Efficient Pick-and-Place Automation: Arduino-Driven Robotics Blueprint

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***Abstract*— Robotics are significant for their capacity to improve efficiency, advance security, and move forward fetched and time productivity over different industries. Robot's spare specialists from performing perilous errands, increment laborer security, and spare time by creating a more noteworthy greatness of items with less squandered material. They too make unused occupations for those who were once on generation lines, pulling representatives from tedious, dull employments and putting them in way better, more challenging ones. In this study, the development and integration of an Arduino Uno-based Pick and Place Robot (PPR) with an ESP32-CAM module, with the goal of increasing the PPR's functionality and automation task capabilities. Advanced sensing, vision-based object recognition, and remote monitoring are made possible by the PPR system by fusing the flexibility of the Arduino Uno with the computational capability and wireless connections. In addition to stepper motors, proximity sensors, an ESP32-CAM module for vision detection, and a mechanical arm with a gripper mechanism make up the PPR system's hardware architecture. The robot can now recognize and find items inside its workspace with greater ease thanks to the inclusion of ESP32-CAM, which provides high-resolution image capture, processing, and object detection. Moreover, the PPR system may be remotely monitored and controlled using a computer interface or smartphone thanks to the wireless connectivity. Operators may troubleshoot problems and modify parameters while remotely monitoring the robot's performance thanks to real-time video streaming and image processing capabilities. This comprehensive solution may propel innovation and efficiency in automation systems across a range of applications in manufacturing, logistics, and other fields.**

Keywords— Arduino Uno, Arduino IDE, Bluetooth, ESP32-CAM

I. Introduction

In a period of fast technological advancement, the integration of robotics into military and security activities has gained favour. Robotic bomb disposal and Android military spies are two examples of notable technological advancements that hold promise for enhancing security and reducing human risk in high-risk situations. The deployment of these robots in defence and military environments highlights how important it is to employ cutting-edge technology to safeguard citizens and uphold effective national security. Android-powered military robots are designed to carry out a range of tasks, such as bomb disposal and reconnaissance and surveillance, which helps to lower the inherent hazards associated with these operations. The name "robot" comes from the Japanese word "robata," which has led the way in robotics breakthroughs by creating humanoids, manipulators, micro robots, and more. Industry is being forced toward automation and robotization by the existing situation. Robotics technology is growing swiftly as a result. We are going to build a robot with command and control soon.

The robot receives signals from the user, interprets them, and performs the necessary action. Mission controllers, disposal professionals, and Armor designers face a number of challenges, including a high level of risk, when performing bomb disposal operations for this project. A typical bomb disposal operation would start with a remote-controlled robot scouting the area and, if possible, remotely disarming the explosive. Sometimes a person with bomb disposal experience is required to disarm the device. Additionally, the system contains a night vision camera that lets you view recordings that were made both at night and during the day. The entire system is controlled using an Android application. With the camera at the top, the arrangement of the robotic arm and camera permits little ground clearance and continuous monitoring. The entire system is controlled using an Android application. The technology sends commands through an Android smartphone to a receiving circuit mounted in the car. The receiving circuit is made up of an Arduino and a Bluetooth device that receive commands from the Android app. To control the direction of the car, the user can press the buttons for forward, backward, right, or left. Besides, the integration of mechanical autonomy into defence and security operations reflects a broader slant towards robotization and innovative development in reaction to advancing dangers and challenges. As foes create progressively advanced strategies, the utilize of mechanical frameworks offers a proactive approach to defending national security interface. By leveraging cutting-edge innovation, military and security powers can upgrade their capabilities, relieve dangers, and adjust to energetic and complex situations viably.

II. Literature Survey

Building science is broadly connected to mechanical technology, which incorporates mechanical technology arranging, displaying, investigation, and utilization. These days, robots are utilized all over in day-by-day life. Robots are utilized in a wide extend of generation forms and segments. Movement required for arc-welding, shower portray, cutting, cleaning, processing, penetrating, get together, choose and put, pressing, palletizing, item assessment, and testing is given by robots. The publication of Mourya and his team was released in 2015 [1,9] and the Contemporary robots, owing to their exceptional velocity, precision, and economic viability in tedious tasks, are currently more likely to be utilized in automated production lines than manual workers. Because they need basic tasks like alignment and direction planning to complete defined tasks, these powerful machines are not truly independent. The relationship between a human administrator and a machine in modern advanced mechanics often consists of the administrator programming and maintaining the machine. The researchers in paper [2] suggested that it is conceivable to program robots with task-level systems to carry out employments at the undertaking level, like "Handle segment A and put it interior box B." This kind of detail is significantly distinctive from what is anticipated for existing advanced robot systems, which do not fair require a representation of a perfect point, but instep need a comprehensive assurance of each activity of the robot. Errand level details are unrelated to the robot performing the work, whereas movement specifics are associated with a specific robot.

In paper [3,7] Farman and team said that robotics is becoming the preferred method of performing precise and exacting tasks over human labor due to its superior performance and minimal dangers. A mechanical arm can be defined as a group of connectors that interface with an end effector through a sequence of spinning joints. The number of joints on a robotic arm is equal to its degrees of freedom (DOF) or levels of opportunity. Servomotors are often used to actuate the joints, providing the necessary force to rotate the joints. The electrical signals required to regulate the rakishmovement of the servomotor shafts are communicated via microcontrollers.

Few authors [4,8] state that when operating a single robot, a straightforward sort or queue in one direction is adequate. More sophisticated algorithms are required when using numerous robots than when using a queue. The idea is to figure out how many robots there are in relation to how many products, boxes, and cars there are. This could be achieved with the use of optimization methods. There are several research studies related to the advancement calculations used in this mechanical application. Adding to it few researches [5,6] said that the capacity to handle objects is a prerequisite for any production automation system. Process times per item should be minimal in advantageous automated P&P offices.

III. Methadology

In order to meet the demand for automated object handling across a range of sectors and applications, we demonstrate in this research paper the development of an Arduino Uno-based pick and place robot. First, a thorough requirements analysis is conducted for the project. This includes duties like item detection, manipulation, and accurate placement within predefined workspace boundaries. An Android-based pick-and-place robot that uses an Arduino Uno and Bluetooth requires a methodical development process that begins with requirement analysis to establish operational goals and workspace requirements. An Arduino Uno microcontroller board is meticulously combined with carefully chosen hardware components, including motors, sensors, and a robotic arm. Modules such as the HC-05 or HC-06 are used to enable Bluetooth connection. Simultaneously, an Android application is created to function as the UI, enabling wireless control and command communication with the robot.

Robotic arm motions and accurate motor movements are made possible for object handling activities by the implementation of control algorithms that interpret commands from the Android app. Robust testing, debugging, and performance assessment are carried out to guarantee dependability, precision, and effectiveness. To improve functionality and user experience, iterative refinement based on testing feedback is used. In order to provide a smooth integration into the intended operational environment, comprehensive documentation of the design, implementation, and testing process is supplied. This is followed by deployment and user training. Developers can efficiently design an Android-based pick and place robot with automatic object manipulation features by following this logical approach. The firmware implements algorithms for motor control, coordinated motion planning for pick and place operations, and sensor data interpretation. It is meticulously designed using the Arduino Integrated Development Environment (IDE). Thorough testing and continuous improvement guarantee the system's dependability and functionality in a range of operational scenarios. In addition, we create an intuitive user interface to help in controlling and observing the robot's movements. Here, a few circuit design tools are being utilized along with the C programming language to code the project.

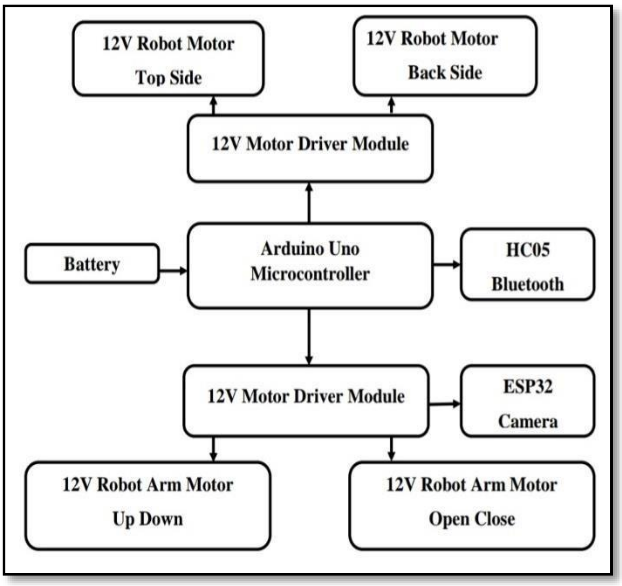

Fig.1 Block Diagram

The block diagram of the project can be seen in Fig.1. With its ATmega328P microcontroller, the Arduino Uno serves as the project's brain. We are using open-source android application to control our robot. This Android app connect with robot using Bluetooth communication. Based on user command, application creates character, each character define different control operation like forward, backward, left, right, arm open close and arm up down. As Bluetooth connected with our robot, after controller receiving this character, it compares with predefine command, and based on that start performing operation. Meantime also triggers the camera module to start video capturing operation. By calling predefine IP address; we can start live streaming video surrounding the robot.

Let see in details about the components used

A. Arduino uno board

Fig 2 shows Arduino uno board, created by Arduino.cc, the Arduino Uno is an open-source microcontroller board that is based on the Microchip ATmega328P microcontroller. Sets of computerized and analog input/output (I/O) pins on the board permit it to be interfaces with other extension sheets (shields) and other circuits. The board may be modified utilizing the Arduino IDE (Coordinates Advancement Environment) and a sort B USB cable. It incorporates six analog and fourteen advanced I/O pins, six of which can be utilized for PWM yield. It takes voltages between 7 and 20 volts; in any case it can be fueled by the USB line or an outside 9-volt battery.

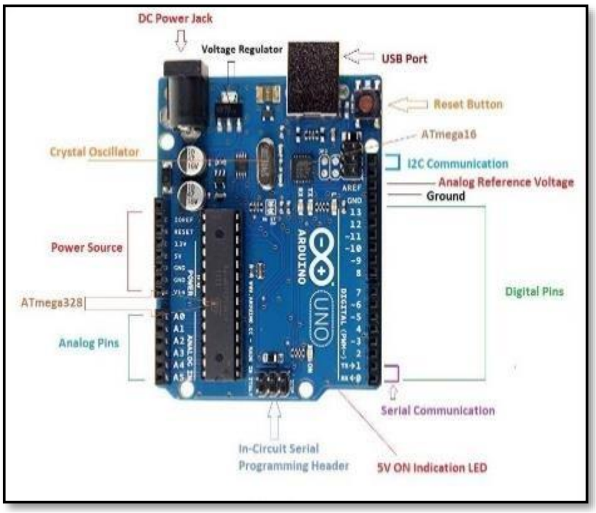

Fig.2. Arduino Uno

B. DC Motor

Any revolving electrical engine that changes electrical vitality from coordinate current into mechanical vitality is alluded to as a DC motor. It moves because of the physical properties of electromagnetic. The inductors found inside DC motors provide the magnetic field that drives motion. A current-carrying conductor suffers torque and has a propensity to move when it is in a magnetic field. Put another way, a mechanical force is created when an electric field and a magnetic field interact. On that premise, a DC motor, also known as a direct current motor, operates. We call this moving action. Example of DC Motor is shown in Fig 3.

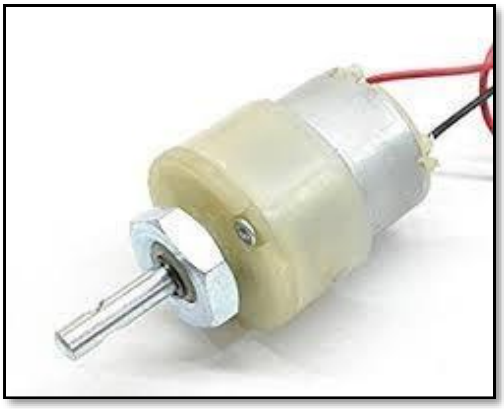

Fig.3. DC Motor

C. Motor Driver IC

Pin out diagram for Motor Driver IC shown in Fig 4. An coordinates circuit chip called a engine driver IC is regularly utilized to direct engines in independent robots. Robot chip and their engines are interfaces with by engine driver coordinates circuits (ICs). L298 arrangement engine driver coordinates circuits (ICs)—L298D, L298NE, etc.—are the most broadly utilized sort. Two DC engines can be controlled concurrently utilizing these coordinates circuits. The L298D is made up of two H-bridge. The most essential circuit for overseeing a engine with a moo current rating is the H-bridge. We will just be using the motor driver IC, L298D, for the purposes of this tutorial. There are 16 pins in the L298D: 4 for ground, 4 for input and output, 2 for enable, and 2 for voltage.

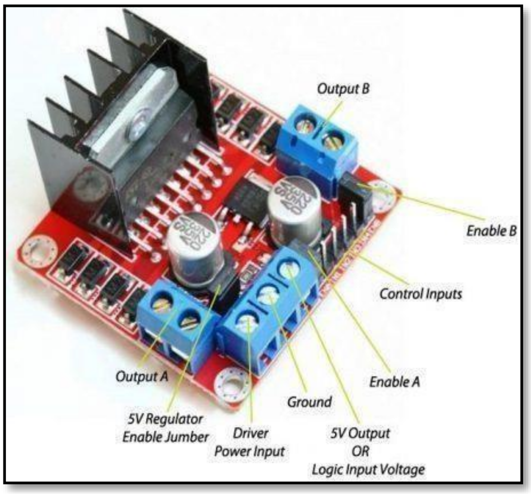

Fig. 4. Motor Driver IC

D. Bluetooth Device

The Bluetooth SPP (Serial Harbour Convention) module, HC-05, is user-friendly and made for straightforward remote serial association setup. The HC-05 Bluetooth module may flip between ace and slave mode, meaning it can be utilized for not one or the other information transmission nor reception. The wireless component's communication channel is controlled by Bluetooth technology. By utilizing two devices, the Bluetooth modules may send and receive data wirelessly. The host controller interface (HCI) enables the Bluetooth module to receive and transmit data from a host system. Fig 5 shows image of Bluetooth Module HC-05.

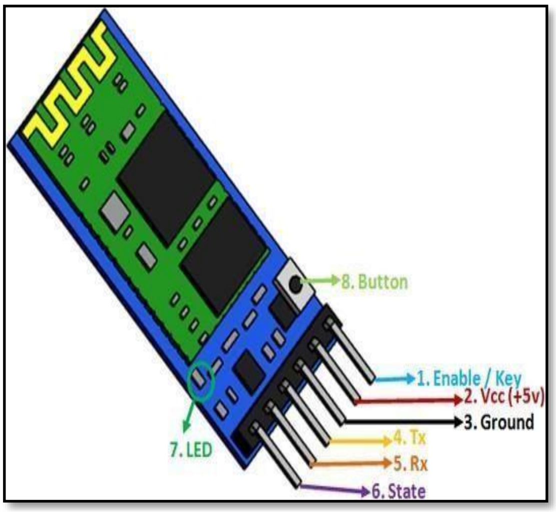

Fig. 5. Bluetooth Device (HC-05)

E. Wireless Camera ESP32-CAM

Based on ESP32, the ESP32-CAM is a compact camera module with negligible control utilization. It incorporates an inbuilt TF card space and an OV2640 camera. Cleverly Web of Things applications like WiFi picture uploading, QR recognizable proof, remote video observing, and more can make broad utilize of the ESP32-CAM. It supports Wi-Fi + Bluetooth and features an onboard ESP32-S module along with an OV2640 camera with flash. Furthermore, it contains an onboard TF card slot that can accommodate a 4G TF card

for data storage. Wi-Fi picture uploading and video monitoring is supported by ESP32. Fig 6 shows outline of ESP32-CAM.

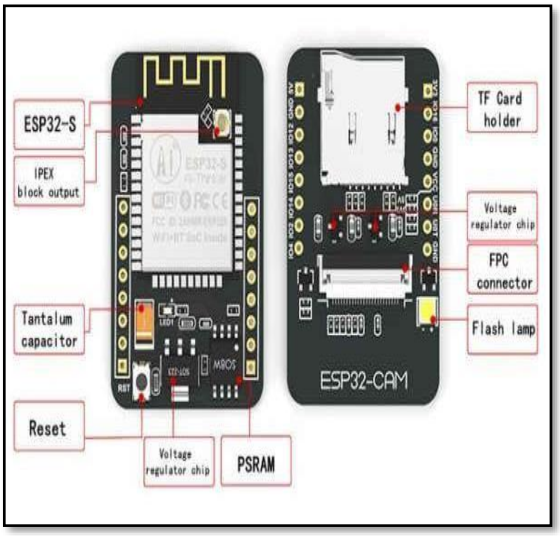

Fig. 6. ESP32-CAM

F. Robotic Arm

One common description of a robotic arm is "mechanical." It is also known as an industrial robot. This gadget functions similarly to a human arm, featuring many joints that may rotate in specific directions or move along an axis. Similar in function to a human arm, a robotic arm is a mechanical arm that can be programmed. It can be a standalone device or a component of a larger, more intricate robot. Such manipulators have joints connecting their linkages, which enable translational (linear) displacement or rotationalmotion (as in an articulated robot). Kinematic chaining can be thought of as being formed by the manipulator's links. Theend effectors, which are similar to the human hand, are the endpoints of the manipulator's kinematic chain. Fig 6 shows the Robotic Arm.

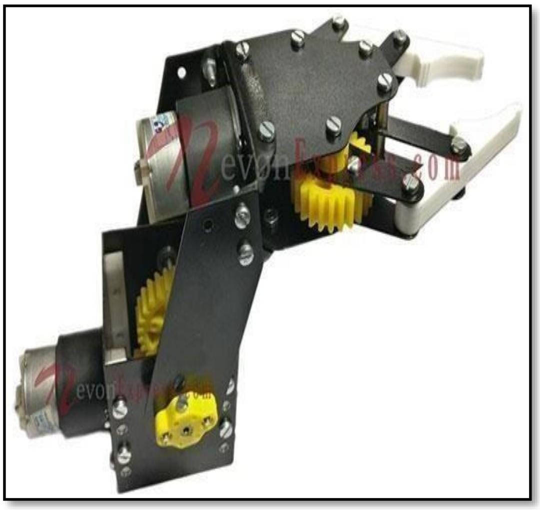

Fig.7. Robotic Arm

G. Tank Chassis

The vehicle's primary support structure, sometimes referred to as the "Frame," is the chassis. It supports all of the vehicle's stresses under both static and dynamic circumstances. It is the project's foundation. It is the project's foundation. We can mount the robotic arm and the PCB-made circuit on this. It has four wheels and tracks affixed to them so that it resembles an army tank and is mobile.

Caterpillar tracks, which more uniformly distribute the vehicle's weight and facilitate smoother movement across uneven terrain, are used by tracked robots. Even though tracked machines are perfect for outdoor applications, most of them also function quite well indoors and can travel across a range of surfaces, including uneven and smooth ones. Sample image of Chassis is shown in Fig 8.

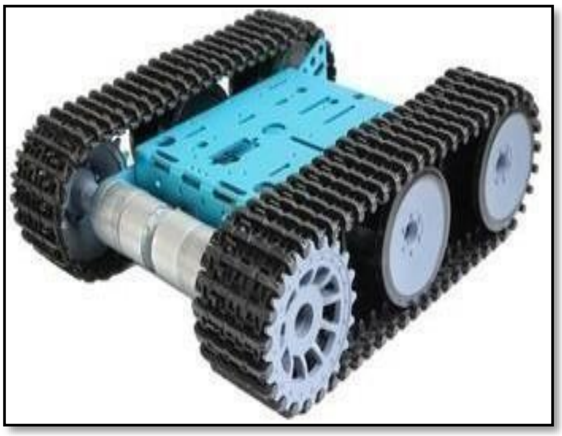

Fig.8. Tank Chassis

H. Bluetooth RC Controller App

Figure blow is the layout of the app which we going to use. To control the robot, we are going to use and android app. The name of the app which is used to control the robot Bluetooth RC Controller App. The four buttons on the app—Forward, Backward, Right, and Left—are used to control the robot's movement in these four directions. Additionally, there is a bar in the right corner that controls the gripper's open and closed movements. First, we have to tune on the Bluetooth. Then go to setting symbol; select the device name and click on connect to car. Then you can see at the left the color will change from red to green which indicated device is connected and ready to work. Layout of mobile application used for controlling the robot which shown in Fig 9.

Fig.9. Bluetooth RC Controller App

IV. WORKING AND RESULT

In which we have use motor driver IC L298, Arduino Uno board, Bluetooth module HC-05, chassis, robotic arm, vehicle motors and arm motor. Three resistors of 220 ohms and 2 resistors of 10k ohms are used, and we have 3 capacitors of 1nf and 2 capacitors of 22pf. We also have used 2 transistors BC547 and 2 diode IN4007. The input supply give to the circuit is 12V. In this circuit we have use LM785 regulator. As we know motor drive IC, Arduino uno does not work at 12V supply so with the help of LM785 regulator we will convert 12V to 5V supply. As regulator converts AC to DC and to get proper DC supply, we have used capacitors which will remove the excess AC. The 5V supply is given to VCC pin of microcontroller Atmega328p and GND pin. To run a Microcontroller Atmega328p it requires a supply and clock signal for that there is a connection of a crystal oscillator which gives 16 MHz clock signal. To crystal oscillator there are two Capacitors of 22pf connected; which will compress excess clock signal. When clock is given to microcontroller it will start working but for working of Microcontroller Atmega328p there should be some input so here we can place external hardware like Bluetooth module, motor drive IC.

Before microcontroller Atmega328p start working with the help of open-source app we will pair mobile with Bluetooth module and will connect Bluetooth module with Arduino uno board. First, we type the program in Keil IDE. Then we complier the program and we got a message that compiling is done. With the help of USB, we upload the program in Arduino uno board. And then we got the output. In this project we have used four vehicle motor. In that four vehicle motors will be controlled by one motor driver IC L298. Now when we will send a command like forward the message will be transferred through Arduino and Arduino will give command to driver IC motor and the function will take place. In a similar manner, the robotic arm is controlled by an additional drive IC motor. The driver IC motor L298 will be connected to the robotic arm.

When the user gives command like up then with the help of Bluetooth module the signal will be transmitted to Arduino and Arduino will give the command to driver IC motor to which the arm is connect and function will take place. In this project there is a connection of wireless camera name ESP32 cam which will be connected on the top of robotic arm. By connecting this camera, we can see the live location or live images on the mobile. To see live images, we have to put IP address of camera and we can see the images in Fig 10.

Fig.10. Output Images

V. Conclusion

The development of an advanced dual-functional pick-and-place robot specifically designed for military use is the main goal of this project. Getting the robot to be able to recognize and eliminate bombs in dangerous regions, such war zones or conflict zones, is the main goal. Moreover, it will be built with effective remote-control functionality for picking up and moving objects to designated areas. Modern components and cutting-edge technologies will be carefully integrated into the pick and place robot's engineering design. Advanced bomb detection sensors, like infrared sensors for heat detection and metal detectors for identifying metallic components frequently present in explosive devices, are examples of this. The arm will have a gripper mechanism that can safely hold objects of different sizes and shapes, making pick and place tasks more effective.

The robot will be equipped with wireless communication capabilities to enable remote control and monitoring,enabling operators to supervise and command its actions froma secure distance. In order to help operators make wise decisions during crucial missions, this remote-control interface will provide real-time input on the robot's condition, sensor data, and operational parameters.

The pick and place robot's adaptability goes beyond military applications; it may also find utility in non-military contexts like border security and disaster relief. In conclusion, a major progress in robotics and military technology has been made with the creation of a pick-and-place robot that can detect and dispose of bombs. This project not only tackles urgent security issues but also shows how robotics can improve efficiency and safety in difficult circumstances by fusing creativity with useful functionality.

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