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Design and Development of Library Management Robot: Part 2 Development of Stationary Shelve Robot

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Abstract - *The said paper is the secondary part of the library management robot. This part consist of a vertical as well as horizontal mechanism robot driven using the power window motor. The transfer mechanism between the mobile robot and shelve robot is carried out using the proximity sensor. A mechanical gripper driven by stepper motor with lead screw mechanism is used as a gripping technique. A transreceiver module is used for the transfer information between the mobile robot and the main server. Pneumatic piston is used to move the gripper back and forth.*

Key Words: Pulley wheel, linear encoder, power window motor, mechanical gripper, proximity sensor.

1. INTRODUCTION

Singapore is the first country to utilize the library using radio frequency identification [2]. Tracking each book on book shelves is one of the most important process for nventry management in the library. Consider an arbitrary library consisting of 100's and 1000's of books to be frequently borrowed and returned these books are placed in specific book shelves and sorted in sequence according to the call number [3]. In order to help the librarians and library users discover the miss-shelved books and to keep the book at the right place and pinpoint where they are and to improve the quality of service we are developing the robotics system. By traditional means, however, keeping the book manually as well as manually checking each bookshelf suffers from extremely intensive labor and long scanning delay [3]. The rail mechanism is used to operate the robot in different position of shelve.

2. FLOWCHART:

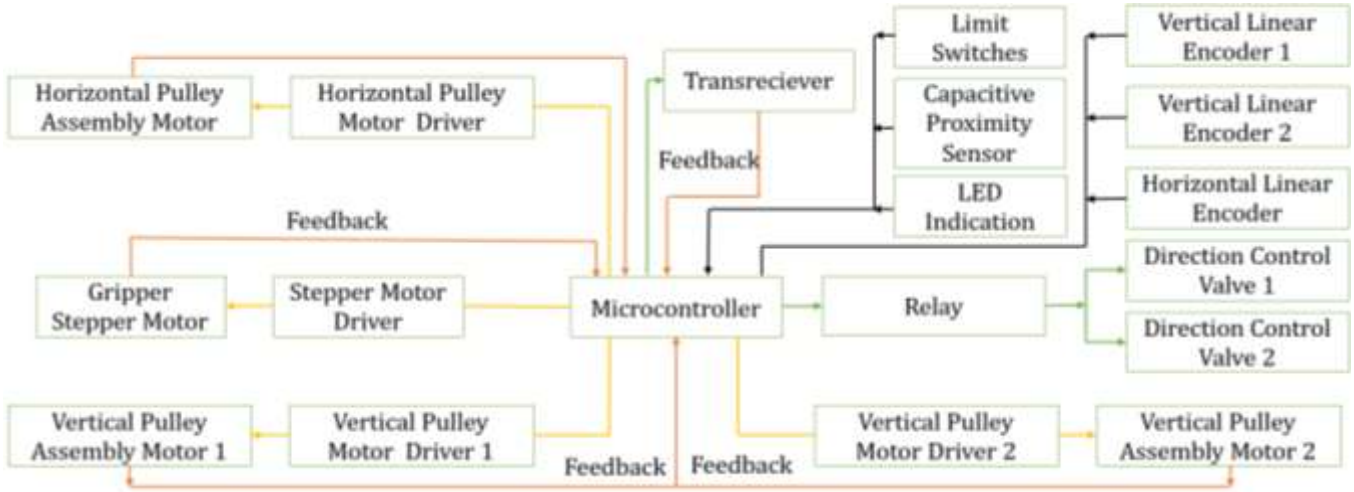

Figure 1: Electronics Flowchart Stationary Shelve Robot

There are total of three power window motors, used for vertical as well as horizontal motion of the shelve robot. They are operated using the pwm signals which is send by the microcontroller to motor driver and then to the individual motors. Each of this motor is equipped with the linear encoder which is used as certain feedback to know the position of the each arm. One linear encoder is placed at the left vertical pulley assembly whereas, one on the right vertical pulley assembly, at the same time one is placed at the horizontal pulley assembly. To operate the gripper the stepper motor is used, this motor is operated using the stepper motor driver connected before it connects to the microcontroller. This stepper motor operates on pwm as well as the enable digital signals as 0 or 1. This gripper is moved back and forth using the pneumatic cylinder operated using the relay and directional control valve. There are two pneumatic cylinder thus two channel relay along with two direction control valve

is used. These direction control valve is a 2/3 solenoid operated direction control valve. At each end of the motion of the arm there is a limit switch is placed to know the end position of the arm. For user reference the led indication is used, whenever any of the limit switch is pressed then the led is blinked once. The transreceiver module is used to transfer the information between the robot, server, and itself. The information may be of book such as shelve number, row number and column number. During any transfer of book from mobile robot to shelve robot the proximity sensor is used as follows: whenever the mobile robot is in front of the respective shelve then the one of the proximity sensor detects the presence of the mobile robot. The shelve robot then moves the gripper in front of the mobile robot arm and operates the gripper to open the arm. When the mobile robot places the book in between the sliding arms of the shelve robot gripper the second proximity sensor detects the presence of the book in between the arms and starts to close the arms. In this way the transfer mechanism works.

3. DESIGN CRIETRIA:

1. The robot should be stationary at it location
2. The robot arm should be travel in every direction with certain degrees of freedom.
3. The gripper should move back and forth
4. Robot should grab the book without losing control.
5. Robot should be rigid enough.

4. MOTOR SELECTION FOR VERTICAL & HORIZONTAL PULLEY ASSEMBLY:

Motor Type	Power Window Motor
Torque Stall Torque: Rated Torque:	 10 Nm 2.9 Nm
RPM Of Base Motor	500 RPM
Motor Pulley Type & Number Of Starts	Spiral Pulley With Two Starts First Start With Clockwise and Second Start With Anti Clockwise Direction Groove
Power Transmission From Motor To motor Pulley	Worm & Worm Wheel Type Of Transmission Mechanism
Power Rating Stall Current Rated Current No Load Current Stall Voltage	 <28 Ampere <15 Ampere <5 Ampere 12 Volt
Pulley RPM	100 RPM
Weight	696 g

5. DESIGN OF VERTICAL PULLEY ASSEMBLY:

Pulley Material & Manufacturing Process	Aluminium, Lathe Machine Operation.
Number Of Pulley Used	4
Pulley Joining Process With Chassis	Welding
Bearing Type & Dimension	Linear Bearing, SKF, Outer Diameter- 40 mm Inner Diameter- 25 mm
Number Of Bearing Used	4
Shaft Type, Shape & Dimension	Stainless Steel, Hollow Circular Cylinder, Outer Diameter- 25mm Thickness- 2 mm
Number Of Shaft Used	4
Shaft Holder shape, Type & Manufacturing Process	Type 1: Flange Type, Circular & Lathe Operation Type 2: Flange Type, Cuboidal & Milling Operation
Number Of Upper & Lower Shaft Holder Used	Type 1: 2 Type 2: 2
Assembly Method	Bolting, welding

1. The right and left side vertical pulley assembly individually uses two pulleys to move the block up and down. One pulley is attached at the top of the chassis using the welding joint, whereas second at the bottom using the welded joint. Structure of the pulleys are like the wheel with the center groove for the string. The arms are attached at both the sides of the wheel and with the spacers inserted in between arms. The place between the shaft and the wheel contains bearing to avoid friction.
2. The motor is attached at the sliding block. The string coming out of the motor is first passes through the first pulley returned to the block. The second string coming out of the motor is passes from the second pulley, through this the string comes upwards and gets attached to the first string end rigidly..
3. This motor when rotates in clockwise direction the first string is pulled inwards and the second string is pushed outside. In this way, the block is pulled upwards.
4. This motor when rotates in anticlockwise direction the first string is pushed outwards and the second string is pulled inside. In this way, the block is pulled downwards.
5. When the block reaches the top position near the pulley 1 then the top limit switch is pressed then the motor is stopped. Whereas when the block is reached near the second pulley at bottom the bottom limit switch is pressed and the motor is stopped. This limit switch worked as feedback signal to stop the motor in both the condition.
6. For vertical lift there are four vertical shafts mounted where the block is sliding along the shaft with the help of linear bearing.
7. The motor is having self-locking property since the transmission between motor and the motor pulley is of worm and worm wheel type internally.

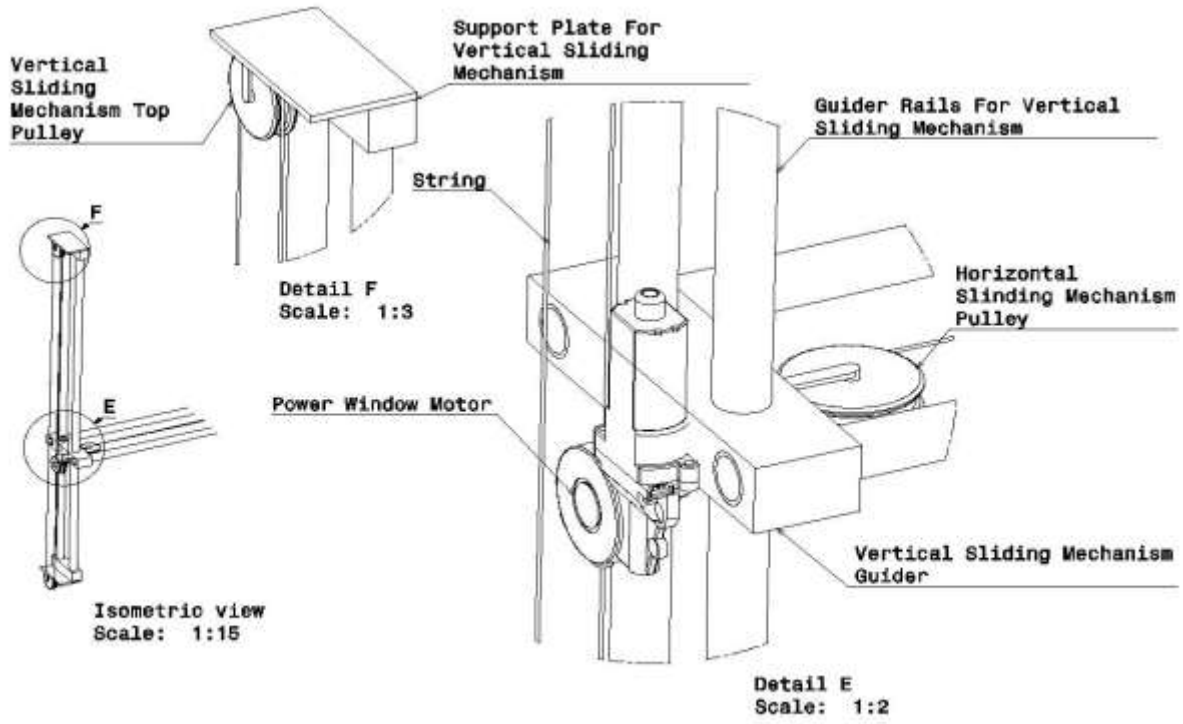

Figure 2: Vertical Pulley Assembly Motor Detailed View

6. DESIGN OF HORIZONTAL PULLEY ASSEMBLY:

Bearing Type & Dimension	Linear Bearing, SKF, Outer Diameter- 32 mm Inner Diameter- 20 mm
Number Of Bearing Used	4
Shaft Type, Shape & Dimension	Stainless Steel, Hollow Circular Cylinder, Outer Diameter- 20mm Thickness- 2 mm

Number Of Shaft Used	2
Shaft Holder shape, Type & Manufacturing Process	Type 1: Flange Type, Circular & Lathe Operation Type 2: Flange Type, Cuboidal & Milling Operation
Number Of Upper & Lower Shaft Holder Used	Type 1: 4 Type 2: 4

1. The horizontal pulley assembly is like vertical pulley assembly only but the difference is a single power window motor is used to slide the gripper block.
2. The motor is attached on the block rigidly. The string coming out of the motor is first passes through the first pulley and comes back to the block, and the second string coming out of the motor is passes through the second pulley on the opposite side and comes back to the block. Both the ends of the string is attached to each other rigidly.
3. This motor when rotates in clockwise direction the first string is pulled inwards and the second string is pushed outside. In this way, the gripper block is moved right side.
4. This motor when rotates in anticlockwise direction the first string is pushed outwards and the second string is pulled inside. In this way, the gripper block is moved left side.
5. When the gripper block reaches near the right end then the right end limit switch is pressed then the motor is stopped. Whereas when the gripper block is reached at the left section end position the left end limit switch is pressed and the motor is stopped. This limit switch worked as feedback signal to stop the motor in both the condition.
6. For horizontal drive there are two horizontal shafts mounted where the shafts are sliding along the block with the help of linear bearing.
7. The motor is having self-locking property since the transmission between motor and the motor pulley is of worm and worm wheel type internally.

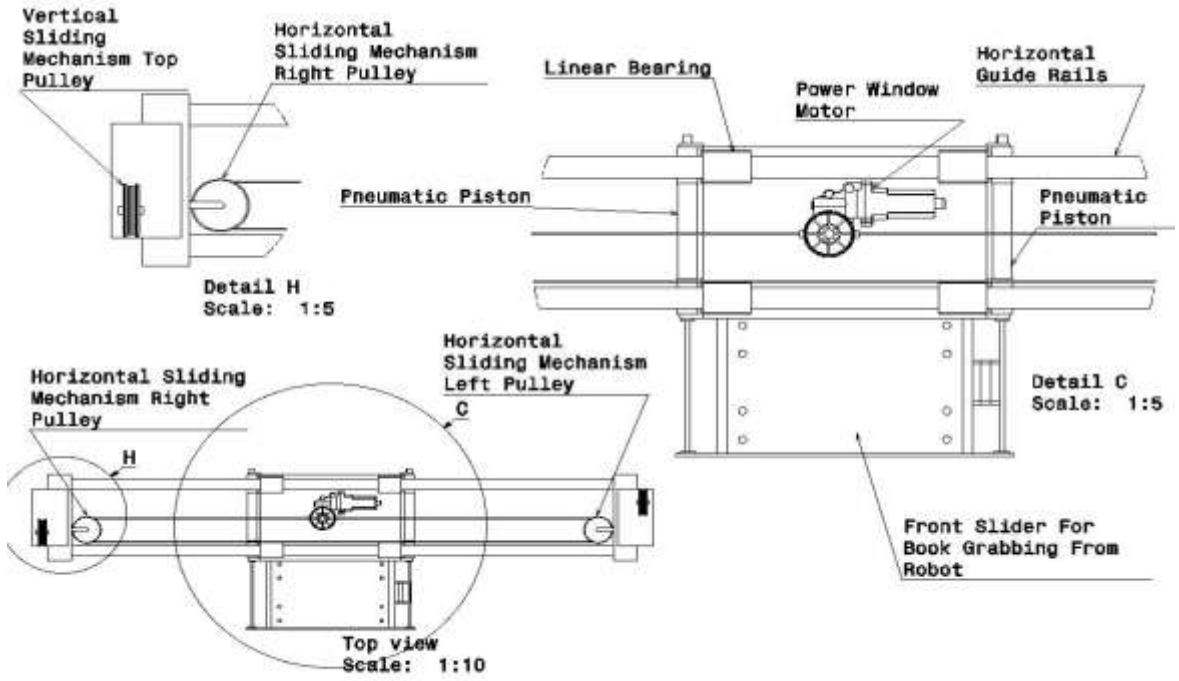

Figure 3: Top View of Horizontal Pulley Assembly

7. DESIGN OF MECHANICAL GRIPPER:

Lead Screw Type & Material	Stainless Steel
Pitch	4 mm
Length	300 mm
Diameter	8 mm
Locking	Self-Gliding

Number Of Start Nut Type & Material Number Of Nut As Arm Number Of Lead Screw	2 Aluminium 2 1
Motor Coupling With Lead Screw Thread Type	Aluminium Flexible Coupling Square
Motor Type	Stepper Motor
Sliding Rod Material Diameter Length Number Of Sliding Rods	Stainless Steel 8 mm 780 mm 2
Lead Screw & Sliding Holder Material & Manufacturing	Aluminium, Milling Process
Bearing Used For Lead Screw	 Single Row Deep Grove Ball Bearing Inner Diameter: 8 mm Outer Diameter: 22 mm
Base Type & Material	Rectangular Type Of sliding plate with in mounting space for linear bearing Made Up Of Aluminium
Assembly Methods	Bolting, Press fit

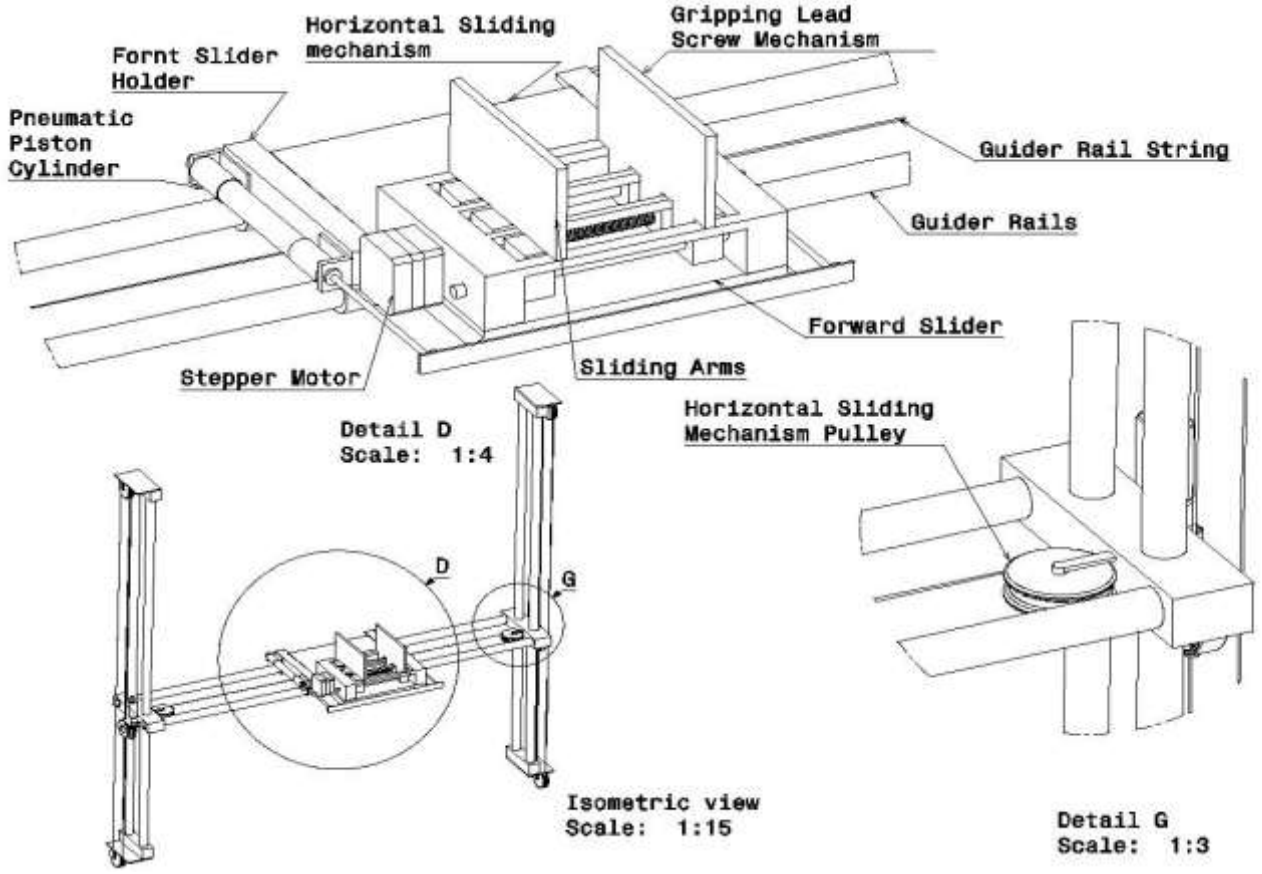

Figure 4: Isometric View & Detailed View of Mechanical Gripper

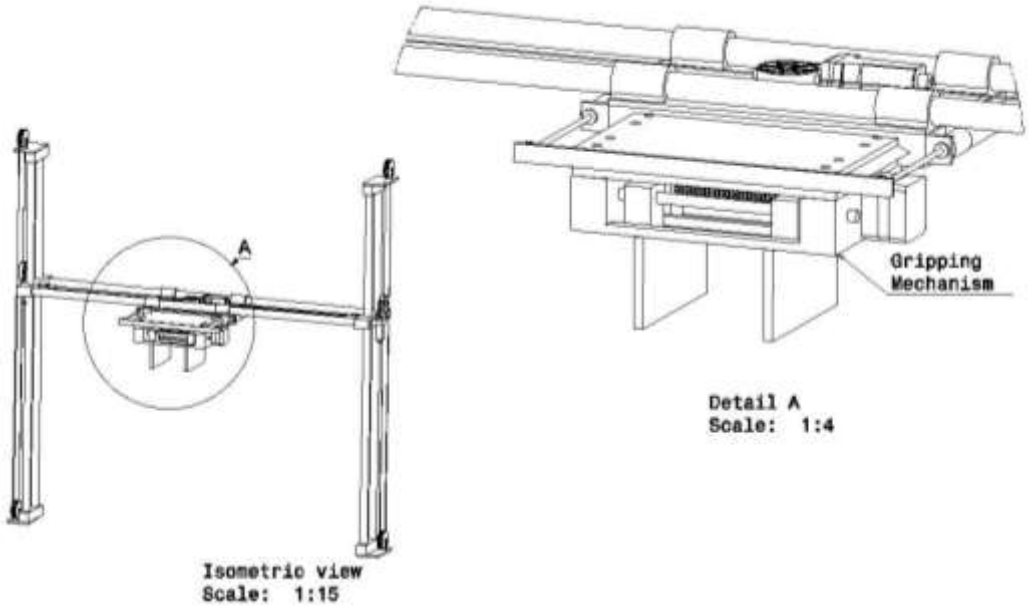

Figure 5: Isomeric View of Mechanical Gripper

1. The base of the mechanical gripper is made up of aluminium rectangular plate with bearing holder at the top side. The holes are drilled at the ends, as well as at the mid-section to clamp the gripper. The bearing holder are cylindrical in shape and used to hold linear bearing.
2. The base plate is attached to internal V slot grove plate, manufactured using the milling operation. The coupling method is bolting with the base plate.
3. The V slot grove plate is used as constarain for the external V slot grove plate. The external v slot grove plate slides in between the internal V slot grove plate.
4. The size of the external V slot grove plate is greater than the internal v slot grove plate.
5. The actuator used in to displace the extertnal v slot grove plate is pneumatic piston which hcould move the plate in two extreme position only. There are two piston used for proper movement of the grove plate.
6. The piston are clamed to the internal v slot grove plate using L clamp at both left and right side of it using bolting.
7. The internal v slot grove plate is also called as front slier holder and the external v slot grove plate is also called as front slider or forward slider.
8. At one of the face of front slider plate the stationary C shaped plate is mounted. The flanges of the C shaped stationary plate is drilled with three holes to hold two sliding bar and one lead screw. The holes are equipped with the ball bearing to avoid friction.
9. The holder is press fitted with the slider bar at the end holes drilled and bearing inserted. This slider bar has 0 degrees of freedom. There is bearing which is press fitted at the center for the lead screw to rotate having only one degree of freedom.
10. At the center and at one edge of the C shaped stationary plate the stepper motor is attached using bolting. At the shaft of the stepper motor the flexible coupling is attached whereas at the other end of the flexible coupling the lead screw is attached.
11. Two grabbing arms are attached at both the sides of the stationary plate internal grove, having freedom to move in between the grove provided along the sliding bars. The arms are L shaped with the three holes at the side face. The side two holes are for sliding along the slider arm equipped with the linear bearing. The center hole is threaded to convert the rotational motion of lead screw (driven by the stepper motor) to linear motion along the axis of the motor.
12. When the stepper motor rotates in clockwise direction, then both the arms closer to each other, whereas, when the motor rotates in anticlockwise direction the arms moves away from each other.
13. When the arm touches the limit of mid-section then the both the mid limit switch is pressed and the motor is stopped. Same as when the arms touches the end section near the sliding bar holder the both the ends of limit switch is pressed and the motor is stopped.

14. To exert a specific amount of pressure there is pressure sensor (not shown in above diagram) is placed to detect the amount of pressure exerted on the object to be grabbed. When the specific setted limit is reached the motor is stopped to avoid any damage to the object.
15. As soon as the pressure limit is reached or thelimit switches are pressed, the controller sends the led indication for user to understand the condition.

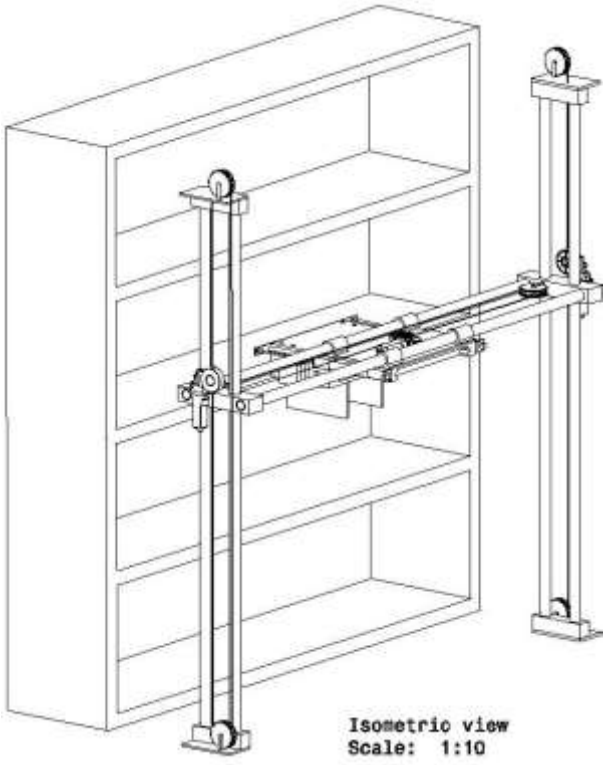

Figure 6: Isometric View of Complete Stationary Shelve Robot with Shelve

8. DISCUSSION

1. The Power window motor is used as an actuator to carry out the vertical as well as horizontal motion.
2. The arm is moving in rectangular coordinate system and have three degree of freedom.
3. Lead screw mechanism provides precise control of gripper.
4. The back and forth operation of gripper can be takes place in two position only because of pneumatic piston used.
5. The linear encoder is used to know the position of the each arm moving because of which location of arm can be control.
6. Limit switches used to avoid the over exceeding of the arm and allows it to move in stated limits.

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