Design and Development of Low Cost Pick And Place Cartesian Robot with use of Servo Gripper

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ABSTRACT- The rapid development of robot-based automation technology provides convenience in a variety of processes, both in the aspect of improving the quality and quantity of the production process. One example of an industrial robot application of this system is a robotic manipulator with a Cartesian configuration type, which low-cost, Python integrated open loop controlled Cartesian robot for the small and medium scale industries. Palletizing is one of the basic requirements of the production industry, Palletizing will be monotonous job for the humans. Hence robots are very essential for the repetitive jobs. Robot size will be X-300, Y-300, Z-300 all axis will be equipped with the Nema17 stepper motors. Belt drive will be used for the Transmission. And reputability of the robot will be around 0.2mm and velocity 1m/min.

Index Terms- Cartesian robot,Industerial,low cost,Pick and place,Python,Nema17 stepper motor

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1 INTRODUCTION

A robot is a machine especially one programmable by a computer capable of carrying out a complex series of action automatically. Robots can be guided by an external control device or control may be embedded within. Robots may be constructed on the lines of human form, but most robots are machines designed to perform a task with no regard to their aesthetics.

1.1 DIFFERENT TYPES OF ROBOTS

Articulated - This robot design features rotary joints and can range from simple two joint structures to 10 or more joints. The arm is connected to the base with a twisting joint. The links in the arm are connected by rotary joints. Each joint is called an axis and provides an additional degree of freedom, or range of motion. Industrial robots commonly have four or six axes.

Cartesian - These are also called rectilinear or gantry robots. Cartesian robots have three linear joints that use the Cartesian coordinate system (X, Y, and Z). They also may have an attached wrist to allow for rotational movement. The three prismatic joints deliver a linear motion along the axis.

Cylindrical - The robot has at least one rotary joint at the base and at least one prismatic joint to connect the links. The rotary joint uses a rotational motion along the joint axis, while the prismatic joint moves in a linear motion. Cylindrical robots operate within a cylindrical-shaped work envelope.

Polar - Also called spherical robots, in this configuration the arm is connected to the base with a twisting joint and a combination of two rotary joints and one linear joint. The axes form a polar coordinate system and create a spherical-shaped work envelope.

SCARA - Commonly used in assembly applications, this selectively compliant arm for robotic assembly is primarily cylindrical in design. It features two parallel joints that provide compliance in one selected plane.

Delta - These spider-like robots are built from jointed parallelograms connected to a common base. The parallelograms move a single EOAT in a dome-shaped work area. Heavily used in the food, pharmaceutical, and electronic industries, this robot configuration is capable of delicate, precise movement.

CARTESIAN ROBOT

A cartesian coordinate robot is an industrial robotwhose threeprincipal axes of control are linear and are atright angles to each other. The three sliding joints correspond to moving the wrist up-down, in-out, back-forth. Among other advantages, this mechanical arrangement simplifies the Robot controlarm solution. It has high reliability and precision when operating in three-dimensional space. As a robot coordinate system, it is also effective for horizontal travel and for stacking bins.

Cartesian coordinate robots with the horizontal member supported at both ends are sometimes called Gantry robots; mechanically, they resemble gantry cranes, although the latter are not generally robots. Gantry robots are often quite large.

2 LITERATURE SURVEY

M .Cianctietti et.al, they get inspired by the Octopus to and make an interesting model in robotics due to its high dexterity, variable stiffness and very complex behaviour. In this experiment they study the key features and patterns of movement of Octopus arm and this features and patterns and patterns of movement are that is elongation, shortening, bending and reaching etc. used for guide the movement of actuator. They conclude that the concept

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proposed for the mechanism at the base of the robotic arm inspired to the Octopus muscular hydrostat where successfully implemented on mock-ups and the corresponding models have been modified and validate [1].

B.O. Omijeh et.al

In paper The design of a Remote Controlled Robotic Vehicle this has been completed. A prototype was built and confirmed functional. This system would make it easier for man to unrivalled the risk of handling suspicious objects which could be hazardous in its present environment and workplace. Complex and complicated duties would be achieved faster and more accurately with this design [2].

Catalin Stefan Teodorescu et.al

The project focuses on a newly built research platform (a robot). Using its vision system, it can identify round objects that are randomly scattered on a table. Then, using its gripper they are picked and placed inside a basket. The control system is tuned such that, the succession of operations runs fast and safe. In this paper we present how this has been achieved: going from concepts to design, validation in simulation and eventually experimental validation. Lessons learned can save time for other parties interested in building prototype robots [3].

Mr.Aaditya Manoj Sonawane et.al

In this paper the design of a remote controled Robotic Vehicle has been completed. A prototype was built and confirmed functional. This system would make it easier for man to unrivalled the risk of handling suspicious objects which could be hazardous in its present environment and workplace. Complex and complicated duties would be achieved faster and more accurately with this design the use of Robots is highly recommended for industries especially for safety and productivity reasons. In their design work, they included a Robotic arm of five Degree of Freedom with its base resting [4].

Darren M. Dawson et.al

A Lyapunov based control strategy is proposed for the regulation of a Cartesian robot manipulator, which is modelled as a flexible cantilever beam with a translational base support. The beam (arm) cross-sectional area is assumed. A Lyapunov-based control strategy is proposed for the regulation of a Cartesian robot manipulator, which is modelled as a flexible cantilever beam with a translational base support. The beam (arm) cross-sectional area is assumed to be uniform and Euler-Bernoulli beam theory assumptions are considered. Moreover, two types of damping mechanisms; namely viscous and structural damping, are considered for the arm material properties [5].

Miomir Vukobratovic´ et.al

In this paper, the problem of simultaneous stabilization of both the robot motion and interaction force in cartesia space, based on the unified approach to contact task problem in robotics, is considered. This control task is solved under the conditions. In this paper, the problem of simultaneous stabilization of both the robot motion and interaction force in Cartesian space, based on the unified approach to contact task problem in robotics, is considered. This control task is solved under the conditions set on environment dynamics which are less restrictive than those in where some particular environment properties are required to ensure overall system stability. Furthermore, the one-to-one correspondence between closed-loop motion and force dynamic equations is obtained and unique control law ensuring system stability and present either motion or force transient response is proposed [6].

3 OBJECTIVES

- To design and Develop Cartesian robot.
- To develop low cost cartesian robot for Small and Medium scale industries.

4 SCOPE OF PROJECT

- It is used for Pick and Place Applications in Industries.
- Low cost design.
- It can be used for small scale industries.

5 MATERIAL AND METHODOLOG

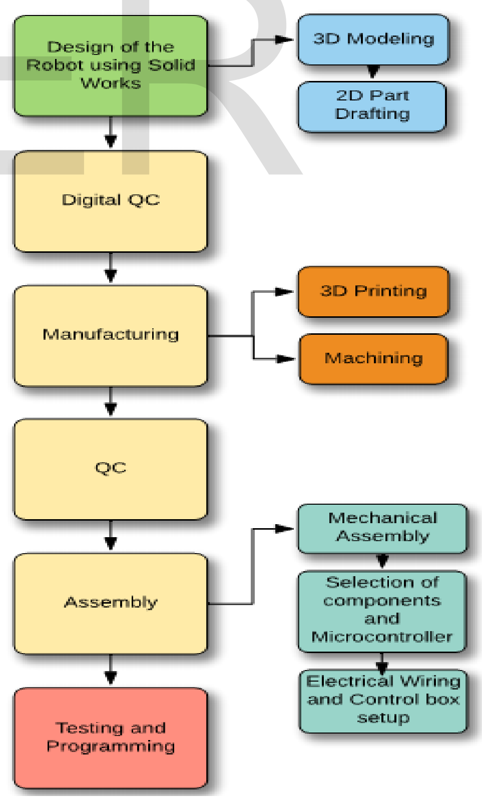

Fig 5:Methodology of robot

The materials and methodology section describe in detail all the materials that have been used in the project to conduct a study as well as the procedures that are undertaken.

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The Materials which were used to Design and Develop the Gantry robot for Nursery Seed Sowing Application consists of Mechanical and Electronic Components and are listed below.

6 COMPONENTS USED:

6.1 Mechanical Components:

1. 20x20 Aluminium Profile
2. Acrylic
3. Flexible Coupling
4. GT2 20T Timing Pulley
5. GT2 Open Belt
6. Rod-10
7. SC10UU Bearing
8. SHF10 End support
9. T8 Lead Screw
10. Wheel with Bearing

6.2 Electronic Components:

1. Ardunio Mega Microcontroller Board CNC Shield
2. Control Software Cartesian Robot
3. Switched-Mode Power Supply (SMPS)
4. Proximity Sensor
5. Stepper Motor
6. TB6600 Stepper Motor Driver Controller
7. A4988

7 EXPECTED OUTCOME:

- Fast and accurate pick & place operation
- Reliability & Customized design
- Programmable

8 EXPERIMENTAL WORK

8.1 Design calculations

8.1.1 Screw Rod Calculation

Helix Angle: $\alpha = \tan^{-1}\frac{l}{\pi D}$

Where l: lead in mm

D: pitch Dia i.e $D = \text{given dia} - \frac{P}{2}$

P: pitch in mm

Torque: $T = \frac{FD}{2}\left(\frac{\mu\pi D + l\cos\alpha}{\pi D\cos\alpha - \mu l}\right)$

Where μ:coeffecient of friction

F:force / load carrying capacity

Problem:

Given Dia = 8mm

Lead=8mm

T=280Nmm

$\alpha = \tan^{-1}\frac{8}{\pi\times 7}$=19.99≈20

280=$\frac{F\times 7}{2}\left(\frac{0.07\pi 7 + 8\cos 20}{\pi 7\cos 20 - 0.07\times 8}\right)$

F=177.58N

F=18.10kg

But practical load carrying capacity, F=9.05kg

8.1.2 Pulley Calculation

Torque: $T = \frac{FD}{2\eta i}$

Where F: force

D: Dia of pulley

i:gear ratio

η:effeciency of motor

Problem:

Given D=12.22mm

T=280mm

280=(FX12.22)/2=45.82N

Load Carrying capacity 4.67kg

Velocity:

$$P = \frac{Fv}{1000}$$

where, F in Newton, v in m/s and P in kW

9 Modelling:

The complete 3D modelling and drafting was done by using solidworks2016 software. A total of 22 parts was designed (12 designed and 10 brought out), which was merged into three sub-assemblies as three of them are prismatic joints. Which was further assembled to get the final assembly of the Cartesian Robot. All the three sub-assemblies and the final assembly is shown below.

9.1 Y & Z-Axis Prismatic Joints:

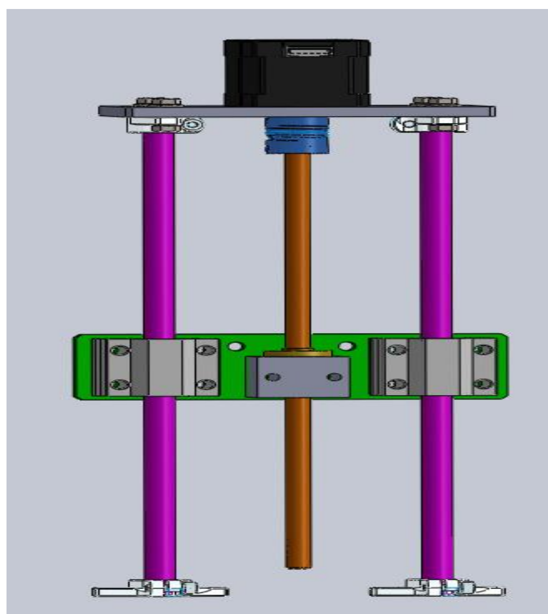

Fig 9.1: Y&Z-axis

This figure shows the isometric view of the Y&Z axis (Prismatic joint) of the robot. The assembly consists of a carriage plate (140*40mm), Motor plate (120*60mm),

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flexible coupling (5 to 8), hex bolt and nut (16 and M6), Bearing rod (10*300mm), screw rod (3*8mm), nut holder (30*25*25mm) NEMA 17 stepper motor.

9.2 X-Axis Prismatic Joint:

This figure shows the isometric view of the assembled X axis (Prismatic joint) of the robot. The assembly consists of an End plate (83*91mm), Motor plate(83*91mm), An Aluminium profile(150mm long), pulley(GT2 20T), hex bolt and nut(16 and M6), NEMA 17 stepper motor.

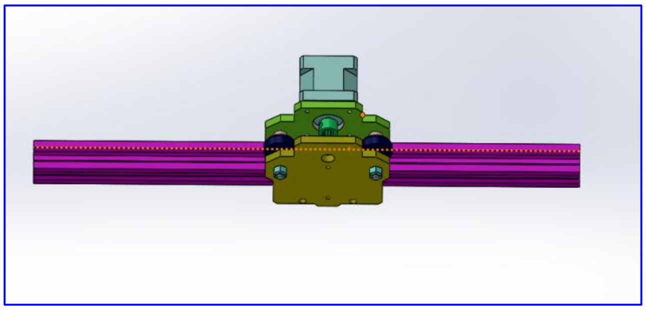

Fig 9.2 :X-axis

9.3 Final Assembly:

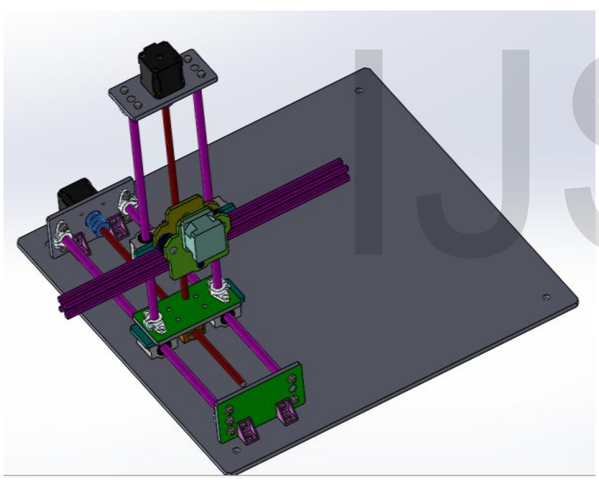

Fig 5.2.3: Assembled Model

The above figure is the isometric view of the final assembled model of the cartesian robot where all the three sub-assemblies are fitted on to the base plate of dim (500*500mm).

9.4 2D Drafting :

Drawings can be created either from parts or assemblies. Views are automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards.

The 2D drafting of few of the designed parts are shown below, it is used mainly for creating the exact dimensions of the different parts.

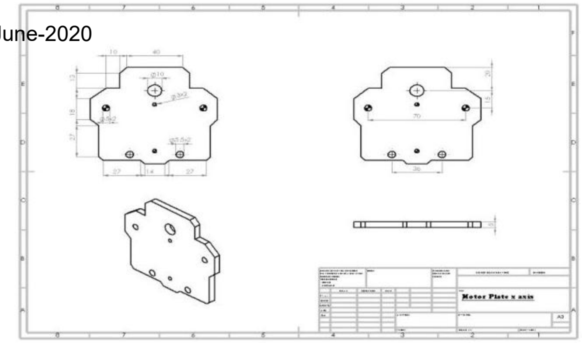

Fig 9.4.1 Motor plate X axis

The front, side and Isometric view of the motor plate is shown in the above figure and this 2D is used for creating exact dimensions of the motor plate.

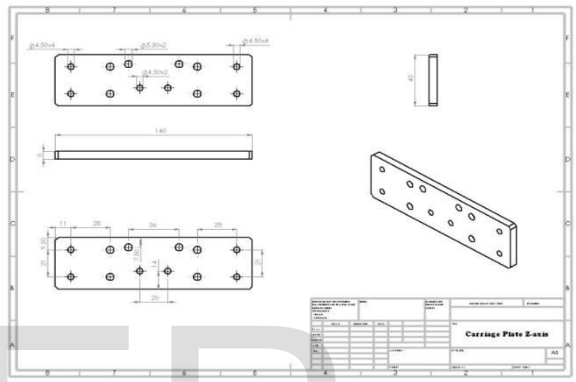

Fig 9.4.2 Carriage Plate Z axis

The front, side and Isometric view of the carriage plate is shown in the above figure and this 2D is used for creating exact dimensions of the carriage plate.

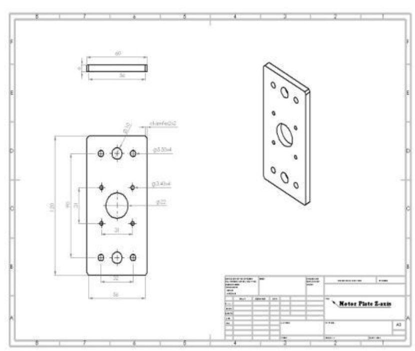

Fig 9.4.3 Motor Plate Z axis

The front, side and Isometric view of the Z axis motor plate is shown in the above figure and this 2D is used for creating exact dimensions of the Z axis Motor plate.

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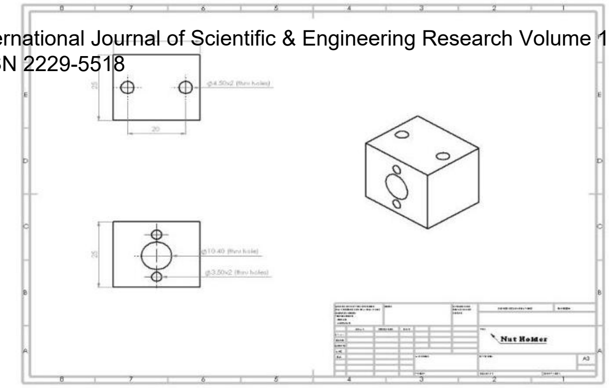

Fig 9.5.4 Nut Holder

The front, side and Isometric view of the Nut Holder is shown in the above figure and this 2D is used for creating exact dimensions of the Nut holder.

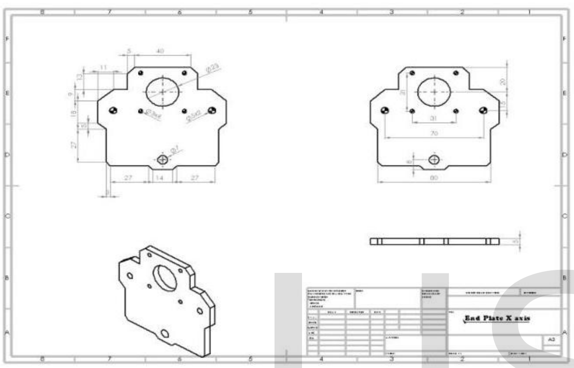

Fig 5.3.5 End Plate X axis

The front, side and Isometric view of the End plate is shown in the above figure and this 2D is used for creating exact dimensions of the End plate.

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