi.org/10.1109/access.2023.3245833>.
- [13] Rahul, Kumar, Hifjur Raheman, and Vinayak Paradkar. "Design of a 4 DOF Parallel Robot Arm and the Firmware Implementation on Embedded System to Transplant Pot Seedlings: Artificial intelligence in agriculture." "ScienceDirect" 4 (January 1, 2020): 172–83. <https://doi.org/10.1016/j.aiaa.2020.09.003>.
- [14] Chandan G R, & Shashidhar R. "Intelligent Robotic Arm for Industry Applications." 2022 Fourth International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT) March 23, 2023. 10.1109/ICERECT56837.2022.10060276

- [15] Muhammad Ahmad Baballe, Mukhtar Ibrahim Bello, Abubakar Abdullah Umar, Abubakar Sadiq Muhammad, Dahiru Bello, Abdulmuhammin Muhammad. "Design and Implementation of the Hand Pick and Place Cobots' Arms for Color Detection". "Zenodo", 2022. <https://doi.org/10.5281/zenodo.8146356>.
- [16] McDonald, Michael. "Active Research Topics in Human Machine Interfaces." "Sandia National Laboratories", December 1, 2000. <https://doi.org/10.2172/773841>.
- [17] Bepery, Chinmay & Baral, Sudipto & Khashkel, Animesh & Hossain, Farhad. "Advanced Home Automation System Using Raspberry-Pi and Arduino." "Researchgate" (2019).
- [18] Karim, Muhammad Zakwan Bin Abdul, and Norashikin M. Thamrin. "Servo Motor Controller Using PID and Graphical User Interface on Raspberry Pi for Robotic Arm." "Journal of Physics." Conference Series 2319, no. 1 (August 1, 2022): 012015. <https://doi.org/10.1088/1742-6596/2319/1/012015>.
- [19] Man, Yemao. "Human-Machine Interface Considerations for Design and Testing in Distributed Sociotechnical Systems." "CHALMERS UNIVERSITY OF TECHNOLOGY", 2015. https://research.chalmers.se/publication/231914/file/231914_Fulltext.pdf.
- [20] Bilal, Muhammad & Ali, Nouman & Khan, Muhammad Osama & Mughal, Awais. "Design and Control of 6 DOF Robotic Manipulator".
- [21] Amazon website, Arduino Uno, <https://www.amazon.in/Arduino-UNO-board-DIP-ATmega328P/dp/B008GRTSV6>
- [22] Robu.in website, Capacitive Touch Screen Display, <https://robu.in/product/waveshare-7inch-1024x600-hdmi-ips-capacitive-touch-screen-lcd-h-with-various-systems-support/>
- [23] Robu.in website, Interfacing cable, servo motors, PCB pannel, <https://robu.in/>
- [24] Raspberrypi website, RabberryPi B+ model, <https://www.raspberrypi.com/products/raspberry-pi-1-model-b-plus/>