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CONTROLLING A ROBOTIC ARM USING HAND RECOGNITION SOFTWARE

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ABSTRACT

Nowadays, robots are a rapidly developing field. A robot is a mechanical device that can perform physical tasks, using human supervision and control. Gesture means the movement of hand and face of humans. The main objective of this project is to control the robotic arm using human gestures. The human gestures are sensed with the help of an accelerometer, also known as inertial sensor. A microcontroller is used in the transmitter section. It is coded in such a way that the required actions for the human gesture are done. Several robots have been built to do dangerous work that is impossible done by humans directly. One type of them that is very popular is the robot arm. In this paper, it is proposed controlling robot arms based on finger and hand movements. This research is aimed at describing simple robot arms that must be controlled by human fingers and human hand movements. We have designed a robot arm with a Fuzzy logic method consisting of flexible sensors on the fingers, and human hand movements to control the robot arm's movement system. The movement of the robot arm is controlled by using a flexible sensor, the Arduino microcontroller, which is connected to several servo motors. The control angle of the robot arm controlled using human hand movements and gyroscopes. All input and output processes on sensors, hand movements, and microcontrollers used are processed by fuzzy logic. With the increasing need of repetitive tasks in the manufacturing industry, robotic automation is becoming a necessity. In the steel industry, workers become less efficient over time, causing interruptions during assembly. Robotic automation is capable of operating at highest efficiency therefore increasing productivity in the steel industry. The robot will be able to pick up and drop metallic object with the help of robotic arm. The handling of the objects will be triggered by the hand gestures from the user. The image to be processed will be captured by an external camera. This robot is built as a prototype for the steel industry. The goal of the project is to create a gesture-controlled robot with a robotic arm that can perform any pick-and-place tasks. A radio frequency transmission is used to control the pick and place robot. For the gripper open and close, up and down, forward and backward, base clockwise and counterclockwise, the Robotic Hand has certain independent commands.

Keywords: *Gesture Recognition, OpenCV, Embedded System Robotic Arm Control, Embedded C.*

I. INTRODUCTION

The aim of this system was to operate the robot with embedded tasks via finger recognition software coming froma video stream from the PC video output due to the reasons listen in the abstract. The image recognition software wasdesigned in OpenCV3, whereas the embedded system was designed in Arduino. Finger recognition works by counting the empty spaces between the fingers. The finger recognition software works using convex hull algorithms and contour detection. In simplerterms, convex hull approach aims to confine a set of given points in a plane by the smallest polygon. OpenCV is a library designed for use in opensource software and real-time image processing applications. This library, which can calculate all the moments of a polygonal and random shape, finds convexity lines through hand recognition. In sectors such as production, repetitive jobs areperformed in most areas. There are many manpower and costincreases. An interactive design has been done by creating a robotic system to perform object recognition and operations.

Autonomous systems aim to control the movement of robots in robotic studies and research. The algorithms used in such systems can make improvements by analyzing the errors that occur during the movements of the robots. These errors are calculated during the experiments on the robotic arms and in the next trials they provide the system with operational response. A new algorithm for real-time and recognition is based onhand movement recognition. This algorithm is based on threemain steps: hand partitioning, hand tracking and gesture recognition. Skin color, hand segmentation and monitoring based algorithm have been proposed for hand recognition. It has been investigated that it leads to good performances on the system. For control of the robotic arm, control of the robotic arm is provided via the analog signals from the sensors. Wearable robotic arm is designed to simulate the natural movements of the human arm.People who work in explosive and security operations are at risk and life-threatening. Therefore, we can keep the danger away from people by the help of a robotic hand on anautonomous device. The robotic arm is controlled via pre-defined actions in Arduino. Today, various robotic hands are employed in robotics research, each with its own set of capabilities and design requirements.

II. LITERATURE SURVEY

The book by John Iovine describes several elements of constructing a robot. It is concerned with various forms of arm design, controlling techniques, vehicle design, and so on. The operation and control of robots is described in this book by ER. Rajput. The Arduino cookbook discusses the intricacies and techniques of connecting hardware components such as DC motors, servo motors, and RF transmitters and receivers. Other sources in the references section explore similar concepts in their own domains, such as colour identification and segregation robots, surveillance robots, pick and place robots controlled by android, and so on.

A history of studies over the past 30 years reported in this paper suggests that Gesture Controlled User Interfaces (GCUI) now provide realistic and affordable opportunities, which may be appropriate for older and disabled people. They have developed a GCUI prototype application, called Open Gesture, to help users carry out everyday activities such as making phone calls, controlling their television and performing mathematical calculations. Open Gesture uses simple hand gestures to perform a diverse range of tasks via a television interface. They describe Open Gesture and reports its usability evaluation. They conclude that this inclusive technology offers some potential to improve the independence and quality of life of older and disabled users along with general users, although there remain significant challenges to be overcome. Stefan Waldherr, Roseli Romero, Sebastian Thrun describes a gesture interface for the control of a mobile robot equipped with a manipulator. The interface uses a camera to track a person and recognize gestures involving arm motion. A fast, adaptive tracking algorithm enables the robot to track and follow a person reliably through office environments with changing lighting conditions. Two alternative methods for gesture recognition are compared: a template-based approach and a neural network approach. Both are combined with the Viterbi algorithm for the recognition of gestures defined through arm motion (in addition to static arm poses). Results are reported in the context of an interactive clean-up task, where a person guides the robot to specific locations that need to be cleaned and instructs the robot to pick up trash.

III. PROPOSED SYSTEM

We have focused on the methods followed to carry out the process of controlling the robot, using either one of the three proposed implementations. An activity chart has been included for each. It represents the three platforms that have been worked on –the controller or app platform, the microprocessor platform and the

robotic arm and the ongoing events and processes in each. we have summarized our work and paved the way for any future work in the field of gesture-controlled robots. New ideas for extending our work have been brought to light along with possible advantages and disadvantages.

The pick and place robot are being used to help with sorting, carrying heavy goods, and other tasks. Heavy goods are often transferred using labor, and if the activity is performed for an extended length of time, the operator may get injuries. The operator will no longer have to bend and lift large weights by employing the robot, reducing injuries, and enhancing job productivity. Every operator, whether little or large, will make mistakes. In today's industrial environment, no mistakes can be tolerated. Because every mistake cost interns time, money, and materials. It basically worked in the field of Service Robotics, and the researchers eventually created a cleaning robot. They created a hand gesture-based interface for controlling a mobile robot with a manipulator.

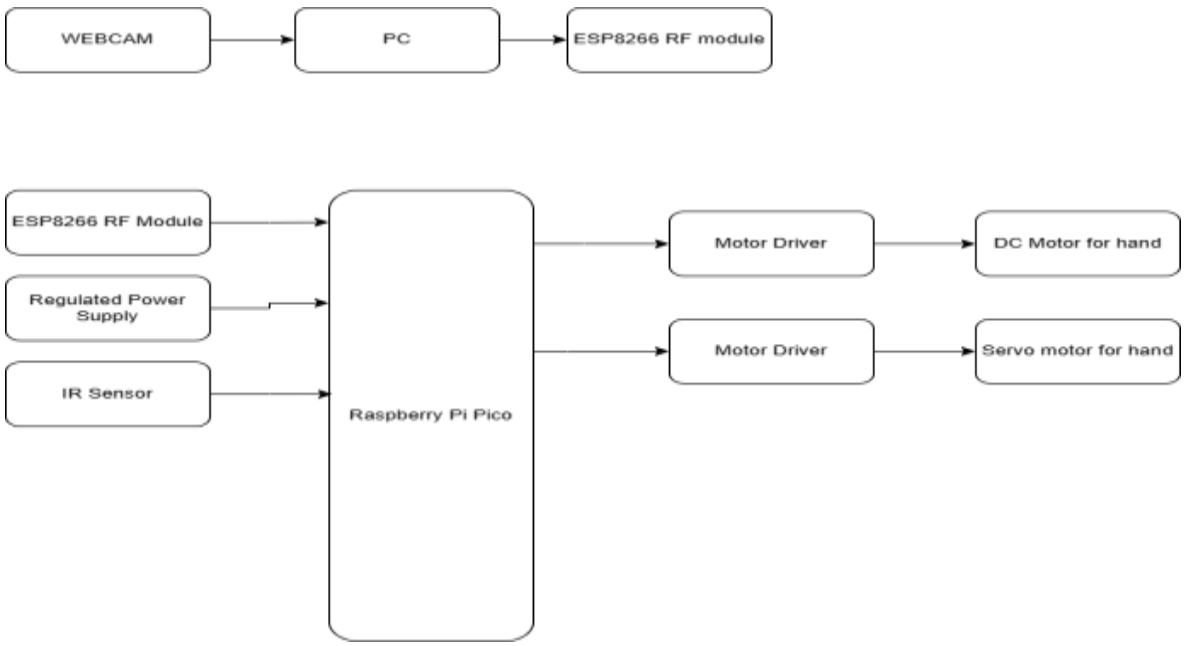

Fig 1. Block Diagram

A camera will be used to follow a person and identify arm motion motions. A quick, adaptive tracking algorithm allows the robot to easily track and follow a human through changing illumination conditions in office surroundings. It will clean and utilize a camera to track its progress. In this paper, we design a robotic arm with four degrees of freedom, which can pick the different object and place them at the different location. Based on functionality, the system has been divided into the following parts like Robotic arm, platform and communication system. This is the most important aspect of the system since it is responsible for picking up and dropping project tasks. The Platform is nothing more than the component of the project on which the Robotic Arm is installed. That communication is critical to the success of the article. Without a communication system, no system or project can function.

System and Software Algorithm's

Firstly, in the code, library and variable definitions were created. There are three servo definitions and three servo angledefinitions. Secondly, in the setup () section, the servos were attachedto their respective pins and the initiation angles to the servos are written. The servo engines initiate at 90 degrees. There is no user input that can keep the servos at 90 degrees, therefore the once the arm stands at a 90-degree angle, the user can understand that the system has initiated. Furthermore, a three-note music is played by the system

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once the serial opens, to make sure that the communication pathway between the Python hand recognition software and Arduino Mega is open.

Lastly, in the loop section, a switch case was created. This switch case operates given the user input from the Python program. According to the number of fingers received from the Python program, different cases in switch are activated,which operates the robotic arm. The Python hand recognition software works using OpenCV and Serial Port. OpenCV proves rather useful when working with computer vision and image recognition due to wide variety of supported libraries and conductedexperiments. OpenCV has more than 47.000 users and more than 14 million estimated downloads. Use extends from interactive art to mine inspection.

Gesture Recognition

The main aim is to recognize and classify such hand gestures to their correct meaning with the maximum accuracy possible. Image identification is becoming a crucial step in most of the modern world problem-solving systems. Approaches for image detection, analysis and classification are available in glut, but the difference between such approaches is still arcane. It essential that proper distinctions between such techniques should be interpreted and they should be analyzed. Here, the gestures can originate from any motion of the body or commonly originate from the face or hand.

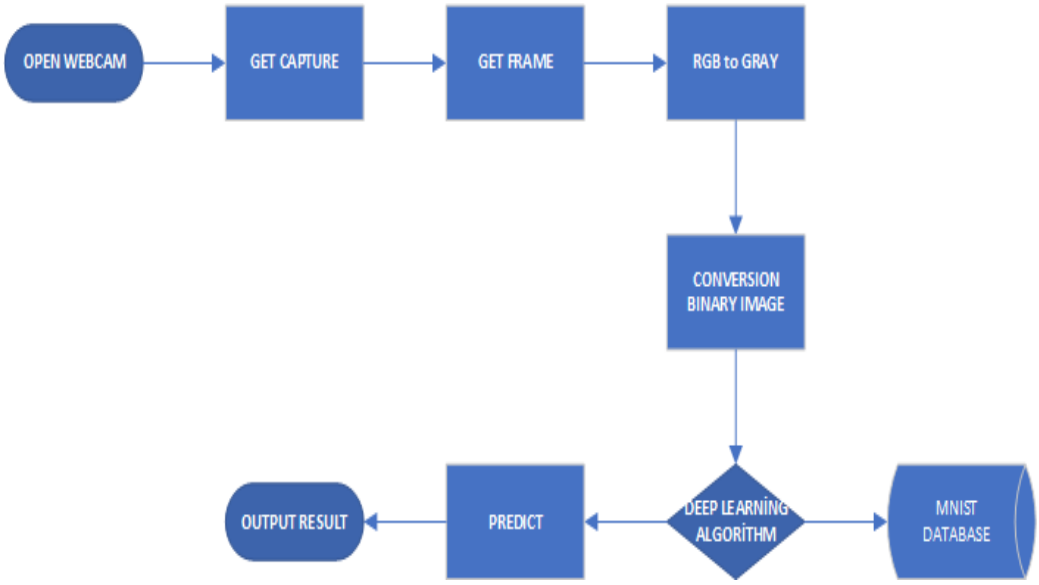

Fig 2. System and Software Algorithm's

Most of the gesture recognition are from face or hand gesture. Users can use thehand gesture technique to interact with the system or to control certain devices without physically touching them. Most of the hand gesture technique uses camera and computer vision algorithms to interpret sign language. Here, some identification and recognition of posture, gait and proxemics, and even human behavior are also subject of gesture recognition techniques. In our work we are using hand gesture recognition technique. Hand gesture recognition can be classified into two types:

1. Static Gestures
2. Dynamic Gestures

A static gesture is a specific hand configuration and pose,represented by a single image while a dynamic gesture is gesture motion, represented by a sequence of images. We will focus on the recognizing of a static gesture.

Gesture Recognition Process

There are two basic approaches in static gesture recognition,as described below.

[1] The top-down approach, where a previously created model of collected information's about hand

configurations is rendered to some feature in the image coordinates. Comparing the likelihood of the rendered image with the real gesture image is thenused to decide whether the gesture of the real image corresponds to the rendered one.

[2] The bottom-up approach, which extracts features from an input image and uses them to query images from a database, where the result is based on a similarity measurement of the database image features and the input features.

The disadvantage of the first approach is that it seems to use a high computational effort in order to achieve robust recognition. The second approach however requires an adequate pre-processing in order to achieve a reliable segmentation. This report mainly keeps the focus on the latter approach since this seems to be the common.

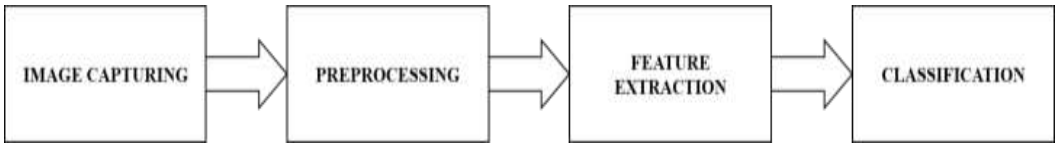

Fig 3. Schematic view of Gesture Recognition

Schematic view of gesture recognition processes the whole process of static gesture recognition can be coarsely divided into four phases, as shown in Fig 1. Each phase performs a specific task, whose result is passed to the next phase. The commonly used techniques for each phase are described in the following subsections.

Image Capturing

The task of this phase is to acquire an image, or a sequence of images (video), which is then processed in the next phases. The capturing is done mostly by using a single camera with the frontal view of the person's hand, where gestures are performed. However, there also exist systems that uses two or more cameras to acquire more information's about the hand gesture. In general, the following phases of the recognition process are less complex if the captured images do not have cluttered backgrounds, although several recognition processes seem to work in a cluttered image. Therefore, the images are captured in a cleaned-up environment having a uniform background. It is also desirable to have an equalized distribution of luminosity to gather images without shadowy regions.

Preprocessing

The basic aim of this phase is to optimally prepare the image obtained from the previous phase to extract the features in the next phase. The optimal result depends mainly on the next step, since some approaches only need an approximate bounding box of the hand, whereas others need a properly segmented hand region in order to get the hand silhouette. In general, some regions of interest, that will be subject of further analysis in the next phase, are searched in this phase. The most used technique to determine the regions of interest is edge detection and skin color detection.

Feature Extraction

The aim of this phase is to find and extract features that can be used to determine the meaning of a given gesture. Such a feature, or a set of such features, should uniquely describe the gesture to achieve a reliable recognition. Therefore, different gestures should result in different, good discriminable features. Furthermore, shift and rotation invariant features lead to a better recognition of hand gestures even if the hand gesture is captured in different angle.

Classification

The classification represents the task of assigning a feature vector or a set of features to some predefined

classes in order to recognize the hand gesture. In previous years several classification methods have been proposed and successfully tested in different recognition systems. In general, a class is defined as a set of reference features thatwere obtained during the training phase of the system or bymanual feature extraction, using a set of training images. Therefore, the classification mainly consists of finding the best matching reference features for the features extractedin the previous phase. This section presents an overview ofthe most used methods in different hand gesturerecognition systems.

Image Processing

Usually, Image Processing system includes treating images as two-dimensional signals while applying already set signal processing methods to them. The techniques used for image processing are hand gesture detection, edge detection, thresholding, contour detection. Using OpenCV, which provides a library collection of functions for different image processing techniques, these input images can be processed, and corresponding keystrokes will be generated. Gesture recognition is the fast-growing field in image processing and artificial technology. The gesture recognition is a process in which the gestures or postures of human body parts are identified and are used to control computers and other electronic appliances. It is among rapidly growing technologies today, with its applications in variousaspects of a business. Image Processing forms core researcharea within engineering and computer science disciplines too. The process in which the gestures or postures of human body parts are identified and are used to control computers and other electronic appliances. The main aim is to recognize and classify such hand gestures to their correct meaning with the maximum accuracy possible.

Image processing basically includes the following three steps.

- Importing the image with optical scanner or by digital photography.
- Analyzing and manipulating the image whichincludes data compression and image Enhancement and spotting patterns that are not tohuman eyes like satellite photographs.
- Output is the last stage in which result can be altered image or report that is based on image analysis.

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HARDWARE TOOLS

Raspberry Pi Pico

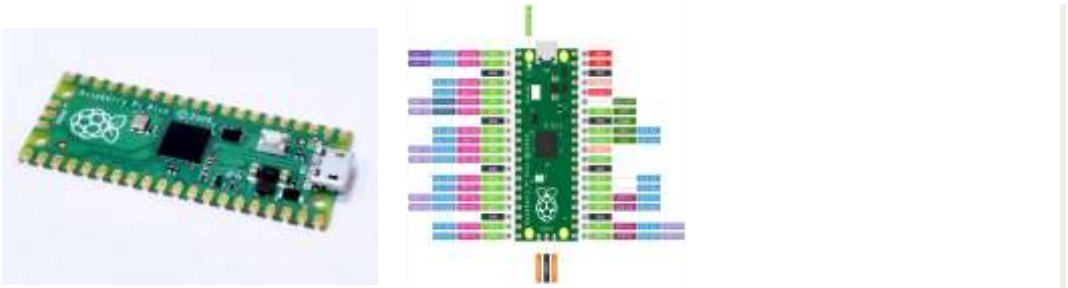

Fig 4. Raspberry Pi Pico Pinout

In IoT, robotics, or automation, then there are good chances that you must have heard about the latest revelation from the Raspberry Pi foundation, i.e., the Pi Pico. If not, then allow me to introduce you the microcontroller board, YES, you read it right, A Microcontroller!!! Pi Pico is the first microcontroller from the manufacturers of Raspberry Pi, based on the Raspberry Pi's RP2040 microcontroller chip and working on ARM's Dual-core cortex M0+ architecture.

Servo Motor SG-90

Micro Servo Motor SG90 is a tiny and lightweight server motor with high output power. Servo can rotate approximately 180 degrees (90 in each direction) and works just like the standard kinds but smaller. You can use any servo code, hardware, or library to control these servos. A motor rotates from 0 to 180 degrees

at each position of 90 degrees so that names it SG90. Servo motors have a gear that reduces the rotational speed of the motor by reducing its RPM and increasing the torque.

Fig 5. Servo Motor SG90

L293, L293D (QUADRUPLE HALF H-DRIVERS)

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications.

IV. RESULT ANALYSIS

Fig 6. It refers front direction.

Fig 7. It refers direction.

Fig 8. It refers right direction.

Fig 9. It refers left direction.

Fig 10. It refers to stop.

Fig 11. Refer to opening of robotic arm.

Fig: 12. Refers to closing of robotic arm

Fig 13. Refers to down direction.

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Fig 14. Refers to up direction.

Fig 15. Refers to Stop direction.

During the experiments there were two potential problemsthat could diminish the results produced by the robot. If the background behind the red square in the software of polluted,the results were incorrect. Secondly, if the user does not leaveadequate space between their fingers, the software often doesnot recognize the spaces between fingers. If these circumstances are satisfied, the results are successful, and therobotic arm movement is established.

V. CONCLUSION & FUTURE ENHANCEMENT

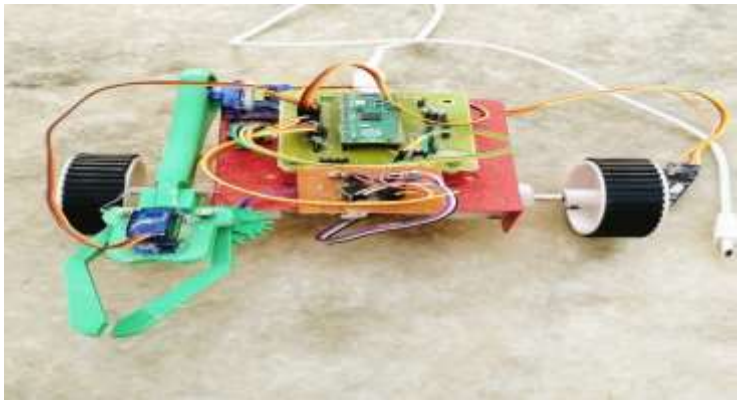

Fig 16. Robotic Arm

As a result, as the distance between the webcam and the image increased, the hand gestures on the background could not read the software clearly, and incorrect operations were encountered. In addition, if the angle between the fingers is small, it has been seen that it defines the movement wrongly. The aesthetic painting engraved on the prosthetic arm resembles natural flesh, which helps the amputee to gain confidence. It was our utmost endeavor to assist and help the mankind by concocting a low-cost prosthetic device capable of performing a bevy of functions. This prosthetic robotic arm can help or assist any human being with their day-to-day tasks. However, the degree of rotation and functions pertinent to flexibility we're not quite same as the human's hand's function.

In spite this, the grasp or grip of the robotic arm diligent concocted by us was strong enough to handle a pen ball, grip other tiny things and perform other functions like waving hand, fist pump, making a signal using fingers etc. The aim of this study is to be able to detect hand gestures of a person with instant camera images

and perform defined operations on embedded systems. In theexperiments, errors were detected in capturing the imagedepending on the distance. Camera resolution is required to correct this error. The light level of the environment can be changed according to the experiment. From observation that has been made, it clearly shows that its movement is precise, accurate, and is easy to control and user friendly to use. This robotic hand control method is expected to overcome the problem such as placing or picking objects that are away from the user, pick and place hazardous objects in a very fast and easy manner or augmenting our abilities to perform such tasks. The result of gesture recognition system is to generate a command based on the dynamic movement of the palm and that is given to the robot. There are mainly four possible gesture commands that can be given to the robot (Forward, Backward, Right and Left).

There are some prospects for future work based on the context of the paper. Devising an exclusive method to make the serial transmission between the arm and the controller entirely wireless will augment the mobility of the system. Gesture recognition can be improved by using controllers that provide depth information in addition to mapping coordinates. To extend the range of mobile applications WIFI modules can be used instead of a Bluetooth module, thereby granting remote access. IoT based methodologies can be simplified by implementing them in environments that utilize web sockets, making the communication between the user and server more interactive. Its having future scope of advanced robotic arms that are designed like the human hand itself can easily controlled using hand gesture only. It also having proposed utility in field of construction, medical science, hazardous waste disposal etc. The robot can be used in a wheelchair that is controlled by the movements of the rider's hand. To access it from a larger distance, Wi-Fi can be utilized instead of Bluetooth for communication.

It can be equipped with edge sensors to prevent the robot from slipping off any surface. The robot configured for pick and place operations may be made more adaptable and efficient by giving feedback and allowing it to perform without human involvement. It is made feasible by an image processing tool that is linked to this Arduino. Line follower. wall hugger, obstacle avoider, metal detector, bomb diffuser, and more characteristics can be added to increase its efficiency and allow it to run on its own without human interaction. Future scope of this project can be controlling the arm from a distant location with the help of camera and high range wireless transmission modules.

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