A Review Paper on Introduction of Parallel Manipulator and Control System

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***Abstract*—The manufacturing community is on the cusp of a development and innovation, a revolution that largely will be driven by technology. It is vital to find the most cost-effective tools and processes to increase productivity and decrease costs within a set capital plan. Robotic automation is a significant part of manufacturing process. Image processing has become a highly adopted tool to improve the productivity of robotic automation in all industries and all facets of placement which offer tremendous flexibility. The the proposed paper gives comparison of the robotic structure such as serial and parallel manipulator and different technologies that have been implemented. The proposed paper introduces use of a mechanism that will automate the production of the solar panels. This objective can be achieved by using a delta robot along with control unit, image processing and a camera. The delta parallel manipulator is a mechanical structure that allows a rigid body (called end effector) to move with respect to a fixed base. The position and the orientation of the end effector can be described by its generalized coordinates which will be controlled by a control unit and image processing.**

Keywords: Image processing, parallel manipulator, serial manipulator .

I.INTRODUCTION

This is era of automation where each and every field is trying to automate the tasks. The robots are one of the key structures used in automation. A robot may be defined as a machine that perform various complex and often repetitive tasks; guided by automatic controls. Industries are the area where the automation is geared up to increment the productivity within given time period. One of such a industries is photovoltaic industry. The global photovoltaic (PV) manufacturing community is on the cusp of a resurgence in investment, development and innovation, a revolution that largely will be driven by technology. Robotic automation is a significant part of solar cell manufacturing. One of the tasks in PV industry is to mount solar cells on the supportive base made up of glass or any other substrate with gentle handling. This process can be done by using parallel manipulators.

1. Necessity:

In recent years, photovoltaic industry has been experiencing an enormous growth at the global level. The increasing costs of conventional fuels as well as the growing demand for Renewable Energy Sources (RES) are known to be the main drivers behind this rapidly expanding industry. Hence, robots in the photovoltaic manufacturing process are important due to their ability to significantly reduce costs while continuing to increase their attractiveness compared to manual labor[13].

History has shown that automation has played a significant role in reducing manufacturing costs in many manufacturing industries. Since the solar cells are fragile, in PV industries they must be handled precisely and gently. Parallel manipulators are suitable for such job which has good repeatability and accuracy. Hence we need an automotive system that will automate the process in PV industry [13].

2. OBJECTIVES:

The objectives of the proposed system are given below

- To select and design a parallel manipulator robot for a required workspace.
- To control the movements of the end effector by using a control unit.
- To develop a MATLAB code for the processing of the images captured by camera to calculate the positional information of the object to be picked.
- To obtain good repeatability and accuracy with high speed movements of the robot.

II. LITERATURE SURVEY

In 1942, Willard L. V. Polard designed and patented the first industrial parallel robot. The development of parallel manipulators can be dated back to the early 1960s, when Gough and Whitehall first devised a six-linear jack system for use as a universal tire testing machine. Later in1965, Stewart developed a platform manipulator for use as a flight simulator.

Since 1980, there has been an increasing interest in the development of parallel manipulators. The potential applications of parallel manipulators include mining machines, walking machines, both terrestrial and space applications including areas such as high speed manipulation, material handling, motion platforms, machine tools, medical fields, planetary exploration, satellite antennas, haptic devices, vehicle suspensions, variable-geometry trusses, cable-actuated cameras, and telescope positioning systems and pointing devices. More recently, they have been used in the development of high precision machine tools by many companies such as Giddings & Lewis, Ingersoll, Hexel, Geodetic and Toyoda, and others. The Hexapod machine tool is one of the widely used parallel manipulators for various industries[16].

It is in the early 1980's when Reymond Clavel comes up with the brilliant idea of using parallelograms to build a parallel robot with three translational and one rotational degree of freedom.

In 1987, commercializing of parallel robots for packaging industry. In 1999, Dr.Clavel is presented with the Golden Robot Award, sponsored by ABB Flexible Automation, for his innovative work on the Delta robot. The patent on the Delta robot was bought by the brothers Demaurex in 1996 [16].

ABB Flexible Automation launched its Delta robot in 1999 under the name IRB 340 Flex Picker. Three industry sectors were aimed: the food, pharmaceutical, and electronics industries. The Flex Picker is equipped with an integrated vacuum system capable of rapid pick and release of objects weighing up to 1 kg. The robot is guided with a machine vision system by Cognex and an ABB S4C controller. After nearly ten years research and experience in the field of packaging technology came Flex Picker IBR 360 with the second generation of Delta ABB robots. This second generation is even more efficient[10].

In 2004, the German company Bosch Group purchased the SIG and SIG Pack Division Demaurex and included it in their packaging technologies. Many Delta robot models have been developed by BOSCH, for example: XR31: higher performance and higher reliability, XR22: a combination of compact design and high accuracy, Paloma D2 built in stainless steel in order to meet hygiene standards and regulations for food industry. These robots have been placed in the following production lines:1) Mono Packer 2) LDM: A very flexible system used to place large volumes of products in containers directly from the manufacturing process. 3) Feed Placer: A system with a vision-guided high-speed Delta robot that accepts aligned or randomly oriented incoming product flow on a wide belt conveyor and it places the product directly into the moving flights of wrapper [10].

III. SYSTEM REVIEW

A robot is a reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks. Robots can be classified according various criteria, such as degrees of freedom, kinematic structure, drive technology, workspace geometry, motion characteristics, control. Serial robot consists of several links connected in series by various types of joints, typically revolute and prismatic. One end of the robot is attached to the ground and the other end is free to move in space. For a serial robot direct kinematics is fairly straightforward, whereas inverse kinematics becomes very difficult. Whereas parallel robot manipulator is composed of two or more closed-loop kinematic chains in which the end-effector (mobile platform) is connected to the fixed base platform by at least two independent kinematic chains. Between the base and end effector platforms are serial chains called limbs[1].The following table 1 shows the comparison between serial and parallel robots.

Table1: Characteristics of serial and parallel robot

Feature	Serial robot	Parallel Robot
Solving inverse kinematics	Easy	Very difficult
Position error	Accumulates	Averages
Stiffnes	low	High
Accuracy	Low	High
Dynamic characteristics	Poor	High

André Olsson implemented The PacDrive automation system by ELAU is used to control different applications with the same software. The applications is programmed with help by the program EPAS-4 and then transferred into a PacDrive controller which controls the motions of the different drives in the system. The PacDrive controller is the brain of the system where the program code is stored, which in turn synchronize and sends information over a SERCOS bus to the different servo drives (MC-4 motor controllers) connected to the system. Each servo drive then controls the motion of the motor shaft using the information from the PacDrive controller[18].

Narit Boonhaijaroena and Ratchatin Chancharoenb introduced walking of a delta robot in image space. It was designed for jogging direction of the robot to follow the trace using convolution technique. The elliptic convolution scanning is proposed to determine the walking direction from an acquired image the elliptic mask, that is best sit on the trace in image space, indicates the direction the robot should walk. The custom built system acquires and processes image at 30 fps. The walking command is then sent via TCP/UDP to the Delta robot's controller which is run at a much higher servo rate[19].

Another system was implemented using robot to play a game of checkers using DSPIC30F4013 using its PWM modules. It involved creating a GUI for two human players to interact with and have the robot carry out the players' actions on a physical checkers board. A more complex sytem using image processing software, the robot could then operate independently of any controlling computer implementation could have included giving the robot an artificial intelligence for checkers and play against the player. Another implementation involved having the robot draw pictures on a piece of paper using a magic marker.

Filippo Sanfilippo and Domenico Prattichizzo proposed an Arduino microcontroller to manage the robot via USB. They programmed the Arduino to read OSC serial messages, and an interface for the iPhone that reads the accelerometer's data and sends them to a server application via OSC messages. When the server receives them, it calculates inverse kinematics and sends the joint angles' values to the Arduino. The angles are used to drive the motors[3].

IV. PROPOSED SYSTEM

The main question that arises is what challenges do we encounter in today's industrial robotics field? As technology is progressing at exponential rates, so are the possibilities and applications of industrial robots. Kemp said that industrial robots are more successful than mobile and/or service robots because they work in a controlled environment. Without vision systems and sensory interfaces, robots have really no perception of their environment, reducing them to programmable machines but with poor added value. So a controlled environment is a prerequisite. By giving robots perceptual systems and tools they can advance in working under un-certain and undetermined environments. This paper proposes the use of delta robot controlled using image processing software and Ardino.

➢ HARDWARE REQUIREMENTS:

1. Parallel manipulator
2. Driver IC
3. DC motor
4. Microcontroller
5. Camera

- Parallel manipulator:

Mechanical systems that allow a rigid body (called end effector) to move with respect to a fixed base is a parallel manipulator .The basic idea behind the Delta parallel robot design is the use of parallelograms. A parallelogram allows an output link to remain at a fixed orientation with respect to an input link. The use of three such parallelograms restrains completely the orientation of the mobile platform which remains only with three purely translational degrees of freedom. The input links of the three parallelograms are mounted on rotating levers via revolute joints. The revolute joints of the rotating levers are actuated in two different ways: with rotational (DC or AC servo) motors or with linear actuators. Finally, a mechanism is used to transmit rotary motion from the base to an end-effector mounted on the mobile platform. The use of base-mounted actuators and low-mass link allows the mobile platform to achieve large accelerations up to in experimental environments and in industrial applications [10]. Mechanical structure of Parallel manipulator is shown in fig 1.

- The special nature of parallel axis robotic technology:

It is a mechanical system that allow a rigid body called end effector to move with respect to a fixed base play a very important role in numerous applications. The design of a Delta Robot is based on parallel axis geometry and is not tied to the conventional limitation of the human arm. Robots that follow the traditional principle usually have a clumsy appearance and are relatively slow. Delta Robots operate on a

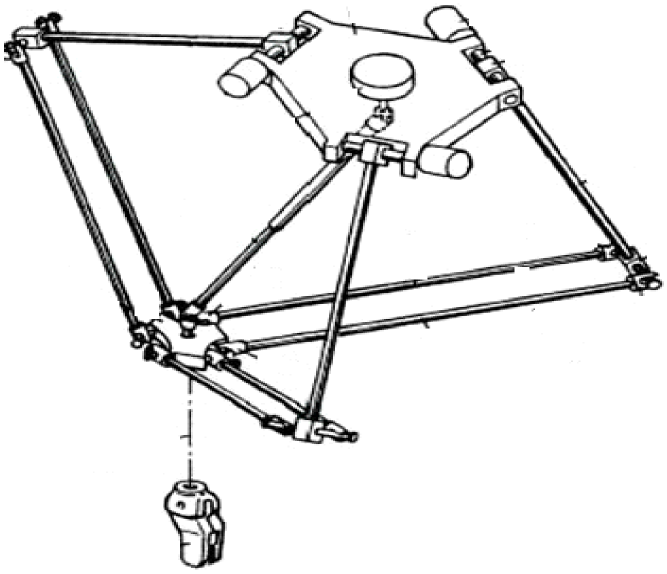


Fig 1: Mechanical structure of Parallel manipulator[10].

completely different principle and their appearance is similar to an inverted three-legged tripod. The three segments or "arms" move independently of one another but share a common connection. The "robot hand" is moved by either extending or retracting one of the segments. This means that Delta Robots can reach every point within their range at the same speed. In contrast to conventional robots, Delta Robots do not need to struggle against gravitational and inertial forces and are thus capable of high speeds. Delta robots can also be equipped with various grippers depending on the application and product type. The most common are vacuum suction cups, whose characteristic features are high speed, precision and gentle product handling. With intelligent vacuum technology, these suckers can even pick up and precisely put down even soft products such as chewy sweets. The system operates with highly modern tracking and programming software, which turns the Delta Robots into highly developed packaging technology [4].

- Visual control systems for more transparency:

Modern manufacturing robots can perform assembly and material handling jobs with speed and precision, yet compared to human workers robots are at a distinct disadvantage in that they cannot ' see' what they are doing. The problems conventional robot manipulators may be summarized as:

1. It is necessary to provide, at considerable cost, highly structured work environments for robots.
2. The limited accuracy of a robot frequently necessitates time-consuming manual teaching of robot positions.

A visually servoed robot does not need to know a priori the coordinates of its workpieces or other objects in its workspace. Delta Robot solutions include 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 workpiece location. More concretely, visual servoing involves the use of one or more cameras and a computer vision system to control the position of the robot's end-effectors relative to the workpiece as required by the task.

- SOFTWARE REQUIREMENT:

- MATLAB Tool:

A personal computer incorporating MATLAB is used in this system for image processing of the image captured by the camera. A MATLAB code is to be developed using this software. The positional information of the object to be picked can be obtained from the image processing output.

- CONTROL SYSTEM:

For a given robot the only parameters necessary to completely locate the end effector of the robot are the angles of each of the joints or displacements of the linear axes. However there are many different ways to define the points. The most common and most convenient way of defining a point is to specify a Cartesian coordinate for it, i.e. the position of the 'end effector' in mm in the X, Y and Z directions relative to the robot's origin. In addition, depending on the types of joints a particular robot may have, the orientation of the end effector in yaw, pitch, and roll and the location of the tool point relative to the robot's faceplate must also be specified. For a jointed arm these coordinates must be converted to joint angles by the robot controller and such conversions are known as Cartesian Transformations which may need to be performed iteratively or recursively for a multiple axis robot. The mathematics of the relationship between joint angles and actual spatial coordinates is called kinematics[8].

Such a control system is shown in following fig The three Drivers control one motor each to actuate the three arms at the Delta-3 robot. From Fig.2, Controller unit calculates inverse kinematics of reference position x,y,z of moving platform in delta robot , actuators drive servo motors under the effect of controller leading the end effector to the target point in minimum time and no error as possible[8].

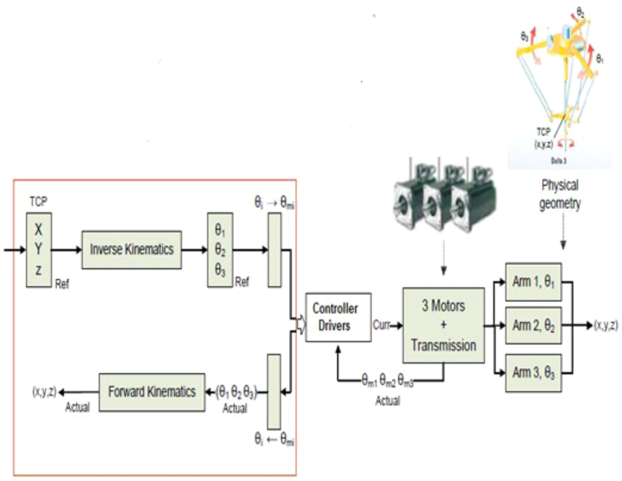
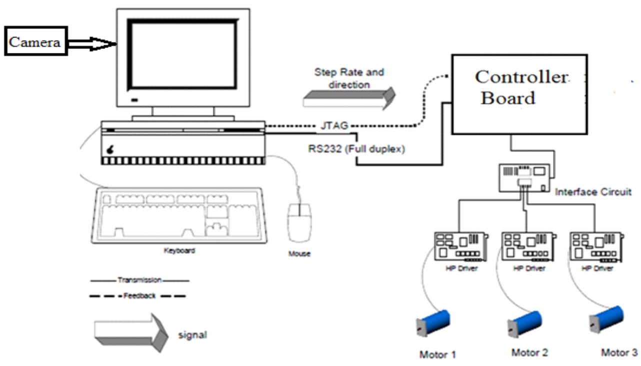


Fig 2: Control system[8].

- SCHEMATIC OF SYSTEM AND WORKING:

The proposed system uses a parallel manipulator along with controller, camera, matlab tool, motors, drivers ICs, etc as shown in above fig 3. 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 will be placed on conveyor belt. This camera is used to capture the images of incoming solar cells. Upon capturing image the image processing will be carried out on that image to calculate the positional information of that object by using suitable algorithm in MATLAB tool. The output of the image processing will be conveyed to microcontroller through serial receiver RS232.



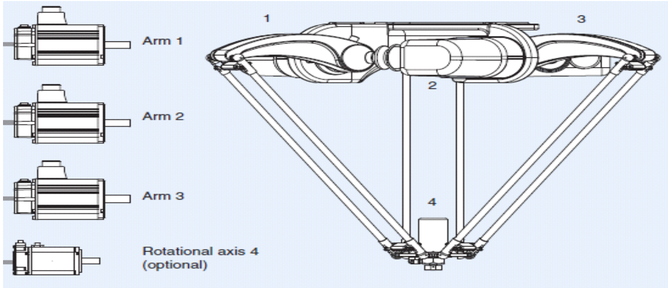


Fig 3: Schematic of system

Depending upon the information provided the microcontroller will generate the output signal to control the movements of motors used in parallel manipulator. According to the movements of the motor the end effector is posed to the required position and the end effector will perform the pick operation.

IV.CONCLUSION

The aim of proposed system is to develop a mechanism that will automate the production of the solar panels. This objective is to be achieved by using a delta robot along with control unit, image processing and a camera. By anlaysing above comparison it is clear that parallel robots offer potential advantages compared with serial, with higher overall stiffness, higher precision and higher operating speeds and accelerations. Many applications incorporating delta parallel robot has been used in industries. Giving robots perceptual systems they can advance in working undetermined environments.

The system proposed thus incorporates the parallel delta manipulator along with control unit and image processing. This system automates the process of producing solar cell module by placing solar cells on the glass substrate. 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.

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