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Pick and Place Robotic Arm: A Review Paper

Sharath Surati[1], Shaunak Hedaoo[1], Tushar Rotti[1], Vaibhav Ahuja[1], Nishigandha Patel[2]

[1]UG students, Dept. of Mechanical Engg., MIT-SOE, MIT-ADT UNIVERSITY, Loni, Pune, Maharashtra, India
[2]Asst. Prof.: Dept. of Mechanical Engg., MIT-SOE, MIT-ADT UNIVERSITY, Loni, Pune, Maharashtra, India

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Abstract - *This review paper highlights the various aspects of a robotic arm after reviewing several successful research papers on manipulators.[26] Nowadays, Robotic arms are being used in industries to minimize the human errors and increase efficiency, productivity, precision of the operations taking place. One of the most important advantages of introducing Robotic arm in Industries is that it can work in crucial conditions like high temperatures, pressures where it's risky for humans to work.[11] Since a manipulator comes under Flexible Automation, they can be updated and modified easily. We have referred several research papers which have been experimentally verified to observe the different types of controllers used and different methodologies used by different authors to decide the degrees of freedom of a manipulator used for the picking of an object and placing it at specified position. Thus, knowledge acquainted after referring all these papers, will help in Designing the Robotic arm.[26]*

Key Words: Robotic Arm, Controller, End Effector.

1.INTRODUCTION

In today's world, robots and humans are working hand-in-hand for completion of their assigned task. An assistance robot is a robot which is self-governed and can work independently to perform the given tasks. Industries, military undertakings, medical sector are some of the fields where these robots are now being used. Working in assignments involving high temperatures or tasks like defusing bombs, handling molten metal might be fatal for people. Hence, Robots can replace humans to perform these kinds of dangerous tasks.[11]

1.1 Robotic Arm Definition:

A Robotic arm is basically a machine which is very similar to a human hand, it consists of a combination of links attached in series or parallel. It can be controlled by programming it to perform a specific task.[27]

Joints of the manipulator connect the links that leads to the displacement which is dither translational or rotational. A kinematic chain is formed by the links of the arm. End Effector is the terminating part of this kinematic chain and it can be considered as the hand of a human.

Fig 1: Proposed Robotic Arm [11]

Types-

- **Cartesian robot**:- Three prismatic joints , whose axes are coincident with a cartesian co-ordinate constitute a cartesian robot. Arc welding, handling precision tools and pick and place work are some of its application.
- **Cylindrical robot**:- A robot having axes that forms a cylindrical co-ordinate system is called as cylindrical robot. Some of its applications include assembly operations, handling at machine tools, spot welding, and handling at diecasting machines.
- **Spherical robot:-** A robot having an axes that forms a polar co-ordinate system is called a spherical robot. It is used for applications such as handling machine tools, spot welding, diecasting, fettling machines, gas welding and arc welding etc.
- **Scara Robot**:- Two rotary joints which are parallel and are used to provide compliance in a plane constitutes a robot termed scara. Its applications

include pick and place work, sealant, assembly operations and handling machine tools.

- **Articulated robot**: - A robot consisting of an arm having atleast 3 rotary joints is termed as Articulated. It is used in diecasting, assembly operations, fettling machines, gas welding, arc welding and spray painting.
- **Parallel Robot**:- Arms having concurrent prismatic or rotary joints constitute a parallel robot. One of the use is a mobile platform handling cockpit flight simulators.
- **Anthropomorphic robot**:- A robotic arm which is similar to a human hand i.e. consists of independent fingers and thumbs is called as Anthropomorphic robot.

1.2 Artificial Intelligence:

Today, robots have become smarter, intelligent and more efficient with the assistance of computer science field. Thus, a very major role is played by Artificial intelligence by not only in advancing the comforts of humans but also by increasing productivity of the industries which includes cost-efficiency both in qualitative and quantitative way.

Artificial Intelligence is nothing but a computer based program that mainly depends on the development and analysis of algorithms which can be termed again as a computer program which has the capability of creating a machine that has its own behavior and intelligence.

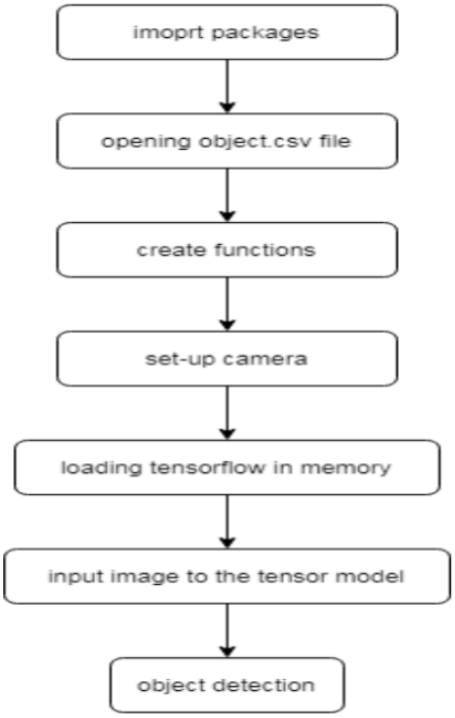

Fig 2: Tenser Flow Construction [18]

1.3 Object Recognition:

In general terms, Object recognition is a collection of related computer vision tasks which includes identifying objects in digital photographs. Predicting the class of one by one objects in an image is what included in image classification. Object localization, one more method under object recognition, refers to identification of location of a single or more than one objects in an image and drawing or creating abounding box around their extent\boundary. So basically, these two tasks are combined together in a Object detection system which again classifies and localizes one object or more objects in an image.

Fig 3: Target Object Recognition using YOLOv3 [21]

1.4 Controller

A device which takes multiple inputs to adjust its output so that the connected gadget operates in a controlled way is called as a controller. Microcontroller can be operated with more than one control outputs and carry out closed loop control. Choosing a specific controller is important for a final operation of a project because different actuators require differing control methods to achieve stable output. Arduino and Raspberry Pi are the most widely used controllers now a days.

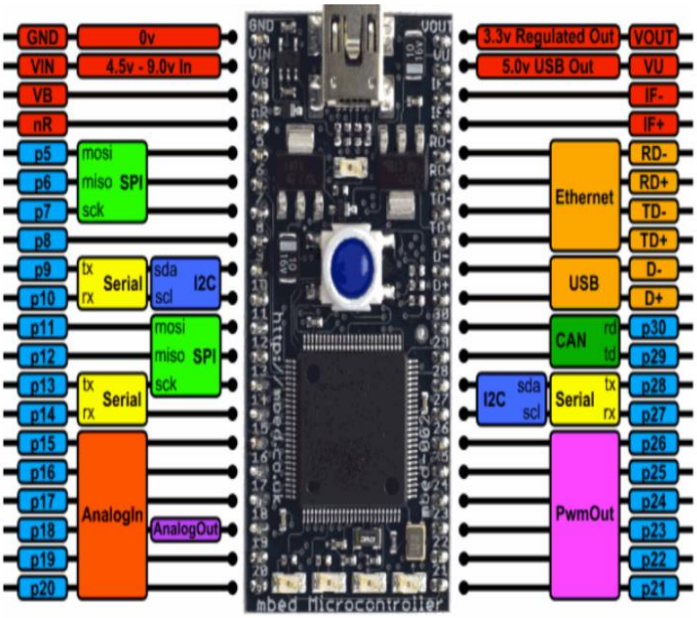

Fig 4: Configuration of Mbed**2 Literature Review**

2 Literature Review

2.1 Development Of Robotic Arm Using Arduino UNO by 1Priyambada Mishra,2Riki Patel, 2Trushit Upadhyaya, 2Arpan Desai:-

In this paper, they have used 4 servo motors to make joints of the robotic arm and the movement will be controlled with the help of potentiometer. The controller used is Arduino UNO. The analogue input signals of the Arduino's is given to the Potentiometer. The arm has been built by the Cardboard and individual parts are attached to the respective servo motors. The arm is specifically created to pick and place light weight objects. So low torque servos, with a rotation of 0 to 180 degrees have been used. Programming is done using Arduino 1.6.10. Thus the paper basically focuses on creating a robotic arm with non useful materials and its application on small purposes.[1]

2.2 Design of Robotic Arm with Gripper and End effector for spot welding' by Puran Singh, Anil Kumar, Mahesh Vashishth

According to the paper the robotic arm consists of 2 degrees of freedom is being made for the purpose of spot welding, gripper will be used in the arm. The end effector consists of an arrangement of spur gears and threaded shafts along with an AC motor. Aims considered while building the robotic arm are-
1.To have a rigid structure.
2.Movement of parts to defined angles.
3.To attain consumption of power at optimum level.
4.To perform spot welding operation with the help of end effectors.
The material used for manufacturing the bottom of robotic arm was plywood which has the dimensions as follows-
Length-48 cm,
Breadth-28 cm,
Thickness-2 cm.
Arm manipulator will be made up of plastic and has the following description-

- Weight=(30)2=60 g for big arm

and (10)2=20 g for small arm.

- Length=25 cm for big arm

And 5cm for small arm.

At the assembly point of wrist and end effector, 2 end effectors are used, in which one end effector is fixed and the other is movable, the end effector assembly has meshing of spur gears and worm gears which are connected to a 9 V stepper motor. The stepper motor has a step angle of 1.8 degrees and a speed of 100rpm. Force calculation on joints is done. This design of the robotic arm has two d.o.f. which performs the function of lifting, and for each linkage the center of mass was acting at the half of the length. Since there are many possible configurations for the robotic arm, the maximum degrees of rotation of each joint is 180 degrees. All the locations of the End Effector to which it can reach so that the workspace required can be calculated. This type of technology which is used in robotic arms can help in doing spot welding operation more efficiently. The material handling was carried out easily by picking and placing of the desired object. We can change the variation in the robot arm structure and their angle of movement.[2]

2.3 Review on Object-Moving Robot Arm basedon Color By Areepen Sengsalonga, Nuryono Satya Widodo

The objective of this finding is to make a manipulator which can sort objects on basis of color using specific motors and photodiode sensors programmed with a Arduino Mega series microcontroller. The light photodiode sensor can identify RGB colors. In this system the output of Arduino Mega 2560 is displayed on a LCD screen which is an indication of the observed color. The first step of object moving process is by distinguishing the RGB color. The gripper of robotic arm will move to pick objects based on color, depending on the color input given by the light photodiode sensor. Arduino Mega 2560 is a microcontroller that uses ATmega2560 which is installed in robotic arm having 54 digital i/o ports segregated into different types. In this

paper a color sensor testing is also carried out ,having a target to determine the ability of Photodiode sensor for distinguishing of color .The resultant voltage from photodiode will be sent to ADC to process and show result on the LCD screen provided.[3]

2.4 Modeling and Simulation of Robotic Arm Movement using Soft Computing by V. K. Banga, Jasjit Kaur, R. Kumar, Y. Singh

In this research paper the authors successfully built a 4 degrees of freedom robotic arm using soft computing. They have formulated ways for controlled movement of robotic arm and planning of trajectory with the help of Genetic Algorithms (GAs) and fuzzy logic (FL). As optimal movement is critical for efficient autonomous robots. This architecture is used to limit the issues related to the motion , friction and the settling time of different components in robotic arm. Genetic optimization is used to find the finest joint angles for this four d-o-f robotic system. This type of optimization replaces the long process of trial and error in search of better combination of joint angles, which are valid as per inverse kinematics for robotic arm movement. These logic models (Fuzzy logic) have been developed for the joint movement, friction and least settling time attributes as the fuzzy logic input.[4]

2.5 Design and Development of a Self-Adaptive, Reconfigurable and Low-Cost Robotic Arm by Kemal Oltun Evliyaoğlu1, Meltem Elitaş

Variety of tasks can be performed by a robotic arm when we do some changes in it , i.e changing the number of links, it can be made self- adaptable , this aspects of a robotic arm is discussed by the author in this paper. The paper represents a basic robotic solution to fulfill different applications with the help of it. The Design consists of two panels which have there individual wiring with it, thus as per the application required the panels are arranged and servo motors are connected to perform the task.[5]

2.6 Design and Implementation of Wireless Robotic Arm Model using Flex and Gyro Sensor by Anughna N, Ranjitha V, Tanuja G

The paper represents the author using accelerometers to collect information. The controller used is Arduino Atmega328. Human arm motion, fingers are located by flex, gyro sensors and signals are sent to Arduino ATmega328 which in turn controls the servo motors and makes the movement of the arm possible. The programming of the Arduino was done with the help of embedded C language. The Flex and Gyro Sensors were placed near the fingers. Whenever the change is detected, the information by both the sensors is processed by the controller. The Future Scope of this paper includes using 5 Flex Sensors near the fingers and more Gyro for the ease of operation.[6]

2.7 A Geometric Approach for Robotic Arm Kinematics with Hardware Design, Electrical Design, and Implementation by Kurt E. Clothier and Ying Shang

In this paper, the author has taken a geometric approach in order to position the robotic arm in an autonomous manner. iRobot command model is the main controller for the robot. For additional hardware, there are four e-ports and it is built around Atmega 168 microcontroller. The number of sensors used externally to iRobot Create are three. Two SharpGP2D12 Range Finder sensors and one GP2D120 Range Finder sensor are used. An infrared beam is emitted from these sensors and the reflection angles are used to find the distance of the objects. Objects in the range of 10-80 cm are detected by GP2D12, whereas the objects as close as 4-30 cm are detected by GP2D120. Element Direct, Inc is the screen used in this project, it came with four charactere Display which was designed for the use with command module. For scanning purposes, in the front of the robot, there are two infrared range finders. A distance in millimeters is received with the help of these sensors when anything blocks their line of sight, and hence we get the position of an object with the help of these distances.[7]

2.8 Design and Structural Analysis of a Robotic Arm by Gurudu Rishank Reddy and Venkata Krishna Prashanth Eranki

In this paper the authors have a successfully built a 4 degrees of freedom robotic arm used for handling metal sheet in a conveyor system. Reducing manual handling of sheet from stack to shearing machine is the main reason of designing this pick and place robotic arm. Two pneumatic cylinders for the feeding mechanism, and a robotic arm for the workers' safety were designed. Integration of the manipulator position sensor in the robot's control unit is done by RCC which is installed in the robotic arm. Robot's ability to interact with the surrounding is possible with the help of RCC control. A self-optimisation system is provided by the manipulator depending upon the given conditions. Self-awareness system of the robot will ensure safety on site. Suction effect is produced by the vacuum cup(which is at the end effector) on the surface of the object. Continuous path, acceptable degree of freedom, speed control, repeatability

and high resolution were the major factors which were processed by the manipulator.[8]

2.9 Industry Based Automatic Robotic Arm by Dr. Bindu A Thomas, Stafford Michahial, Shreeraksha.P, Vijayashri B Nagvi, Suresh M

This paper includes the design of an automatic robotic arm which is based according to the industrial applications. A functional prototype was constructed. This framework would make it simpler for man to maintain a strategic distance from the danger of dealing with objects which could be unsafe at the working environment. The utilization of robots is strongly suggested for Businesses particularly for security and profitability reasons. In their design work, they included a manipulator with 5 Dof. The microcontroller issues order to the individual channels that makes up the link. The electric motor operates as per given command and the speed of the motor as well as the direction and motion is controlled by the microcontroller. Meanwhile, in the mode of operation of robot, an obstacle sensor was programmed by the microcontroller such that it detects the presence of the obstacle in 10cm of radius. If an obstacle is sensed for the first time it pauses the work. Again if the problem is not cleared, a feedback system such as buzzer gets turned on to bring this problem on notice of a personnel to clear the object. [9]

2.10 **Robotic object recognition and grasping with a natural background by A Hui Wei and B Yang Chen**

In this paper, the authors had developed an efficient grasp synthesis method that could be used for closed-loop robotic grasping with the help of only a single monocular camera, they had proposed an approach which can detect contour information from an image in real time and then determine the precise position of an object to be grasped by matching its contour with a given template. This approach was much lighter than the currently prevailing methods, especially vision-based deep-learning techniques which requires no prior training. They have used the state-of-the-art techniques of edge detection, superpixel segmentation, and shape matching. The visual servoing methods that the authors developed for this system did not rely on accurate camera calibration or position control and was able to adapt to dynamic environments. Experiments showed that this approach provided high levels of compliance, performance, and robustness under diverse experimental conditions and environment.[10]

2.11 Design and Development Of 5-DOF Robotic Arm Manipulators by Yagna Jadeja, Bhavesh Pandya

The authors of this paper have built a 5 degrees of freedom robotic arm. They have used one cortex microcontroller which is M3 LPC1768 (Mbed). It can lift maximum mass of 100g. Ultrasonic sensors were used in this system, to detect the distance of the object from the robotic arm system. The object can be identified through the transmitter, which sends a signal which has frequency higher than that of the sound. The signals from the transmitter are reflected back by the target object and received by the receivers. In this way the object detection takes place in their robotic arm manipulator system. Once the object is detected the microcontroller send signals to the servo motors which are placed in the robotic arm to perform the pick and place mechanism.[11]

2.12 'Robotic Arm Tracing Curve Recognized by Camera' by Timothy Karl Findling

This paper was a thesis on solving the problem of soldering a line on a remote surface using a laser beam with the help of a robotic arm consisting of 6 servo motors controlled by Arduino micro-controller. With the help of various algorithms, this robotic arm was used to solder the cracks on a surface. A camera was used as the feedback device to give the position feedback to the controlling software by giving the current position of the laser dot. The software used in this research consists mainly of an Arduino micro-controller embedded software, an image processing software and a control software. The robotic laser arm was kept 81.28 cm away from a white board. Joysticks can also be used to position the robotic arm, in that the Arduino controller was disconnected from the PC.[12]

2.13 'Hand Gestures Remote Controlled Robotic Arm' by Shamsheer Verma

In this paper a manipulator with 3 d.o.f was made which was controlled by hand gestures. There is a glove which is a transmitter and the robotic arm is the receiver which functions according to the signals from the transmitter. The glove has a circuitry consisting of Arduino Mega 2560 which is programmed so as to transfer information through APC-220 Module and receive data from the robotic arm. Three angles, alpha, beta and gamma are assigned to the hand, this, along with the acceleration in the three directions is taken care by the gyroscope and accelerometer by sending the signal to the Arduino Mega through wires, where all the information is combined and processed. A flex sensor was also used to send the signals for the movement of the finger

to the controller. The chassis of the robotic arm was made up of acrylic. [13]

2.14 'Modeling and Control of 2-DOF Robot Arm' by Nasr M. Ghaleb and Ayman A. Aly

In this paper, modeling, simulation and controlling of 2 DOF robotic arm consisting of two links was done. Denavit-Hartenberg parameters were used to determine the forward kinematics of the robotic arm. Inverse kinematics of the robotic arm was carried out to find the variables of the cartesian coordinates of the end effector. A Permanent Magnet DC (PMDC) motor was used for the working of the arm. MATLAB was used for the simulation. [14]

2.15 'Path Planning and Co-simulation Control of 8 DOF Anthropomorphic Robotic Arm' by Sudharsan, J.* & Karunamoorthy, L.

This paper was published to focus on the efficiency of the path planning with the help of Matlab and ADAMS simulation software. The software's were used to execute the control algorithm in real time case and see the functional behavior of the system. This showed the results of the real time working of the manipulator. To control the motions of joints a joint cubic path control algorithm are used with the help of MATLAB. The end effector of the robotic arm was kept similar to human palm and fingers. The arm was modelled in Pro-E software tool. Through simulations they got the results on torque, position, velocity and acceleration of the robotic arm. [15]

2.16 Smart Robotic Arm By Dishant Khosla, Manvinder Sharma, Sachin Krishan Khanna, Pratibha Khanna, Gurpreet Kaur.

It is a study research based on a smart robotic arm which provides technical information and basics about it. The robotic arm is an issue which is being researched due to problems being faced in day to day life and due to this there are varieties of robotic arms present in market. This study includes the work of robotic arm and in which field it can be used.

As we know robotic arm can be operated through various methods like app, remote control, voice command. In their project they have used GUI which comforts the user to use this app efficiently and conveniently. It gives choice to user that whether he/she has to cut fruits or vegetable; if fruits, then which type of fruits; if vegetable, then which type of vegetable and how it should be cut.

Artificial intelligence and machine learning can also be used in robotic arm to provide extra smartness to the arm that will make it to think by its own and complete the task without human intervention.

- Elements used in robotic arm are:
  - Arduino
  - Servo motor
  - Gear box
  - Side shaft geared motor
  - L298n motor . [16]

2.17 Modeling and Simulation of 5 DOF Educational Robot By Mohammed Abu Qassem , Iyad Abuhadrous , Hatem Elaydi .

In this study paper they have built a virtual software through which they can control the manipulator consisting of 5 d.o.f. This software is being used for educational purpose and for educating people about the functioning of the robotic arm. In this they have designed a 5 d.o.f. robotic arm which consists of servo motors for the functioning of the joints and the end actuator. In this paper they have also discussed about the simulation results which were carried out on the robotic arm. The results show that they have used card generated motion for the communication between the controller and the robotic arm due to which the time resolution for the accurate positioning of the arm is 1μs and to generate extremely smooth moves a dc motor control was used. [17]

2.18 INTELLIGENT ROBOTIC ARM by *Prasad Ban* , Shweta *Desal*, *Revati Barge* , *Pallavi* Chava

Spotting of specific material or any element in physical world by any machine by inherited man made intelligence is still a tedious task. These smart machines have the ability to complete a task as instructed by their operator. Real time element identification includes recognition of objects by the help of Computer Vision and men made intelligence, which also involves Machine Learning concepts. Smart Robots are used to make individuals life easier by decreasing the work load and also by ensuring better accuracy.

These advancements can make a robotic arm capable of picking and placing of objects which will be recognized by the system, this whole process of recognition depends on the data stored in the processing system. The physical world data is acquired and the recognition system is complied with this acquired data through intelligent technology. The more the amount of acquired data will be, more will be the accuracy of the detection system incorporated in robotic arm.

In this research paper an uncomplicated machined arm having a dof of six. The robotic arm has three basic components.

[a]Actuators (motor): Responsible for movements in different axis.
[b]End Effector : For performing various task like picking ,placing ,drilling ,cutting etc.
[c]Controller (Arduino) : Brain of whole system ,this part controls every motion occurring.[18]

2.19 Design and fabrication of pick and place robotic arm By Dr.T.Sunil kumar, K.sarath, Sd.Famil, A.V.S.Bhagyesh and Sk.Althaf.

In this project they have designed a manipulator of improved accuracy by using servos to power the joints in the robotic arm.The robotic arm is designed using CATIA software. In this project we are going to fabricate robotic arm which performs ASRS function. The project covers the procedure for selection of the servos used to power each joint of the arm in
details. We are selecting Aluminum as our fabrication material. The torque exerting at each of the joints is going to calculate in this project and a servo with the required torque rating is being selected for each joint. Selecting a suitable servo controller and control software for the Robotic arm is developed using Microsoft's programming language.

Kinematic Analysis
The branch of mechanic which deals with the study of system of bodies without giving any importance to any other factor like force, mass is called Kinematics. There are two categories of kinematics for robotic arm:
• Forward kinematics
• Inverse kinematics.[19]

2.20 PLC based Robot Manipulator Control using Position based and Image based Algorithm By Harshavardhan Reddy Kunchala & Jack Toporovsky

The author of this paper has used Programmable Logic Controller for controlling the manipulator and also used two artificial intelligence algorithms that is position based and image based algorithms. The manipulator used has 5 Degrees of Freedom. The position based algorithm calculates the joint velocity by the data provided by the algorithm based on images.

The main purpose of this paper was to use the data from the images captured by the camera and the space co-ordinates to the specific object which at last controls the movement of the robot while performing certain task. The position determining algorithm outputs the X co-ordinates and Y co-ordinates in the image frame captured by integrated camera along with a scaling factor. The measurement related to gripper are done according to scaling factor and used to get an idea of the height of the gripper from the datum. This makes process easier for machine to detect the position of object and come in same plane of the object. [20]

2.21 Autonomous Object Detection and Grasping Using Deep Learning for Design of an Intelligent Assistive Robot Manipulation System by Sanzhar Rakhimkul, Anton Kim, Askarbek Pazylbekov and Almas Shintemirov

This paper highlights the method of designing a smarter human machine interface for a robotic arm which is controlled by a joystick. This was done by integrating a set of methods based on machine learning for automatic object detection, an estimation of its position which was done by RGB-D sensor using processing of the collected data. A three fingered mechanical gripper was used to grasp the target object. The movement of robot towards the object was started by selection of a desired element in the GUI.

The occlusion of a target object by the robotic arm is the key issue experienced during the implementation process. When the robot approaches a target object at a short distance and, subsequently, the manipulator closes part of the target object, an object recognition model can no longer provide stable performance.[21]

2.22 Object Detection and Recognition for a Pick and Place Robot by Rahul Kumar, Sunil Lal, Sanjesh Kumar and Praneel Chand.

In this paper, the authors presented the modelling and implementation of feature extraction algorithm and two classifiers for object recognition and detection. The major challenge faced in developing this image processing algorithm was that of making the test subjects in compliance with the classifier parameters, resizing of the images conceded in the loss of pixel data. Therefore, a centered image approach method was applied. The accuracy of the classifier developed in this paper was 99.33% and the accuracy for the feature extraction algorithm was 83.6443%. The overall system performance of the image processing algorithm developed by the authors after experimentation was 82.7162%. The authors developed an IP technique which will involve the FE (Feature Extraction) and classification algorithms suitable for object sorting task. The system developed was tested on a real time basis. Further the developed IP technique was used on SCORBOT ER-4U (robotic arm platform) which was refurbished and utilized to sort electronic components. This paper also covers the algorithms of feature extraction and classification. Further

discusses on the determination of object location and also portrays all the results carried out for the development of the algorithms.[22]

2.23 Review of ' Robot Motion Planning for Pouring Liquids' by Zherong Pan, Chonhyon Park, Dinesh Mnocha.

This paper presents a algorithm to provide a collision free trajectory for a robotic arm. Concepts of Computational Fluid Dynamics were used and the planning algorithm was made by taking into account the fluid dynamics constraints. The drawback mentioned was that the surrounding must be static and the target is fixed.[23]

2.24 Utilising Artificial Intelligence in Software Defined Wireless Sensor Network By Omolemo Godwill Matlou and Adnan M.Abu Mahfouz

This paper shows how a significant role is played by AI in our society. WSNs have been used in industries where reliability and network performance are very important for success. Improved network management, security in SDWSN which result in a more reliable network are achieved when AI algorithms are applied to SDN. One topic that has been researched very frequently in almost all research arenas by engineers and scientists is AI.[24]

2.25 Smart Robot Arm Motion Using Computer Vision by Bilal Iscimen , Huseyin Atasoy , Yakup Kutlu , Serdar Yildirim , Esen Yildirim

The combination of computer's vision and robotic arm is shown by the author in this paper to design a smart robotic arm system which can identify objects from images automatically and perform desired tasks. In this paper, a serving robot application was carried out in which specific tableware can be identified and lifted from a table. A new database was created by uploading images of objects used in serving a meal. Their study consisted of two phases: First phase includes the recognition of the objects through computer vision algorithms and determining the specified objects' coordinates. Second phase was the self-actuation of the robot arm's movement to the given coordinates. Artificial neural network was used for object recognition in this system. The authors have achieved an overall accuracy of 98.30%. Robot arm's joint angles were calculated by using coordinate dictionary for moving the arm to desired coordinates and the operation of the robotic arm was performed successfully.[25]

3. CONCLUSIONS

Hence, we have successfully reviewed several research papers published by different authors for the better understanding of the development of the Robotic Arm.

4. ACKNOWLEDGEMENT

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