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Visually Guided Parallel Manipulator for Pick and Place Operations in Industrial Automation.

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***Abstract* —Parallel Manipulators have brought a new level of flexibility to traditional automation tasks such as tabletop manipulation, but are not yet capable of the same speed and reliability as industrial automation. The paper approaches to 2D perception and manipulation that enable a general purpose robotic platform to recognize and manipulate the objects having random position and orientation on the conveyor belt, at a rate of 3.91cm/s for one pick-and-place operation, using a parallel manipulator.**

Keywords- parallel manipulator, perception, manipulation.

I. INTRODUCTION

Robotics is a leading branch of engineering which demands hardware, sensors, actuators and programming. For an autonomous robot, sensor fusion is important to perceive its environment. Without knowing the surroundings it is not possible for system to navigate around. An autonomous robot moves unsupervised. It obtains information of surrounding environments using its sensors and decides its course of action according to its programming without any external help. If the information provided is inaccurate or incomplete, it becomes hard for the robot to decide its next action. Robots featured with vision allows it to perceive its surroundings like human beings. So, the task is to develop a system for the purpose of object detection and size measurement which is cost effective. Many systems have already been implemented incorporating high- tech motors and drive systems. The result is a system which can be made to do a lot of different things. However, to develop such a system is expensive and difficult too. So, here is presented a plan to build an autonomous industrial system which is able to detect and locate the object on a continuous flowing conveyor belt having random orientation, pick it from the calculated position and place it to the desired location to make a module of solar cells(object). Many works had done for object detection. Those robots are efficient in the purpose of accuracy. But they are very costly. So we move in a direction where we can have a robot that is cost effective and good enough in its accuracy[1].

A. Related work

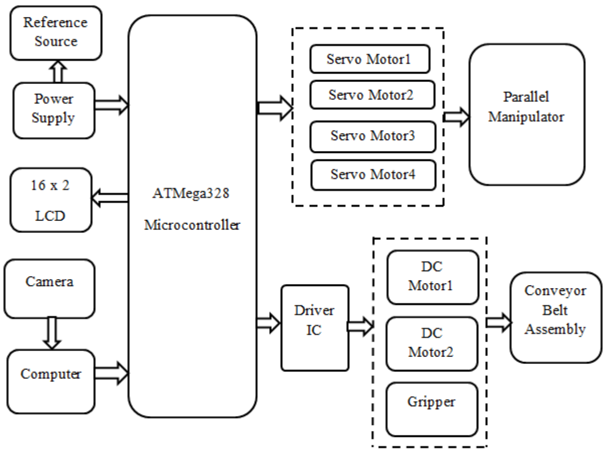
Two main categories of robot include Serial robot and Parallel robots. The serial robots have a single arm with many links. These links are connected to each other using a actuator making a joint. So each joint has an actuator giving it a motion. Motors are used as actuators. The major disadvantage of serial robots is that they accumulate the errors. The parallel robot overcomes this inaccuracy by averaging the errors [3]. Different types of sensors are often fused to detect the objects on the conveyor belts. For the detection of object two main ways exist. First is use of IR sensors. Active infrared sensors are the types of infrared sensor that emit infrared radiation which is later received by the receiver. IR sensors can be implemented in two configurations : Break beam sensors and reflectance sensors. In break beam type , IR sensor have emitter and receiver placed in such a way that the IR emitted by the emitter falls directly in to the receiver. During the operation, IR beam is emitted continuously towards the receiver. The flow of IR can be interrupted by placing an object between the emitter and receiver. If the radiation is completely blocked the receiver can detect it and provide the desired output. The reflectance types of sensors use reflective property of IR. The IR LED and the photodiode are placed side by side on the conveyor belt. The emitter emits an IR beam which is reflected by the object. The reflected IR is the detected by the receiver. The object causes change in the property of the reflected IR or the amount of IR received by the receiver varies. The degree of change is dependent on the reflectance of the object. But it shows some disadvantages for using its use in solar industries. It is universal that black colour absorbs the entire radiation incident on it hence the radiations once incident on the solar can not be reflected back towards the receiver. Also, as mentioned earlier the solar elements are very thin, 3mm in height. Hence, even if we try to use the breakbeam system the system may have chances of failure in detecting objects. The result of the IR sensor is affected by various external factors such as temperature change, sunlight. Fayaz Shahdib, Md. Kamrul Hasan used an ultrasonic sensor to easily detect presence of an object. These researchers proposed new technique which can detect an obstacle, judge its distance and measure the size of the obstacle using one camera and one ultrasonic sensor[4]. The technique is cheap in terms of sensor cost and in terms of computational cost. But the efficiency of the system in calculating the physical parameter was found to be lower.

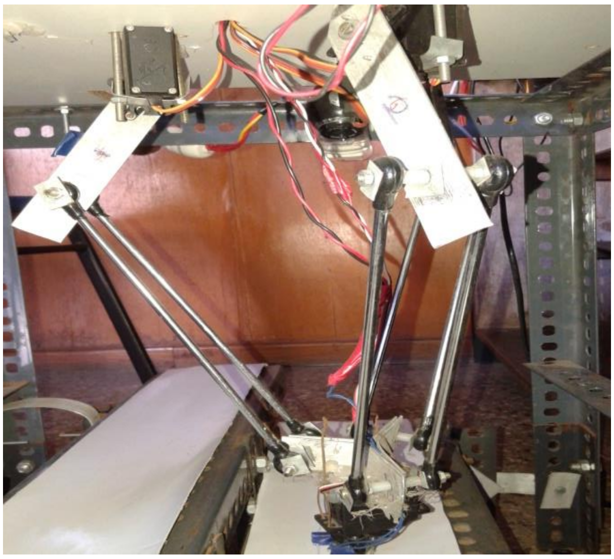
B. PROPOSED SYSTEM

Pick and place operation is achieved through following main stages

- Detection of object
- Calculating its positional information on conveyor belt
- Classification of objects
- Manipulation

The proposed system uses a parallel manipulator along with controller, camera, MATLAB tool, motors, drivers ICs, etc as shown in above fig 1(a). In this system, the pick and the place of the object at appropriate position is to be carried out. For this purpose the camera is used which is placed on the assembly. This camera is used to capture the images of incoming solar cells. Upon capturing image the positional information of that object is calculated by using suitable algorithm in MATLAB tool. The output of the image processing will be conveyed to microcontroller through serial receiver. The proposed visually servoed robot does not need to know a priori the position of objects in its workspace. It has integrated visual control systems to monitor precise product pickup and placement. This avoids positioning errors and incorrectly aligned products, thus reducing downtimes. Visual servoing is a rapidly maturing approach to the control of robot manipulators that is based on visual perception of robot and work piece location. More concretely, visual servoing involves the use of camera to control the position of the robot's end-effectors relative to the work piece as required by the task.





(a) **(b)**

Fig.1: (a) Block diagram of proposed system ; (b) Implemented Parallel manipulator.

The implemented parallel manipulator structure is shown in above fig.1(b). The Parallel Manipulator is a mechanical structure having three arms mounted on the steady platform in such a way that the three links are at 120 degrees each[2]. The movement of the links is carried out by the three servo motors. The system uses ATmega328 to control these servos as well as the conveyor belts. There are two conveyor belts one for the incoming solar cells and other for the outgoing solar panel (module). These conveyor belts are driven by the DC motors. A camera is mounted over conveyor belt. The captured images will be processed by the image processing tool MATLAB. The solar cells may have some inclination or may not be properly oriented. Hence it calculates its actual orientation and then conveys it to the controller. This in turn makes appropriate movement of robots and hence the end effector is positioned at the solar cell to be picked. The gripper attached to the end effector is an electromagnet to pick up the object. The camera can be a standard web cam of any resolution. However, it is preferred that the resolution is not too great, since a larger size of image would require more computation power. A 680 *480 camera has been used to take image and MATLAB for processing of that image. In MATLAB a continuous video is input; which is then converted to grayscale image for computational simplicity. Grayscale is an image in which the value of each pixel carries only intensity information. Images of this sort are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. After conversion to gray scale we have performed thresholding on the image to separate the object from the back ground. Thresholding is a simple method of segmentation. Thresholding can be used to convert grayscale images to binary images. Following the thresholding, we perform opening and closing on the image to eliminate all noises from the image. The term opening means to perform erosion followed by dilation on the image and closing is dilation performed before erosion. Opening removes small objects from the foreground of an image, placing them in the background, while closing removes small holes in the foreground. After isolating the object in the image we measure the dimensions of the object in the image. To calculate the position of object on the conveyor a reference source is used. The centroid of the reference is calculated. The images taken by camera are then checked for locating objects. Images in sequences are taken to inspect the location of object. Once the object lies in the vicinity of gripper the final centroid of object is calculated. With respect to the centroid of reference source the position and hence distance of object is calculated. Based on this, a logic is developed to classify the object location in the three linear patch and sub-block is calculated. According to this information the actuators are given the angles to set the motion of the manipualator and hence end effector. The sequence of operation is shown in following flowchart in fig 2.

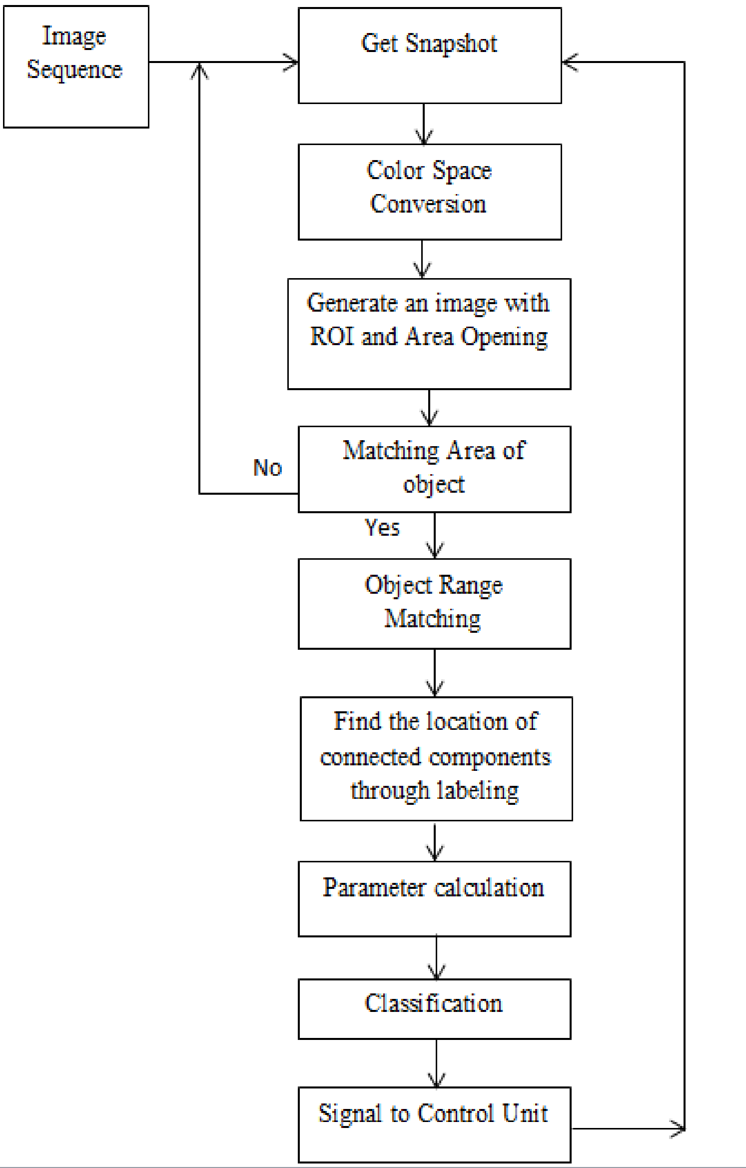


Fig.2 : General Workflow model of System.

A. Motion planning: Motion planning for pick-and-place of moving objects needs to be performed as fast as possible so the robot has enough time to execute the computed motions in time. So taking the workspace in consideration the linear part of the conveyor belt is found out where one of the actuator arm moves linearly in specific region. Three regions were then decided where end effector was moving linearly. Respected actuation angles are then calculated according to the output.

B. Manipulation: At start the manipulator arms, and hence end effector is positioned to initial position at the top. When an object is detected, the pick-and-place manipulation function gets called to pick up the approaching object and move it to a desired location. The manipulation function is comprised of three main components, namely grasping, motion planning and execution.

C. Grasping: Reliable grasping of an object by a robot's endeffector can be a difficult task given the uncertainty in each part of the system, from the object pose estimation to the robot's mechanical calibration. Additional problems arise when the object is moving at a fast speed. Once an object is detected, inverse kinematics is calculated to pick the object.. The process of picking up an object requires the end-effector to move between three different poses:

1. Pregrasp - An end-effector pose that is offset from the object.
2. Grasp - The pose of the end-effector in which it is in position to reliably pick the object.
3. Postgrasp - The end-effector pose after it moved away from the surface with the object grasped. The inverse kinematics is then used to compute a feasible motion for the arm that takes the end-effector from the postgrasp to the desired place.

D. Place Action: After the object is grasped and raised to the postgrasp, there is not much work left to do. The computed path with the upright orientation constraint on the endeffector is executed immediatly. After the end-effector is turned off electrically, allowing the object to be placed at the desired position, the arm returns to the waiting configuration.

III. EXPERIMENT

A. Computing Platforms

MATLAB has many advantages compared to conventional computer languages (e.g. C, FORTRAN) for solving technical problems. It also has easy to use graphics commands that make the visualization of results immediately available. The input to the computer is a continuous video signal. A personal computer incorporating MATLAB is used in this system for image processing of the image captured by the camera. The positional information as well as physical parameters of the object to be picked can be obtained from the image processing output.

B. Object Selection

For demonstration purpose an object of size 4.7cm in length and 1.6 cm in width is used. These objects also display a variety of orientations, which affects their localization and how the objects may be grasped.

C. Pick-and-Place

In the s grasp configuration, the manipulator's head is oriented so that it is looking down at the conveyor belt, and objects are placed on conveyor belt with random orientation and position. As soon as the robot begins to clear the work surface with an object picked, a new object is placed on the surface with varying position and orientation. The experiment conducted in the grasp configuration involved 20 pick-and-place operations in which the robot removes an object placed onto the work surface in front of it, and places the object on the second conveyor belt as per predefined positions. Of the 20 attempted actions, 17 were successful. The most common failure mode involved the object slipping out of the robot's gripper due to an insecure grasp. These 20 actions were timed yielding an average of 5.38 s per pick-and-place action.

III. RESULT

A Graphical User Interface has been constructed to display the calculated parameters. Centroid, length, width, area, angle and error in percentage these parameters are calculated and based on these parameters decisions are made. Following fig.3 shows the number of iterations and the calculated parameters. This GU shows that for the elements that have physical parameters more than required are eliminated. Out of eight iterations four iterations have been performed by the system. In third iteration the robot eliminates the solar cell (object) due to its excess size.

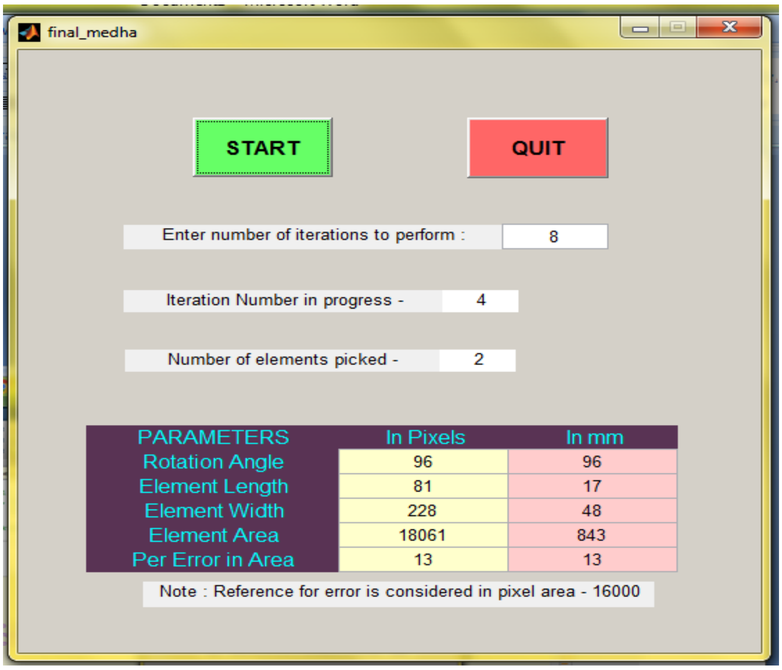


Fig 3: GUI showing the calculated parameters and iterations.

The system is designed to arrange the objects solar cells to form a module. As mentioned earlier the robot has been programmed to make 2 x 2 arrays. To make the array minimum 4 iterations are required. The constructed module is shown below in fig.4.

Fig 4: Arranged objects in 2 by 2 array.

The performance of system is evaluated by recording the number of attempts with different object positions and its orientation on the conveyor belt. Following table 1 shows no of attempts with objects at different locations and status column shows that whether the object has been picked or not.

Table 1: Attempts taken at various position and orientation.

Sr. No.	Positional Information			Status
	x	y	Angle(degree)	
1.	0	6	58	Picked
2.	0	4	49	Picked
3.	0	5	3	Picked
4.	1	1	177	Picked
5.	1	2	10	Picked
6.	1	3	4	Picked
7.	1	5	180	Picked
8.	1	1	45	Picked
9.	1	4	1	Picked
10.	0	6	37	Skipped
11.	2	4	0	Picked
12.	2	0	156	Picked
13.	2	3	34	Picked
14.	1	6	59	Picked
15.	2	1	123	Picked
16.	2	7	94	Picked
17.	2	0	78	Skipped
18.	0	7	22	Picked
19.	2	9	53	Picked
20.	1	7	28	Skipped

The error is calculated as (Total no. of attempts - no. of attempts succeeded to pick) / 100. From above table, it can be concluded that the system gives error of about 15% to pick up the object. The reason behind the failure is the undefined speed up of the DC motors.

Sometime it may happen that an object having undesired size may travel on the conveyor belt accidently. The system has been programmed to remove such unwanted objects. Another analysis was done to find that whether it is able to reject the unwanted object or not. The following table 2 illustrates it. It was found that the system provides enough good accuracy.

Table 2: Calculation of object parameters.

Expected values (mm)		MATLAB Output(mm)		Status
length	**width**	**length**	**width**	
35	45	39	48	Rejected
45	51	45	48	Rejected
50	35	47	30	Rejected
50	31	48	35	Rejected
25	15	-	-	Too small hence skipped directly

The main constraint of any system which defines its performance is time required to execute the task. During the execution, the time for different attempts for single iteration has been measured and the average time and velocity is calculated.

Table 3: Calculation of Speed.

Sr. no	Time (sec)	Average time (sec)	Speed
1.	5.42	5.358 s	3.91cm/sec
2.	5.55		
3.	5.20		
4.	5.25		
5.	5.34		
6.	5.25		
7.	5.20		
8.	5.25		
9.	5.45		
10.	5.67		

IV. CONCLUSION

The manipulators available in the market are very costly. So the proposed system is a step towards the low cost solution to industrial robot. This system automates the process of producing solar cell module by placing solar cells on the substrate. Many applications incorporating a parallel robot has been used in industries. It can be concluded that giving robots a perceptual systems can advance them working in undetermined environments. Pick-and-place operations have been demonstrated by the system which yield 85% success rate. The execution time is measured for single iteration and it is found that the system works at a rate of 3.91cm/s. After considering the limitations of IR sensor and other detection systems, complete detection of objects on the conveyor belt is completely done using image processing in spite of using sensor network to detect the object. This system can be customized easily to meet the needs of a wide range of wafer and solar cell handling tasks. Even subsequent changes typically only involve reprogramming. The optional integration of image processing systems provides efficient identification of objects and their position. Also instead of using hierarchical model based system, use of vision systems makes it faster and more accurate.

REFERENCES

[1] Viera Poppeova, Juraj Uricek, Vladimir Bulej, Peter Sindler, "Delta robots – robots for high speed manipulation", 'Technical Gazette 18', 2011, PP. 435-445.

[2] Y. D. Patel, P. M. George, "Parallel Manipulators Applications—A Survey", 'Modern Mechanical Engineering', 2012, 2, 57-64.

[3] Zoran Pandilov, Vladimir Dukovski, "Comparison of the characteristics between serial and parallel robots", 'Acta Tehnical – Bulletin of Engineering Tome VII Fascicule', ISSN: 2067 – 3809, 2014, PP. 143-160.

[4] Fayaz Shahdip, MD.wali Ullah ,"Obstacle Detection and Object Size Measurement for Autonomous Mobile Robot using Sensor", 'International Journal of Computer Applications (0975 – 8887)', March 2013,Volume 66– No, PP. 28-33.

[5] Filippo Sanfilippo, Domenico Prattichizzo,"Study of a parallel delta robot controlled via iPhone accelerometer", 'Università degli Studi di Siena', 2010.

[6] Anthony Cowley, Benjamin Cohen, William Marshall, Camillo J. Taylor and Maxim Likhachev, "Perception and Motion Planning for Pick-and-Place of Dynamic Object" .