

Design and Development of Pick And Place Robot

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Abstract - In this study, the design and development of an automatic pick and place robotic system for increasing efficiency and effectiveness in material handling tasks have been considered. The pick and place robotic system comprises mechanical components, sensors, actuators, and control systems. This robot is designed to complete repeated activities with minimum human involvement. This robot is capable of identifying, picking, and moving the objects from one point to another. The use of servo motors ensures accurate and steady movements, while control logic programming makes the system adaptable to various sizes of objects under different operating conditions. Experimental findings show that this system is fast, reliable, and repeatable, surpassing the manual handling technique in terms of labor costs, safety, and effectiveness. The suggested system represents a cost-efficient approach to automation that could be extended through the use of emerging technologies like machine vision and artificial intelligence.

Keywords - Pick and Place Robot , Servo Motor, Automation, Robotic panel, Microcontroller, Scissor mechanism, ESP32, STM32. 12Volt geared DC Motor for sustain mobility

I. INTRODUCTION

Today, automation has been an essential component of the modern industrial process since it makes processes more productive and accurate while minimizing human work. Some of the automated systems used in the modern industry include the use of robotics for precise operations in factories and other material handling processes. One of the most common applications of robotics in the industry is the pick-and-place application, where objects are picked from one place and placed into another place with precision and consistency.

Pick-and-place robots have been developed through innovation in mechanical systems, electronic engineering, and artificial intelligence algorithms. Pick-and-place robots are basically robotic systems that comprise robotic arms capable of movement in various directions, end effectors that grasp objects, detection sensors, and controller components. They have been applied extensively in industrial fields like packaging, sorting, assembly, and inspection operations.

The past few years have witnessed increasing attention towards designing cheap and effective robots for small to medium scale manufacturing plants. Thanks to the advancements in technology such as the use of microcontrollers, sensors, and actuators; designing effective yet inexpensive pick-and-place robots has now become an easy task. The aim of this research is to explore ways to design an efficient pick-and-place robot that can help save labor costs and improve efficiency. In addition, further possibilities will be explored in future regarding the application of machine vision and artificial intelligence in pick-and-place robots.

II. LITERATURE REVIEW

Sobhan and Shaikat present an approach that emphasizes the implementation of a pick-and-place robotic arm for efficient automation and accurate manipulation of products in warehouse management. However, the approach by Iqdyamat and Stamatescu introduces reinforcement learning that enables a robot with a six-degree-of-freedom manipulator to make intelligent decisions in a warehouse environment. On the other hand, van Delden et al. present an innovative method that integrates human interaction in robotic manipulators through voice and visual commands in pick-and-place operations. [1-3]

This paper by C.C.Liang et al introduces a robot picking system that is automated and can be used in online stores. The second paper by Muhammad Aqib Khan outlines a robot system where mobile robots and manipulators work together to handle logistics. Lastly, the third paper by Hung-Yu Lee & Chase C. Murray discusses optimal storage arrangements within the warehouse setting. All these articles focus on improving systems, combining mobility and manipulation, and optimal storage and routing within warehouses. [4-6]

The study conducted by M. Z. Ur Rahman et al. explores a robot designed for autonomous warehousing operations that employs intelligent software systems to facilitate decision making and navigate through its environment. On the other hand, E. Najafi and M. Ansari explore an industry 4.0-compliant design methodology for modeling robots that

perform pick-and-place tasks. Krishna Vamshi Ganduri et al. advocate the use of adaptive intelligence approaches for robots used in varying environments. [7-9]

The research done by R. V. Subrahmanyam addresses the design of the automated warehouse sorter robot, with emphasis on systematic material handling. The works of András Kovács and Ferenc Gábor Erdős involve the study of planning and optimization methods for robotic pick-and-place tasks in restricted settings. Moreover, the research conducted by Faisal Ahmed Shanta et al. involves the creation of a cost-effective automated pick-and-place robot that utilizes color recognition technology. [10-12]

Research work by Khawaja Abdul Raffay et al. brings to light the concept of adaptive robots in warehouse management and particularly emphasizes the use of flexibility in pick-and-place applications. On the other hand, the paper by Jingyang Xiang et al. offers a comprehensive overview of various methodologies related to the classification, design, and optimization of picking robots. Lastly, Loh Poh Chuan develops a warehouse robot with the help of RFID technology that helps trace the objects within the warehouse. [13-15]

The article by P. Kushwaha et al. describes the design and manufacturing processes involved in the construction of the delta robot which is designed to perform pick-and-place operations at high speed and accuracy. Ronit Shah et al. investigate the use of a domestic service robot manipulator, where pick-and-place operations are carried out away from the industrial environment. The work by M.A. Riyadi et al. involves the use of a robot that uses RFID and STM32 for identifying and classifying objects. [16-18]

The study by Sadhasivam Udhaykumar et al introduces an automatic system of products searching in warehouses, which increases the efficiency of work with storage and retrieval operations. A. Paupiah and V. Oree design a robotized picking-up and placing intelligent and controlled system. Floyd D'Souza et al combine robots with AGVs in order to create a coordinated warehouse automation process. Lastly, V. K. Prajapati et al introduce the idea of vision-assisted pick and place robots.[19-22]

III. SYSTEM DESIGN

The Pick and Place Robot, as envisaged in the design, would be built as an economical, efficient, and relatively compact automated system ideal for small-scale industries or educational purposes. The whole system will be managed and regulated using the ESP32 STM32 microcontroller, which serves as the CPU of the robot

It uses a 15V DC source to operate. There is also an incorporation of a DC buck converter in order to control and reduce the voltage to a lower value like 12V and 5V. The use of a DC buck converter makes sure that the voltage does not fluctuate within the system.

The object detection process is carried out by a sensor, which constantly checks for any objects that are present in its field of view. When an object is detected, the sensor sends a

signal to the ESP32 controller, which then triggers a 12V DC high-torque

Motor that is used to perform mechanical movements. For controlling the mechanical movements and getting accurate positioning, a rotary encoder is attached to the shaft of the motor. Rotary encoder gives feedback on the angular distance covered and speed of rotation.

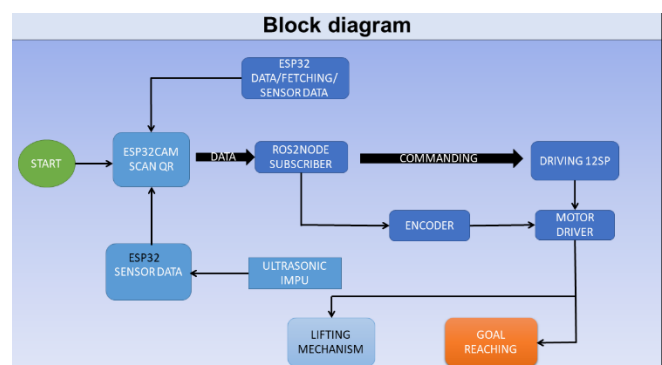
In order to ensure that there will be no structural weaknesses in the design, the robot body will be made out of PVC conduits and a plywood platform. This way, it would have enough rigidity to be able to support the weight of the mechanical system while maintaining a relatively low weight.

The vertical lift system is realized by using a mechanism called Caesar (scissor lift mechanism). This mechanism helps in controlling vertical movements for extending and retracting movements, which will help the robot to regulate its height according to the objects' positions. The robot makes use of a 12V DC Geared motor which runs the scissor mechanism and an encoder that controls the height. A micro switch has been used to detect limits

WORKING SEQUENCE

1. The sensor detect the presence of an object.
2. The ESP32 microcontroller processes the input signal
3. The geared motor is activated to initiate movement
4. The scissor mechanism extend to reach the object.
5. The object is securely picked .
6. The Robot moves toward the designated placement location.
7. The mechanism retract and place the object accurately at the target position .

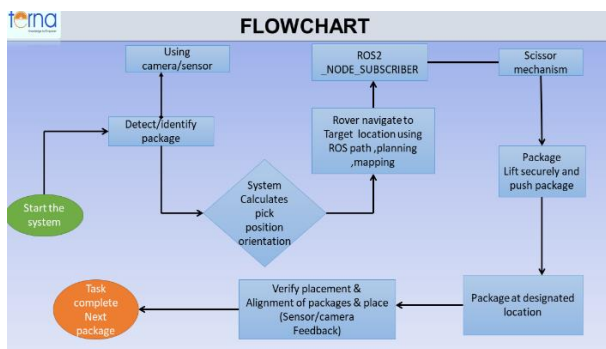
The whole robot has been designed by incorporating sensing, control, and mechanical systems in such a way that the robot is able to provide accurate pick and place operations in an automated manner. The robot design has been made keeping in mind accuracy, safety, economy, and scalability considerations.



Block Diagram depicts how the robotic system functions in a closed loop that consists of sensing, computation, and actuation. It all starts from the start when the ESP32-CAM carries out scanning of the surrounding area. As a result of scanning, visual information is sent to the ROS2 node (subscriber). It functions as the computing module that processes inputs and generates outputs in the form of commands. At the

same time, the ESP32 receives and processes data provided by the sensors that enables real-time decisions.

After processing the information obtained from the sensors, commands are sent to the driving system that operates from a 12V power supply source. The robot's movement is controlled by sending commands to the motor driver that, in turn, controls the robot's locomotion. Feedback concerning the robot's movements is received due to encoders installed at the motor driver. Ultrasonic sensors measure distances and detect any obstacles or objects, providing data for the ESP32 processing. At the same time, the output signal from the ultrasonic sensor controls the functioning of the lifting mechanism when needed. The whole system works in a closed loop and continues until the robot accomplishes its task.



The flow chart represents the total work procedure of the autonomous pick-and-place robot system for the purpose of warehousing. The work of the robot begins with the initiation of the system, and then the robot scans its surroundings through cameras and sensors for detecting the object. After detection, calculation of the picking position and orientation takes place to pick the object correctly. With the help of this information, the robot moves towards the destination with the help of ROS2 based navigation, mapping, and path planning algorithms.

Once it reaches the desired destination, the scissor lift mechanism lifts the object and pushes it into the desired position. Then, the robot picks and places the object in its right place. Further, sensors and cameras give feedback about the correctness of the placement of the object. In case, everything goes well, then it is considered complete. Now the robot moves forward to pick and place the next object.

IV.RESULTS AND DISCUSSION

A. Design Calculations

Weight :- 7 kg
 Calculated weight:- 5kg
 Force = F = mg
 $F = 7 \times 9.81 = 68 \text{ N (lift -6 target)}$

$$\text{Torque} = T = \frac{m \times g \times p}{2}$$

$$= \frac{7 \times 9.81 \times 0.05}{2} = 1.71 \text{ Nm}$$

Speed Calculation :-
 $C = \pi \times D$
 $C = 3.14 \times 0.1 = 0.314 \text{ m}$

Wheel Diameter = 11 cm = 0.11 m
 New weight :- 75 kg
 Gravity :- 9.81 m/s²
 Wheel radius = 5.5 cm
 $= \frac{5.5}{100}$
 $= 0.055 \text{ m}$
 $F = mg = 7 \times 9.81 = 68.6 \approx 68 \text{ N}$
 Force per wheel $\approx \frac{168.6}{2}$
 $= 34.3$
 Torque = F x r = 34.3 x 0.055 = 1.88 Nm

For easy visualization converting torque to kg.cm
 $c = 1.89 \times 10.2 \approx 19.2 \text{ kg.cm}$
 Required torque is 20 kg cm
 Safety margin = 1.5 -2
 $20 \times 1.5 = 30 \text{ kg.cm}$
 Required torque = 20 kg cm

Brief stall :- 7.5 A
 Voltage :- 5-30 A
 Continuous:- 10 A
 PWM + DIR
 Output Speed -100RPM
 Output torque – 85 kg.cm
 Wheel diameter – 70 mm ≈ 0.07
 Circumference = $\pi D = 3.14 \times 0.07 = 0.2198 \text{ m}$
 Speed = $1000 \times \pi D / 60 = 1000 \times 0.2198 / 60 = 366 \text{ m/s}$
 Gradian -> 1:1

$$T = 8, \sin(A = P \left(1 + \frac{r}{n}\right)^{nt})$$

5. CAD MODEL.



Here we have an innovative robotic pick and place system that utilizes the scissor lift technique for vertical movement. It involves a lead screw drive with the help of a motor, whose rotation leads to a linear motion to make scissor joints move up and down in a controlled way to achieve lifting from the ground level to the top. The bottom frame has been kept for placing the power supply source, switches, and other control circuit elements for its reliable functioning. This is intended for small scale industrial

Applications of automation and materials transfer. Through its integration of mechanical design and electrical control, the system exhibits how mechatronics concepts such as motion transformation, actuation, and automation can be applied to

achieve an economical and effective means of picking and placing objects.

B. Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named “Heading 1”, “Heading 2”, “Heading 3”, and “Heading 4” are prescribed.

C. Figures and Tables

a) *Positioning Figures and Tables:* Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1”, even at the beginning of a sentence.

TABLE I. TABLE TYPE STYLES

Table Head	Table Column Head		
	Table column subhead	Subhead	Subhead
copy	More table copy ^a		

^a Sample of a Table footnote. (Table footnote)

Fig. 1. Example of a figure caption. (figure caption)

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

ACKNOWLEDGMENT (Heading 5)

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

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