Design and Fabrication of Cartesian System Integrated with Machine Vision

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***Abstract*: The work is intended to build up a Cartesian organize automated framework for pick and drop a pre-designed article originating from the conveyor or non-moving part to the predefined compartment. Because of the work space limitation different mechanical framework like Articulate, Cartesian or Gantry, Delta, SCARA (Selective Compliance Assembly Robot Arm) are uncovered. In light of the improvement the Cartesian mechanical framework is exceptionally appropriate for this application and it is chosen for pick and drop an article in productive way on rectangular territory. Here the Cartesian automated framework is constrained by an Arduino joined with CNC shield. Microcontroller utilizes kinematic calculations to keep up position control on actuators. The camera is put at the highest point of the framework which center the transport framework. The length and expansiveness of the object got from the camera is characterized in the program. By utilizing this predefined measurement, the Geometric codes for every pixel from the camera see is aligned. Here python coded program makes a sequential correspondence between the camera and the microcontroller which sends the order to the CNC controller to control the stepper motor and to control the end effectors.**

***Keywords*: Arduino, Camera , Cartesian , Framework, Geometrical codes, Python.**

1. Introduction

Modern robot as characterized by ISO 8373: An automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either, fixed setup or versatile for use in mechanical robotization applications. It ought to be structured with high endurance, speed, and precision for the accompanying reasons:

- Improving nature of work for representative
- Increasing production output rates
- Improving product quality and consistency
- Increasing adaptability in product fabricating
- Reducing working expenses

A mechanical robot tasks indicated activities dependent on details for characterized movement. The most basic application of an modern robot is pick and place operation in which it picks up a part at one location and moves it to another location. For pick and place operation, one of the major element in the specifications of task is kinematics. For the accurate analysis and less kinematic calculation, the Cartesian coordinate robot has been chosen with 3 degree of freedom, working in X, Y and Z axis. Due to the need of a modular structure so that, the components of the robot can be easily substituted and removed without disturbing the whole structure. For instance in this system, we have added an end-effecter in Z axis which is now a suction cup and an Electromagnet for pick and place mechanism.

Regardless the strong structure ought to be financially savvy and simple to control which prompted the decision of a Gantry robot. The task is portrayed in different areas like controlling the Arduino, Methodology, Machine vision camera, transport framework and end effectors. The benefit of this pick and place gantry robot are its abilities to move in X, Y and Z axis and no kinematic computation. It is anything but difficult to program and works precisely. The payload is more. The principle objective of this undertaking is to pick objects with various shading and shapes and place in particular compartments. This is assessed utilizing the base gantry framework, transport framework, camera vision and Arduino.

2. Literature Review

i. Nischay kumar Hegde (2018), learning in fundamentals of python programming.

ii. Yousif Mohsin Hasan , et al., (2018), in their work in 3-Axis Plotter Machine by using Arduino Uno and CNC Shield concluded that a 3 axis system actuated using stepper motor can be controlled by using Arduino Uno and a CNC shield. The movement of 3 axis is done by sending G-code using Universal G-code sender software.

iii. Shubhi Thatere, et al.,(2016), in their work they have done a Gantry robot system using DC motors. And they have used Proximity sensors to detect the metal Obstacles which are passing them. From this, we came to know about the way to control the DC motor and how proximity sensors work.

iv. Sofu M M, et al.,(2016), in their experiment it is well known about the basic algorithm concept for pick and place operation using machine vision is known.

v. *Mohamed Y Tarnini (2015),* carried out a study on the use of stepper motor and its characteristics. Many drivers such as H bridge, Polulu drivers etc, are used to control the stepper motors. From this a wide knowledge on Stepper motor driver were known and a little knowledge in DC motor controlling is also obtained.

vi. Yusuf Abdullahi Badamasi (2014), the purpose of this study was to gain knowledge about the Arduino Board's hardware components and software used to program it. From this we came to know about the

Arduino IDE software which is used to send the program to the Arduino.

3. Methodology

The aim of this project, 'Implementing Machine vision in Cartesian system' is to design, fabricate and bring functionality to a XYZ axis gantry robotic system which performs pick and place operation that could reduce labor and improve productivity in the manufacturing companies by producing the machine with low cost compared to the conventional automated machines. The Flowchart of the Methodology is shown in Fig. 1.

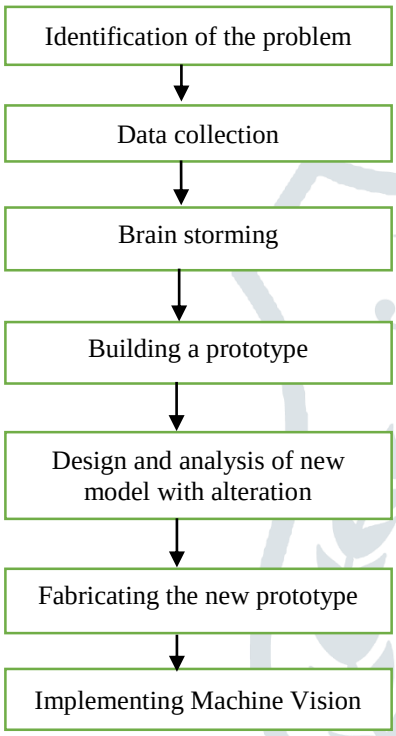

Fig. 1. Methodology

1) Identification of the problem

High-speed pick and place robots take product from one location to another with pinpoint accuracy. Human pick and place applications can require repetitive motion over a long duration resulting in possible ergonomic issues. So to do errorless operation, robots are introduced to automate pick and place operation with high level accuracy and high consistency.

2) Data collection

Large amount of data's where collected in related to robotic system, about microcontroller, actuators and machine vision. From the data collected so far been helpful in building a automated pick and place robotic system. Data's which are collected so far are shortlisted and particular data were gathered which are required to build the system. The data's which are collected and shortlisted to build this system.

3) Brain storming

After all the data's are collected so far a clear cut planning is done. In this brain storming stage all the problems were discussed with the team members and with the guidance of staff, critical problems were solved. After a complete discussion, it is desired to do XYZ axis pick and place robotic system integrated with machine vision capability.

4) Building a prototype

For building a mini prototype, all the materials were purchased. After some machining work all the components were assembled and electronic board connections[10] are done. By using a software which helps us to send G-code command to the system. By using Arduino Uno[9] we have controlled 3 axis of the system.

During the test run of the prototype we came across some problems such as,

- High friction in rollers during the movement of X, Y and Z axis.
- The system is unstable due to improper support.

To overcome these problems we have planned to replace plastic rollers in the place of bearings to get smooth motion in X,Y and Z direction. And to make the system stable we have planned to increase the support and to replace 20mmx20mm aluminium extrusion with 20mmx40mm aluminium extrusion.

5) Design and analysis of new model with alterations

In this new design prototype as shown in fig. 2, the system size has been increased and the problems that arose during previous prototype has been solved by replacing linear guide rail in the place of plastic rollers and in which the system will be stable and travels smooth in X,Y and Z direction.

The new system after fixing linear guide rail, the system is tested at its high speed and at its maximum load. During the testing, it is found that this system can hold upto 5N in the Z axis carriage. The X axis and Y axis carriage is also tested with 3N load.

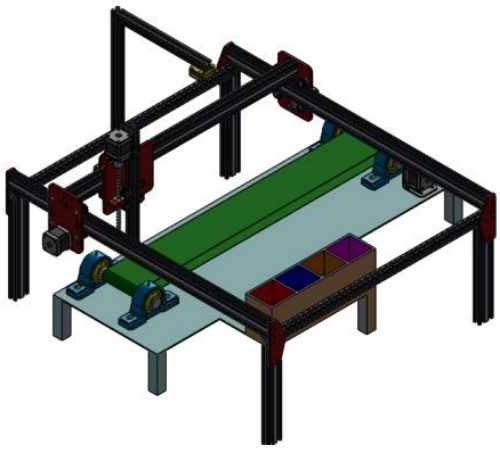

Fig. 2. Conceptual design

6) Fabricating the new prototype

For new prototype the materials are bought and machining of motor mount, pulley mount, limit switch mount, stand for the system is done. The new linear guide rail is fixed over aluminium extrusion in X,Y and Z direction. The timing belt is fixed between motor and idler pulley.

For the passage of the product which has to be picked and placed, a new conveyor system lengths 1meter has been built and in attachment to this 4 containers are made to store the segregated products. The Frame of the conveyor system is made of 30mmx30mm aluminium extrusion.

The system is also built with interchangeable end effectors. The end effectors used in this system is Electromagnet[2] and Pneumatic suction. We can change the end effectors as per the products which travels through the conveyor.To separate magnetic particles Electromagnets are used and to separate Ferro magnetic particles suction mechanism is used.

7) Implementing Machine Vision

After total mechanical setup is completed, a new separate stand to hold Machine vision camera is made and fixed in a stationary position. In the electronic setup we have used Arduino board and CNC shield is used to control the whole system. The Python program is written as per the required function to be carried out by the system. The python program[6] for machine vision[8] is uploaded to the Arduino and while performing the pick and place operation, from the input data captured from the machine vision camera is sent to the Arduino from the Arduino the python does the pick and place operation as per the program created.

4. Materials

A) Structural Frame

In this project, the base frame[7] used is Mild steel stand and Aluminum extrusion of 1000mm x 800mm dimensions representing X and Y axis of robot with the Linear Guide rail for the movement of the end effector in X and Y directions as shown in the Fig. 3. The motions from one position to another are taking place using NEMA 17 Stepper motors[5] which is controlled by using A4988 Driver with Arduino which works on 12 volts. The Stepper motor used in X and Y axis with 4.2 kgcm torque and 1.7 amperes current. On the Z axis, the end effectors is connected which is vacuum suction cup and an Electromagnet. The minimum position is configured using Limit switches in X, Y and Z axis.

Fig. 3. Structural frame

B) Conveyor system

The conveyor system[4] is basically to place metal and non-metal object from where the end effector will pick the metal which will be detected through the Machine vision camera fixed to top of the conveyor. The system shown in the Fig. 4 is driven by a 12V geared DC motor of 10 rpm, torque of 90 Kg cm and current of 4.8 amperes.

Fig. 4. Conveyor system

C) Microcontroller

The system is fully controlled by Arduino board. The X,Y and Z axis movement is achieved by using stepper motor drive[3], CNC shield[1] fixed above the Arduino board[9]. The DC motor in Conveyor system, Electromagnet and Solenoid to control the vacuum suction cup are connected with the Relay modules and controlled by Arduino Board.

D) End effectors

It is attached to the bottom of the z-axis which consists of electromagnet[2] and suction cup for pick and place the object, where the electromagnet is powered by 12V- DC supply and suction cap is controlled by the solenoid valve (one end is attached to the compressor and another end is attached to the suction cup) which is actuated by the dc supply.

5. Result

The Products are lined up and travels through the conveyor system. When the products comes to the machine vision camera range, the color of the product is detected and the information is passed to the controller. The controller controls the XYZ direction and end effector's function. It sends the command to move the end effector to the respective position by moving XYZ axis. At this position the end effector is powered up and thus electromagnet or pneumatic suction operation is carried out and thus picks the product. The picked product is placed to the respective container which is already preprogrammed a separate location for the specific colors. Likewise, the products which are passed through the camera range with different specified color has been picked and placed in the respective containers and at last the segregated products are taken.

A) Machine Vision

In this system, relays and microcontrollers are used as controllers instead of PLC system. The system also has machine vision capability. A 720 pixel camera is fixed at the top of the system which covers the conveyor system through which the objects moves. The system will do pick and place objects which are different in colors and shapes. The machine vision camera is integrated with the python program[6]. The machine vision camera will get the image of the object as shown in Fig. 5 and the python program helps in detecting the color and shape and also calibrates the individual position of the object even when there are different color or shape objects in single camera frame.

Fig. 5. Detecting object based on shape by using Machine Vision

B) Fabricated prototype

The gantry robot is fabricated with good industrial practices the prototype[7] was designed such that it will have better performance while in operation. The fabricated prototype is shown in Fig. 6.

SI. No	Description	units
1	Maximum acceleration X axis	35mm/sec^2
2	Maximum acceleration Y axis	25mm/sec^2
3	Maximum acceleration Z axis	10mm/sec^2
4	Total weight	25 kg

No of trails	Manual process (Minute)	Produced model (Minute)
Trail 1	20	25
Trail 2	22	25

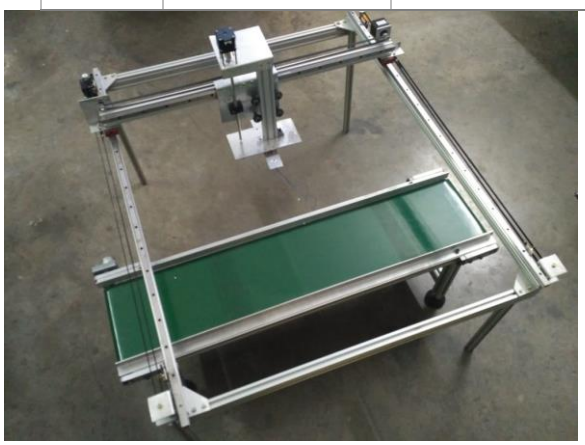

Fig. 6. Fabricated prototype

C) Working

i. Initially the systems and software's are pre checked for safe working and the objects to be picked and placed will be lined up in the conveyor.
ii. The objects lined up in the conveyor will be in different shape, color and possess magnetic or Ferro-magnetic property.
iii. The system will be in home position and when the conveyor starts moving, the objects start travel through the conveyor belt.
iv. A machine vision camera is been placed above the conveyor system which helps in detecting the object and gives input to the system controller.
v. Here Arduino helps in controlling the whole system. The Python program for this system is done and uploaded in the Arduino board.
vi. In this program, we have predefined some set of instructions in detecting the object so that the system will perform only those instructions and we can modify or add new instructions for later use.
vii. The objects coming through the conveyor will be detected by the machine vision camera, and after that the X,Y and Z axis moves accordingly and comes to the position exact above the object.
viii. At this time the end effector gets powered up and picks the object. The picked object is then moved near to the respective container to be placed. After going to the position, the end effector's power will cut off so that the object will be dropped in the container.
ix. And then the system comes to pick the other object directly from the dropping position. The process will continue until all the objects are travelled through the conveyor.
x. And then at last the segregated objects can be taken out.

D) Specification

The overall specification of gantry robot system is given in Table 1.1. The overall weight of the machine is low so it is easy for handling and portability. The comparison of time consumption between manual and automatic procedure is shown in table 1.2.

Table 1.1 Specification

Table 1.2 Comparison of time consumption between manual and automatic

6. Conclusion

The development of the gantry robot system proved that the usage this machine will be more effective than the manual pick and place process. As per the test conducted in the different process the developed machine reduces 25 % of the time consumed by the manual. In order to increase the efficiency of the process, two or more system can be introduced to pick and place more objects with fast moving conveyor. The design is simple and more effective for the

regular usage of the gantry robot. With the help of the gantry robot the pick and place operation can be automated and the production lead time can be reduced by increasing its productivity. The further development of the gantry robot involves the replacement of servo motor instead of the stepper motor which makes the feedback system easier.

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