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Seeking Smart Manufacturing Talents

The 7th Delta Advanced Automation Contest

Project Proposal

Team Code: **delta2021090**

Proposal Name	PSP Bot (Pick Sort and Place Bot)			
Team Name	DNS		**University/ Affiliation**	Veermata Jijabai Technological Institute, Mumbai, India.
Team Leader	**Name**	Ninad Jangle	**Department**	B.Tech Electronics Engineering
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	Email	ninadjangle3011@gmail.com		
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Team Building:

1. **Mr. Ninad Sunil Jangle (Age 21):**

   Bachelor of Technology Electronics Engineering, Veermata Jijabai Technological Institute (VJTI)

   ninja3011 (Ninad S. Jangle) (github.com)

   - **Bachelor of Technology Electronics and Telecommunication Engineering, 9.57 CGPA as of III semester (2019 - present)**
   - **Coursework: Monash University(36 credits) towards Bachelors in Engineering(2017 to 2018)**
   - **12th (CBSE) (Science), 92% (2015 to 2017)**
   - **All India Secondary Certificate Examination (10th Standard), 95.8% (2015)**

Role: Electronics, Automation, and Programming.

Skills:

- **Hardware:** NodeMCU, Esp32, Arduino
- **Software Program:** Octave, Verilog, Multisim, Proteus, LTSpice, GNUSim.
- **Technologies:** Robot Operating System (ROS), ESP-IDF, MakerChip.
- **Programming Languages:** C++, C, Python, Embedded C, JavaScript.

Specialization: **Electronics and Electrical Aspect, Sensor Integration, Automation, and Programming.**

Achievements:

- Rank 1 in College Academics by Branch till present (Semester 3).
- Reached Top 20 in All India Eyantra E-YRC Robotics Competition under the theme Vitarana Drone.
- Qualified for Eklavya Summer Mentorship program Held by SRA VJTI under which I made an 8-bit computer interface with an assembler.
- Reached Rank 4 in SAC Autosim Challenge set by SRA VJTI in 2020,
- Worked and delivered lectures on Wall-E Robot to implement self-balancing and line following with custom designed and built hardware, 3- DOF Robotic Arm Manipulator under the Patronage of SRA - Society of Robotics and Automation, VJTI.

Projects:

- **Eyantra Drone Disaster Management(Oct 2020- Mar21):** notes**:** A national-level competition-based project**.** Participating in a team of four, we are working towards implementing a **drone** that can **pick and drop** off loads **autonomously** using **waypoint navigation** for disaster management.
- **Obstacle Avoidance DDR(Sept 2020):** DDR stands for **Differential Drive Robot.** Simulated in **Gazebo,** and using **ROS,** a DDR was modelled and programmed to keep moving in any environment avoiding the obstacles it encounters.
- **HACK Computer(Sept 2020):** Gave my own Implementation to a **16 bit computer** using Harvard architecture model, following the nand2tetris site and it's coursera course.
  Software: **nand2tetris emulators and HDL.**
- **Mini Projects(Aug 2020): tinder bot, Weather App, 2048 game:**
  - **tinder bot:** Allows a user to test using virtual clicks on opening browser->logging in->closing popups->swiping->messaging. **Uses Selenium.**
  - **Weather App:** Returns the weather of a city using an **api call** asked by a user on a gui window made using **Tkinter library.**
  - **2048 game:** A well known and popular **game** recreated using **Tkinter GUI** and basic logic.
- **8 Bit Computer (May 2020):** Successfully developed an 8 bit computer system using basic gates and logic knowledge to recreate chips using ad-hoc models and integrated the said chips in a harvard architecture to make an operational computer system with an assembly to code in.
  Software: **Logisim**

2. **Mr. Karthik Swaminathan(Age 19):**

   Bachelor of Technology Mechanical Engineering, Veermata Jijabai Technological Institute (VJTI)

   kart1802 (github.com)

   - **Bachelor of Technology Mechanical Engineering, 9.38 CGPA as on III semester (08/2019 - present)**
   - **Maharashtra State Board Higher Secondary Certificate (Science), 86.46% (08/2017 to 05/2019)**
   - **All India Secondary Certificate Examination (10th Standard), 92.60 % (04/2016 to 04/2017)**

Role: Mechanical System Design, Automation, Simulation and Programming

Skills:

- **Hardware:** Esp32, Arduino
- **Software Program:** Matlab, SolidWorks, Fusion 360, Ansys, Coppeliasim
- **Technologies:** Robot Operating System (ROS), ESP-IDF, Heroku(For Web Server Deployment)
- **Programming Languages:** C++, C, Python, Lua, Javascript, HTML .

Specialization: Robotics, Mechanical design and Simulation

Achievements:

- Was part of a Team which were in **Top 20** of the **All India Eyantra E-YRC Robotics Competition** under the theme Vitarana Drone.
- **Rank 6** in College Academics till present.
- Reached **Rank 4** in **SAC Autosim Challenge** set by SRA VJTI in 2020, where we had to make a bot and line follow and solve the maze in ROS, Gazebo and image processing.
- Worked on **Wall-E Robot** (line following and self following bot) and contributed to the simulation part of it.

Projects:

- Worked on a project related to **Automatic Parking System** in simulation (Eklavya Mentorship Program by SRA, VJTI).
- Worked on a project called **Mobile Manipulator** which is based on a statement of **University Rover Challenge(URC)** where a bot with arm attached to it is used to identify different types of screws and carry them and

drop in desired location.

- Designed various things in different softwares like Bicycle in **AutoCad**, Bearings in **Solidworks** and many more.
- Worked on **Data Relay**(sending and receiving sensor data) using **MQTT Protocol**.

3. **Mr. Dhairya Jigar Shah (Age 19):**

   Bachelor of Technology Electronics and Telecommunication Engineering, Veermata Jijabai Technological Institute (VJTI)

   dhairyashah1 (github.com)

   - **Bachelor of Technology Electronics and Telecommunication Engineering, 9.97 CGPA as on III semester (08/2019 - present)**
   - **Maharashtra State Board Higher Secondary Certificate (Science), 87.54% (08/2017 to 05/2019)**
   - **All India Secondary Certificate Examination (10th Standard), 94.20 % (04/2016 to 04/2017)**

Role: Embedded Systems, Image Processing, Automation and Programming

Work Experience:

- **Embedded Development Intern :** Munga Innovations Pvt. Ltd., Mumbai

  Worked as an Embedded Backend Developer and Implementer under Robofever's **Home Automation** Project for an **economically viable Cooler and Sanitation Chamber System** using Espressif's NodeMCU 1.0 Module.

Skills:

- **Hardware:** NodeMCU, ESP32, Arduino, 8085 Microprocessor.
- **Software Program:** Matlab, Octave, KiCAD(PCB Design), Multisim, Logisim, Proteus, Android Studio, Photoshop.
- **Technologies:** Robot Operating System (ROS), Gazebo, ESP-IDF, Android Application Development.
- **Programming Languages:** C++, C, Python, Embedded C, Kotlin, HTML.

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Specialization: Robotics, Embedded Systems, IoT and PCB design.

Achievements:

- **Rank 1** in College Academics till present (Semester 3).
- Led my Team to **Top 20** in **All India** Eyantra E-YRC Robotics Competition under the theme Vitarana Drone.
- **All India First Class Merit** Ranker in Middle School and High School Scholarship Exam.
- Led my Team to **Rank 2** in SAC - Society of Robotics and Automation's **AutoSim** Challenge.
- Worked and **delivered lectures** on **Wall-E Robot** to implement self balancing and line following with customly designed and built hardware, **3-DOF Robotic Arm Manipulator** under the Patronage of SRA - Society of Robotics and Automation, VJTI.

Projects:

1. **Vitarana Drone:** A pick and place Drone automated software implementation using ROS(Robot Operating System) and based on Gazebo simulation**.**
2. **USBee32-S2:** Designed an Open Source USB A and USB C Breakout PCB Board useful for smart IOT control applications using Espressif's ESP32-S2.
3. **Human Recogniser:** An Image processing project which detects the nearest human in a picture frame and returns its coordinates with respect to the image making use of a self trained Haar Cascade Model.
4. **Binary Line Follower with self Balancing:** A two wheeled Robot that self balances itself while following its path along a binary(black and white) line using Espressif's ESP32 microcontroller chip.

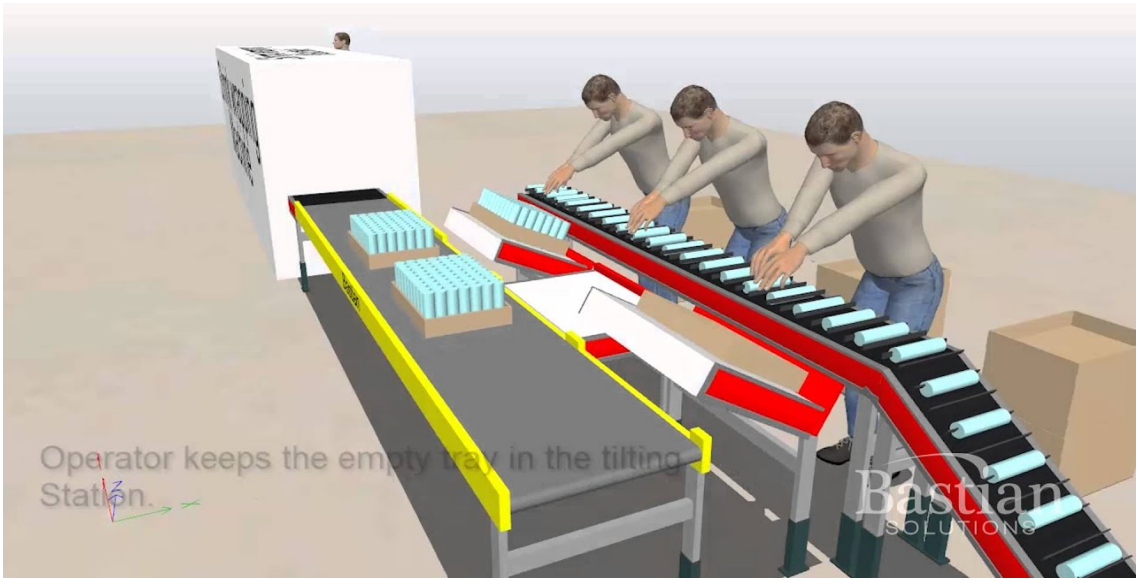
Motivation and Design Idea:

Problem Insight:

In the 21st century, urbanisation and modernization has boosted the industry and level of quantitative and qualitative production in wide aspects. The demand for varied types of quality products is increasing day by day. Hence, multinational product supply chains and E-Commerce companies ship various products across the globe in huge quantities.

Consider the following cases:

1. There are many parcels that need to be shipped to one location. Instead of manually packing the parcels for one location, automation can do better. Packaging the parcels in a bigger parcel altogether will not only ensure extra safety for the parcels but also they won't be misplaced and would rather stay intact .
2. Companies consume products in bulk and hence they prefer to keep them stored batchwise, altogether.

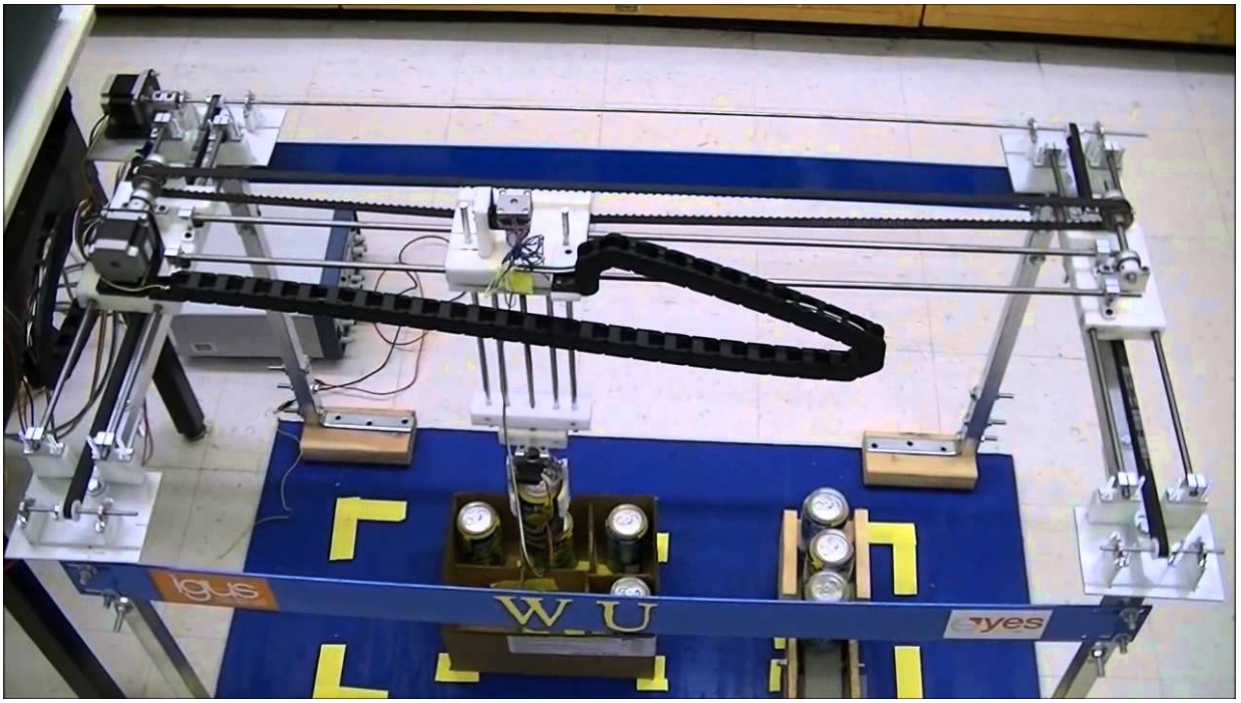


Inefficient way of manual product packaging

In these cases, manual packaging and segregation is not an efficient solution. Improper handling, error while package placement and unprecedented damage are some of the drawbacks of this method.

Hence, picking the items from the conveyor line, placing similar items either based on size, shape, shipping address into a common container , maximising the

available space in it by an Automated Robot can solve the manual labor problem. Hence, we came up with the idea of PSP (Pack, Sort and Place) Bot.



Efficient way of automized product packaging

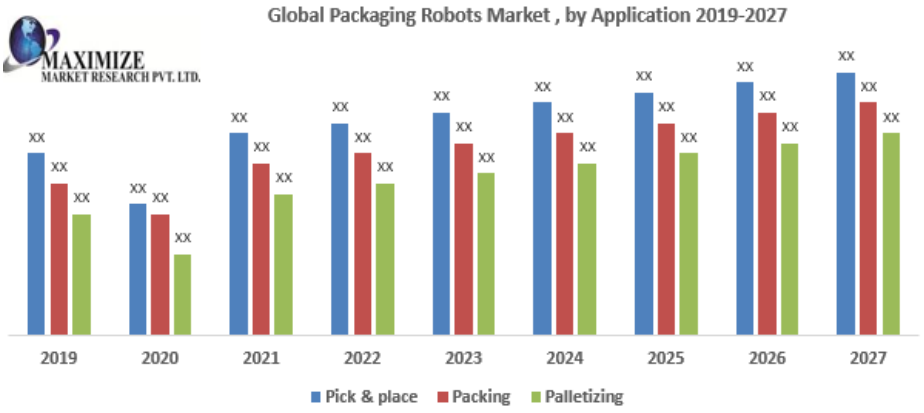
Motivation :

Packing bots which are currently used in the **industry** face a **challenge** when provided with items of varied sizes to be fit into a box/ container. This has **inhibited the mass production** of domains like subscription boxes, and **customised packages** of all fields. Manual labor is required when dealing with **dynamically changing loads**. To **solve this problem** we came up with the idea of a **PSP** (Pick-Sort-Place Bot) which can handle items of varied sizes and pack them into a box/container with higher efficiency.

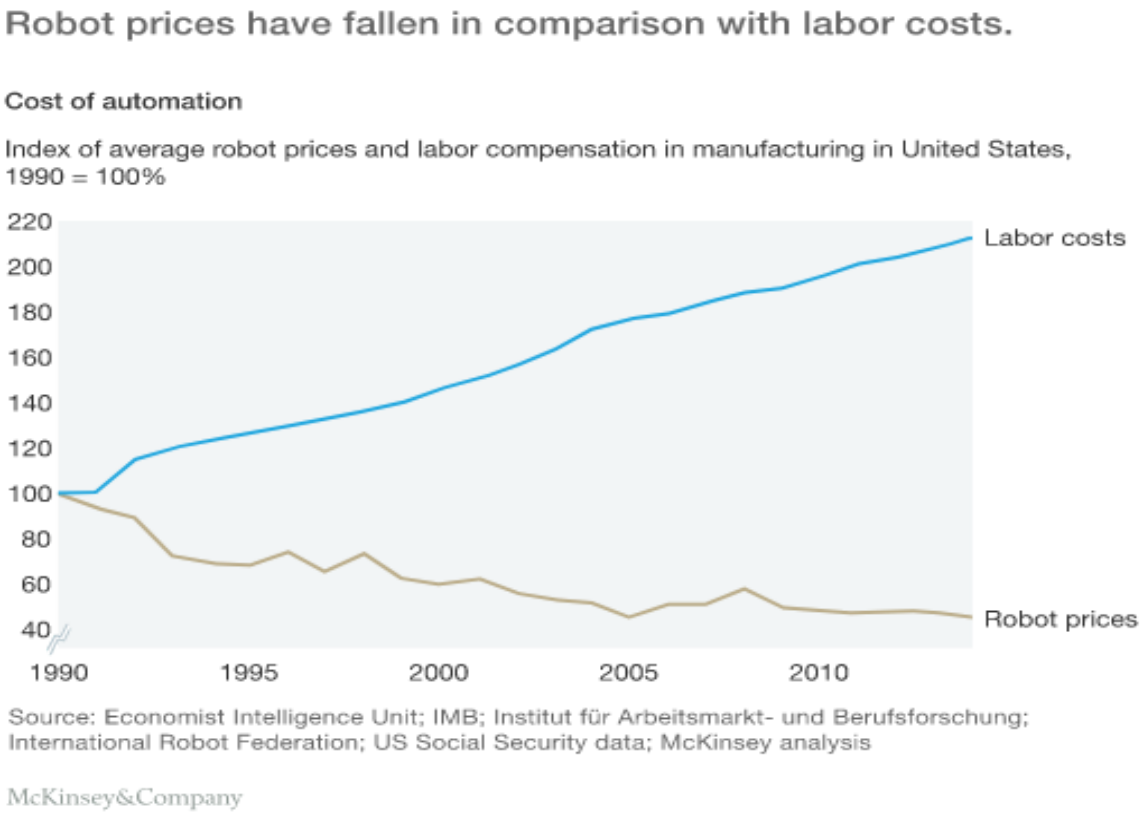
Some Statistics:

The global Packaging Robots Market was valued US$ 2.53 Bn in 2019 and is expected to reach US$ 6.40 Bn by 2027, at a CAGR of 14.18 % during a forecast period.

With the advent of covid, came an advent in automated industrial machines. Many countries launched laws about worker distancing and workers per sq. feet caps. To tackle such hurdles, industries in all spheres.



Over the years, the price of Labor has increased exponentially while the price of robots has dropped significantly. For the field of custom packaging, which is still heavily dependent on the human resource, this is a money pit.



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Global Packaging Robots Market, By Gripper Type

1. Clamp
2. Claw
3. Vacuum
4. Others

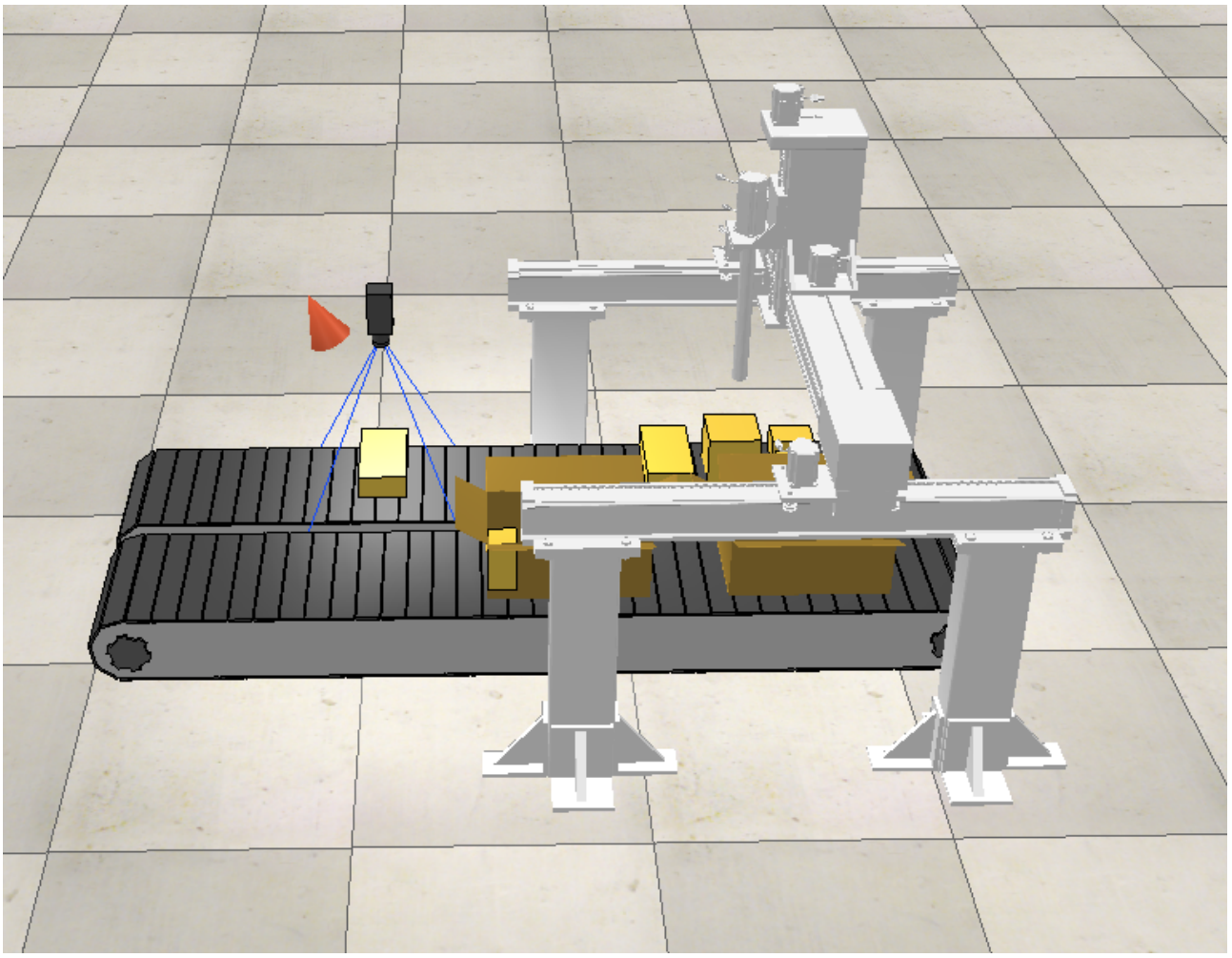
Project Idea:

Building on the concept of **Industry 4.0** and **Seeking smart IIOT Talent** satisfying **Smart Factory**, Innovative production process for a cost effective solution to the **packaging industry** when dealing with **customised boxes, parcel orders** will deliver quality improvement, higher reliability and lower maintenance. We propose the **PSP (Pick-Sort-Place Bot)** is a xyz gantry system which utilizes a **Bin Packing Algorithm**. The objective of this robot are to:

- **Identify** the **number** and **dimensions** of the **item loads** on the conveyor.
- Run the **bin packing algorithm** to decide the orientation of each item/parcel during packaging.
- **Pick** the items/ packages from the conveyor line **and Place** them into the box/container as per its decided orientation to achieve maximum use of the space available.
- Repeat this until either of the items/ container limit is reached.

Objectives:

- **Enable scaling** of packaging custom boxes.
- **Maximise the profit** made per box.
- **Drive down costs** of fulfilling custom orders.
- Achieving a **higher packaging efficiency**.
- Able to deal with items/ packages of **different shapes/sizes**.
- **Reduce dependency on manual labor**.
- **Reduce the cost** of maintenance of the system.
- **Increase productivity** of the custom order packaging.



Preview of PSP bot model

Innovative Planning and Value

Innovative ideas and their practice in manufacturing

Applications (User Stories) :

1. **Problem:** An E-Commerce company (e.g, Amazon) wants to ship various package items to one major distribution region or area via common transportation mode. It would be better to pack and ship it in large containers. This would add to their safety and will reduce the chances to misplace it before reaching the user/ distribution unit.

   Solution: Implementing the PSP bot will allow them to handle one conveyor line to pack all the different orders.

2. **Problem:** A business wants to handle packaging of a customised monthly subscription box. This would require special placement of items in the boxes which as of now is done manually. Our future view is to modulate the process in this region too.

   Solution: Use the PSP bot to handle packing the random sized items.

3. **Problem:** Filling recycle or waste bins .

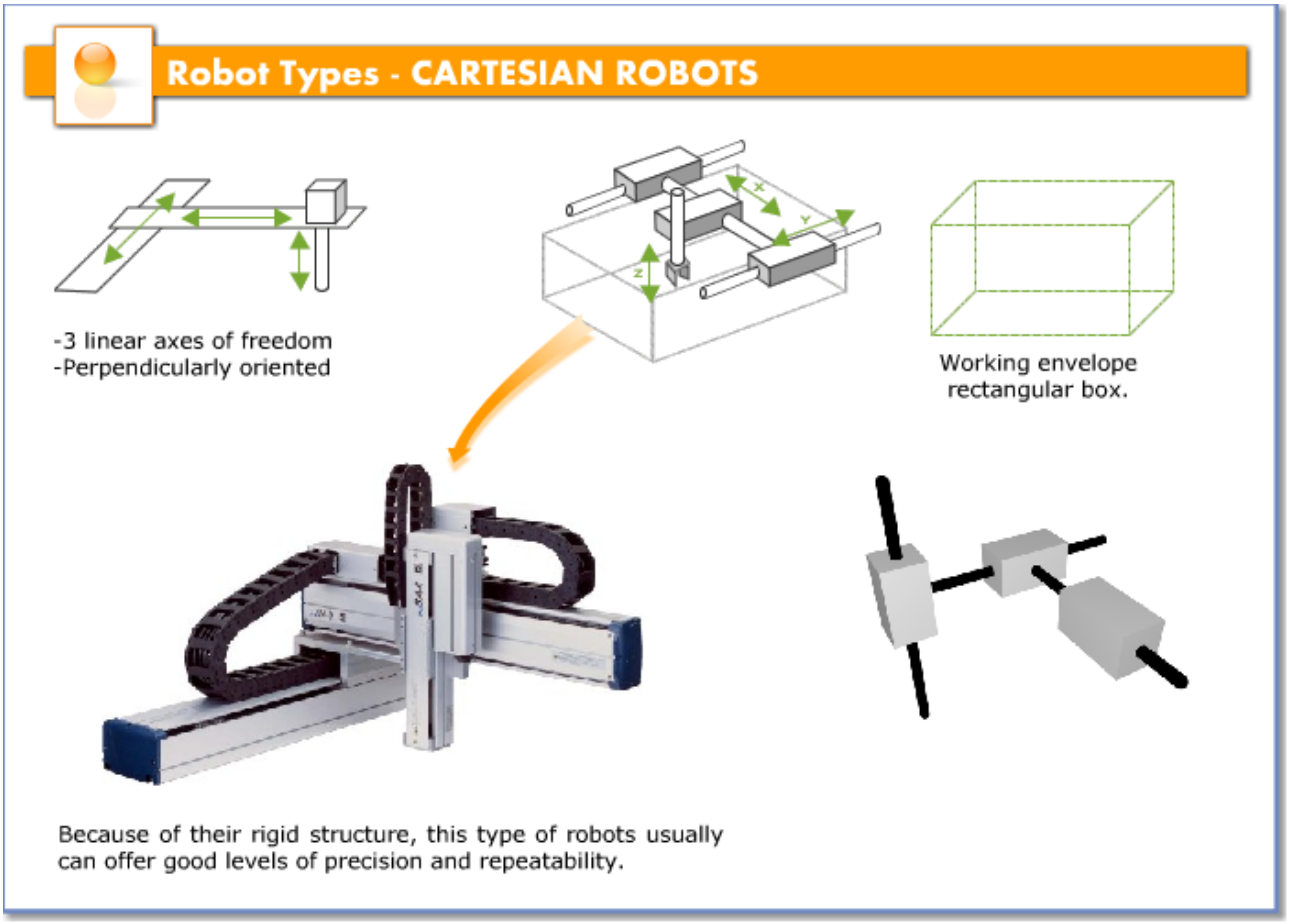
   Solution: Use the PSP bot to maximise the space and utilise the space to fill the bin efficiently.

Our planning includes:

- PSP Bot can be used for **packaging items of varying sizes**
- It achieves a **higher possible packaging efficiency**
- It can handle a **random number of items** and varying dimensions on the fly.
- It comes with a **HMI Integration** which makes it more operator friendly and provides freedom to the user/operator.
- It is a **cheaper alternative to the Palletizer robo**t when it comes to packaging items.
- **Lower maintenance and cost**.
- It houses a **simplistic design**, it will be **easy to assemble and maintain**.
- Uses an **efficient item sorting algorithm** based on weights, sizes or preferences as per requirement of the user.

Modern Solutions:

PSP bot is a **3-axis xyz gantry with rotation**. The design can be thought of in a simple manner as two parallel linear guide rails with a bridge arm connecting it. This forms the basis of translation of the bot in the X and Y axis respectively. The X and Y axis are defined in the XY - plane which is considered parallel to the ground as per our convention. The Z-axis will be perpendicular to the ground towards the sky, This forms the basis of our cartesian coordinate system. Similarly, each object/ item, machine and the world will have their own coordinate system to locate, move with respect to the world coordinates as stated by the **illustration** below.



Our **actuator/gripper** will be housed on this parallel arm as the end effector tool. It will be able to handle items weighing up to 5-10 kilograms at high speed, good accuracy, and repeatability. Robot Gantries can be delivered with up to 3 motion axes, and for maximum capacity in tandem design.

The end effector can be changed as per the need of the operation:

1. **Vacuum based End Effector:** Useful for varied shapes and unsymmetrical items.
2. **Flat Gripper based End Effector:** Useful in case of cuboidal or symmetrical boxes.
3. **Claw based End Effector:** Useful for varied shaped or unsymmetrical items.

Flat Gripper based End Effector

Claw based End Effector

Vacuum based End Effector

The motions from one position to another are taking place using a servos which is carried out using relays to interface motors with PLCs. 24V DC servos are used in the X and Y axis. On the Z axis, the end effectors are connected, which is a gripper.

The end effector is tied up with a proximity sensor which senses the box for the gripper to start performing its action.

The end effector on the Z arm can be replaced to fit the intended operation.

One of the most popular applications for the vacuum based gripper is packaging and palletizing, they can handle many different types of items even when those items are imperfectly positioned. With the vacuum based gripper an air compressor will be required.

For a mechanical claw only a set of servos need to be added to control the open and close of the claw. Hence based on the end application and category of weights, appropriate end effector can be selected.

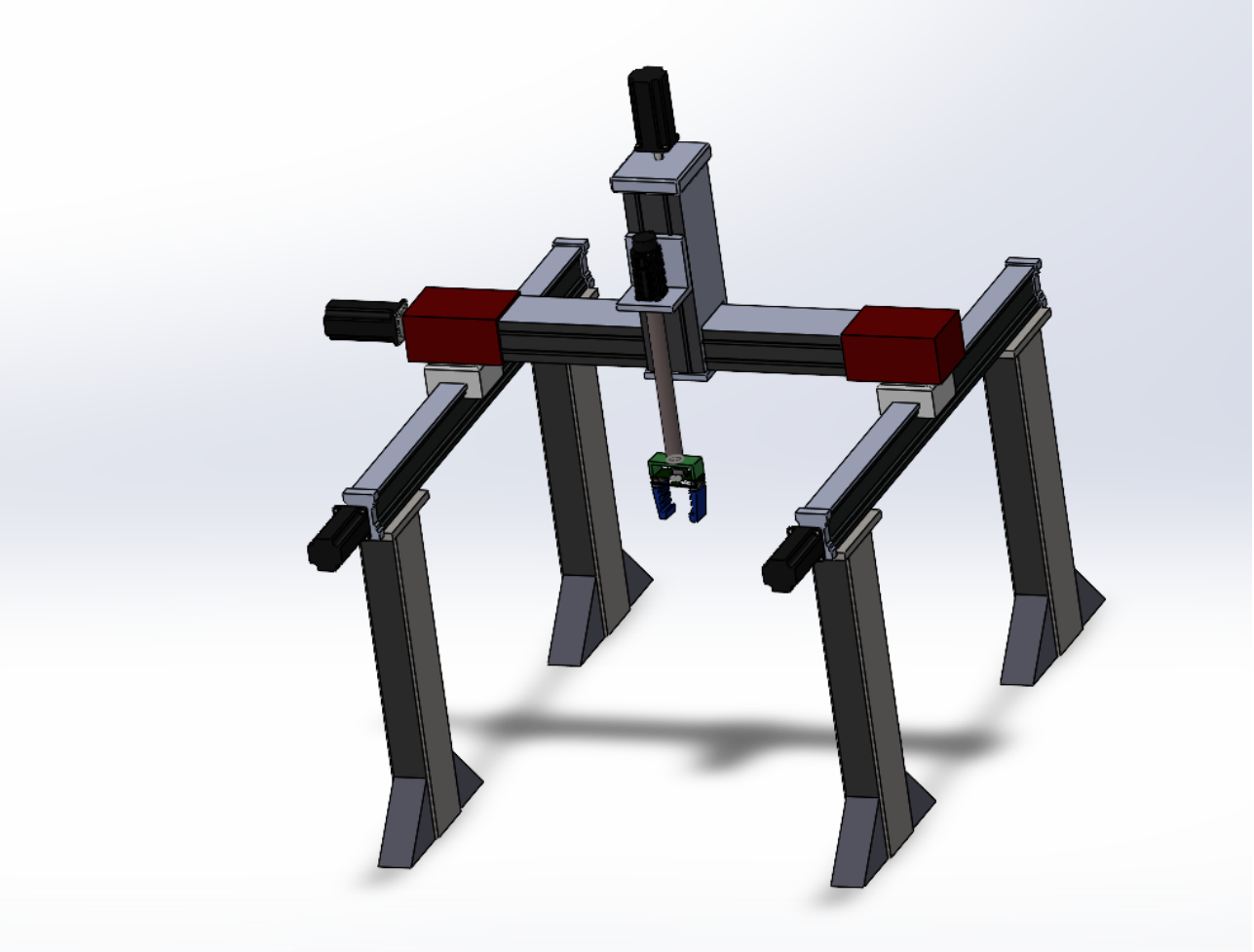
Also, regardless of the gripper, it will also be able to rotate about the Z axis. This will contribute in perpendicular and effective alignment of parcels and items in the packaging container as per calculated position and orientation as calculated by the Bin Placement Algorithm.

The conveyor system is basically to help move the items and for identifying the dimensions of the items. From here, the end effector will pick the item which will be detected through the delta vision sensor fixed to one end of the conveyor.

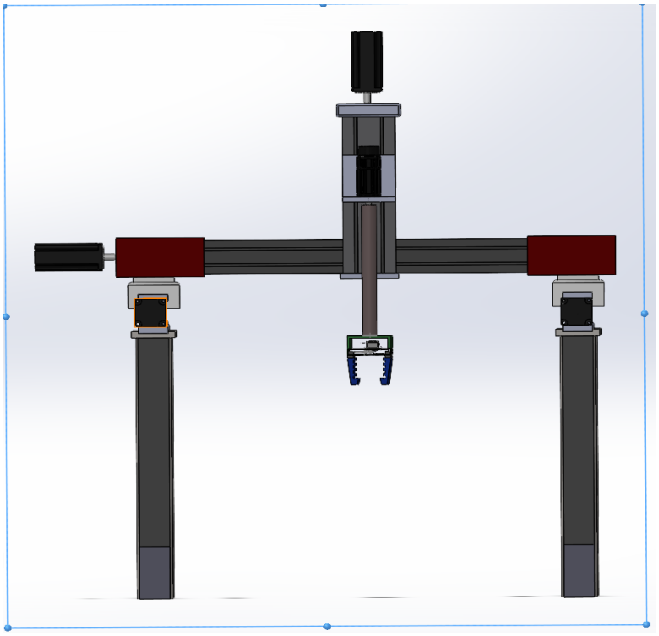
The movement will be coordinated using the delta PLC. It has input/output modules for initializing different I/Os with specific addresses, there are relay modules, Push buttons and hoses (wires used in PLCs).For PLC and the robot interfacing the major role is played by the directional control valves which help the air cylinder and vacuum cup to work. Speed control valves, vacuum ejector distributors, connectors are some other pneumatic components used to complete the circuitry.

The entire operation can be visually assessed during the run using the HMI. HMI is a human machine interface which provides a link between the inputs and the PLC and can be used as the indicator. Visualization is generally used to create a GUI (Graphical User Interface) to provide an easy hand on working on the application and supervision of the project and automation unit.

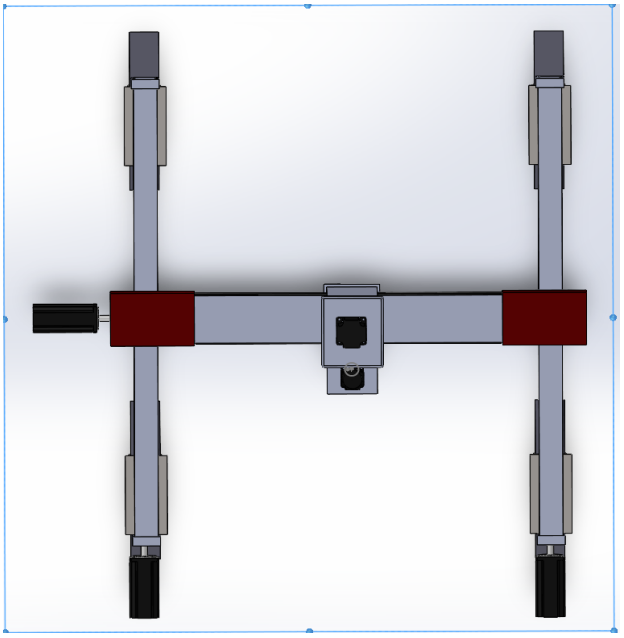
Isometric View of the Gantry Frame:



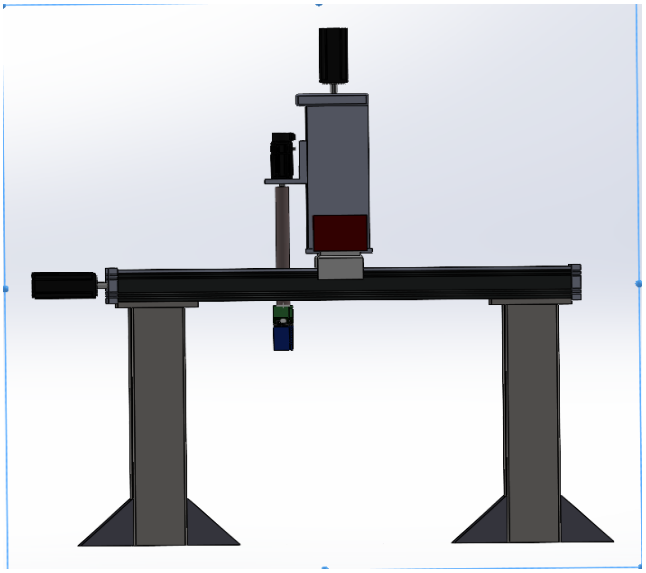
Orthogonal Views of the Gantry Frame:



Front View

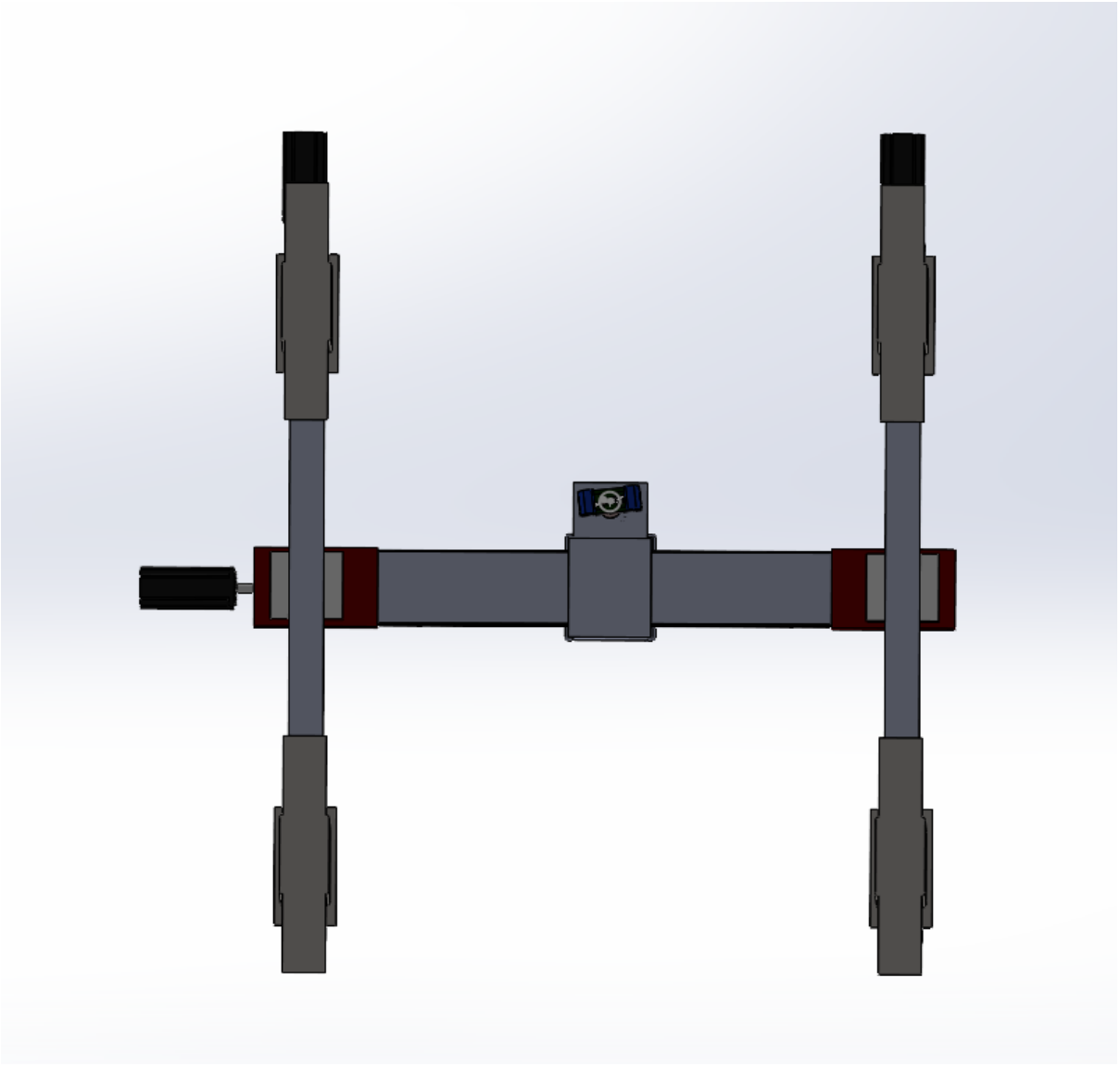


Top View



Side View

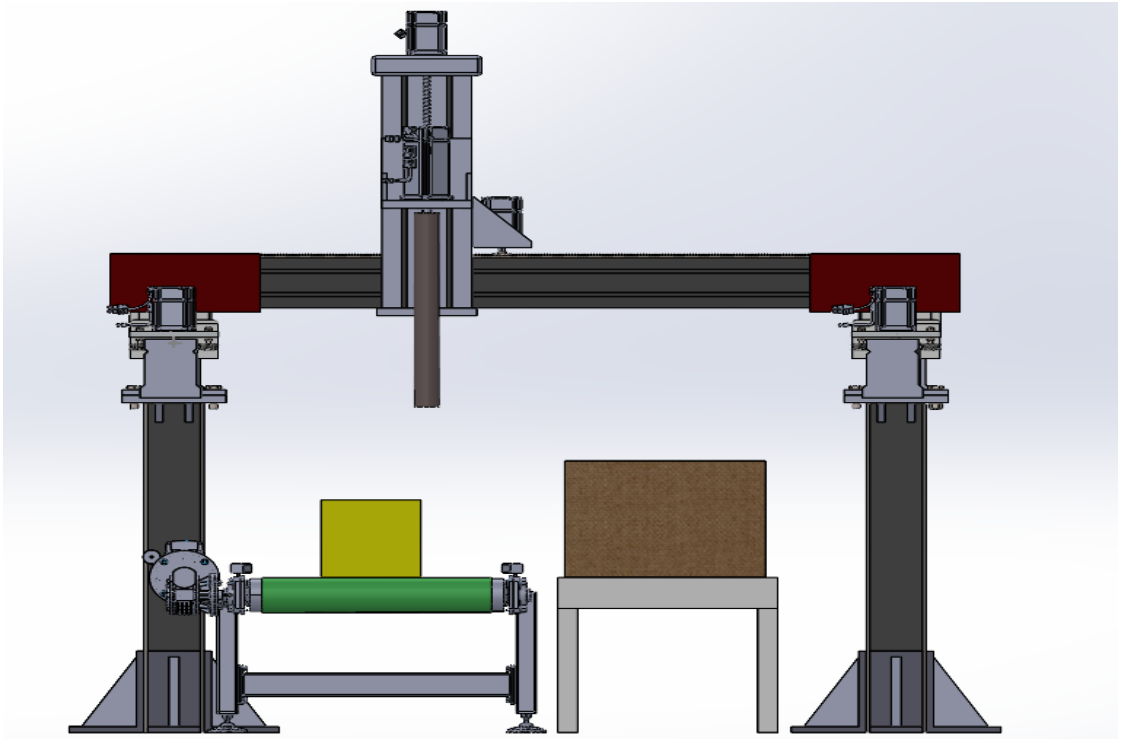
Bottom view of the PSP bot gripping a package:



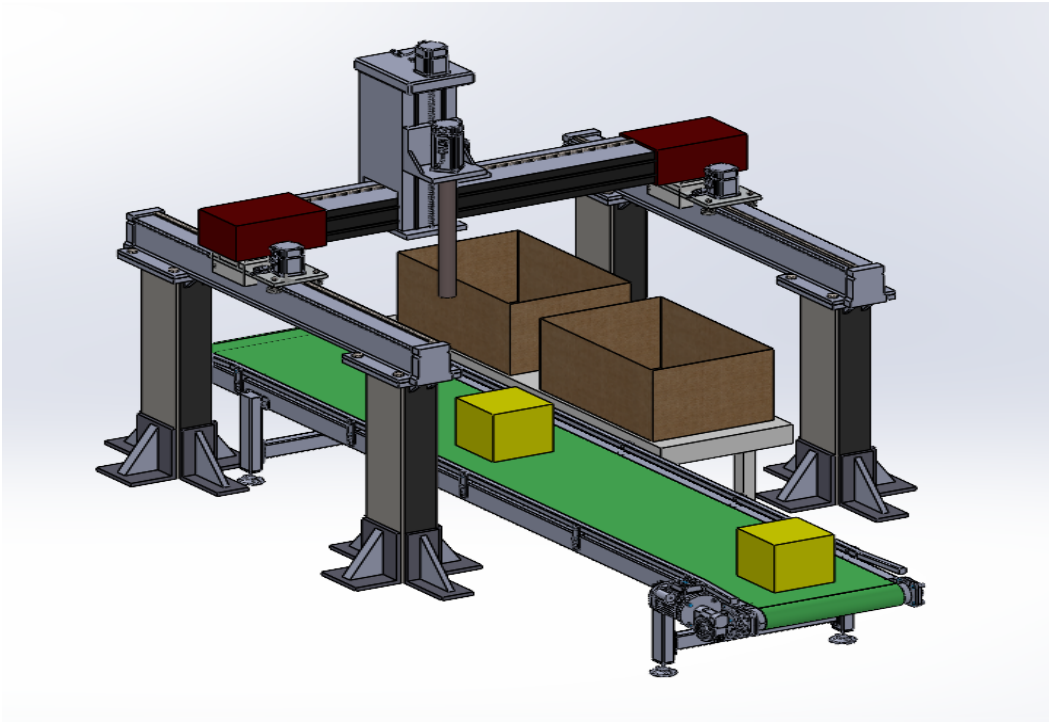
Bottom View

1. This model is customly designed by us in Solidworks. It can be found on GrabCad for reusability and implementation.
2. A working video demonstrating the motion of the Bot can be found here.

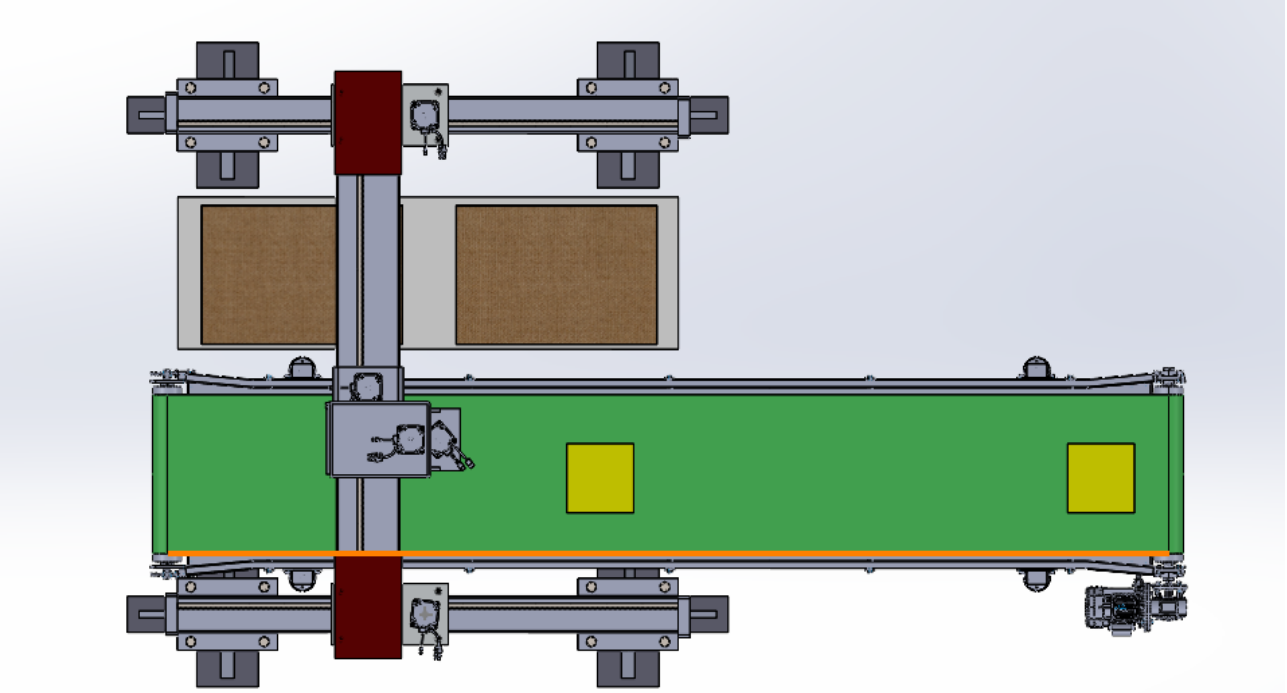
Basic Setup Model:



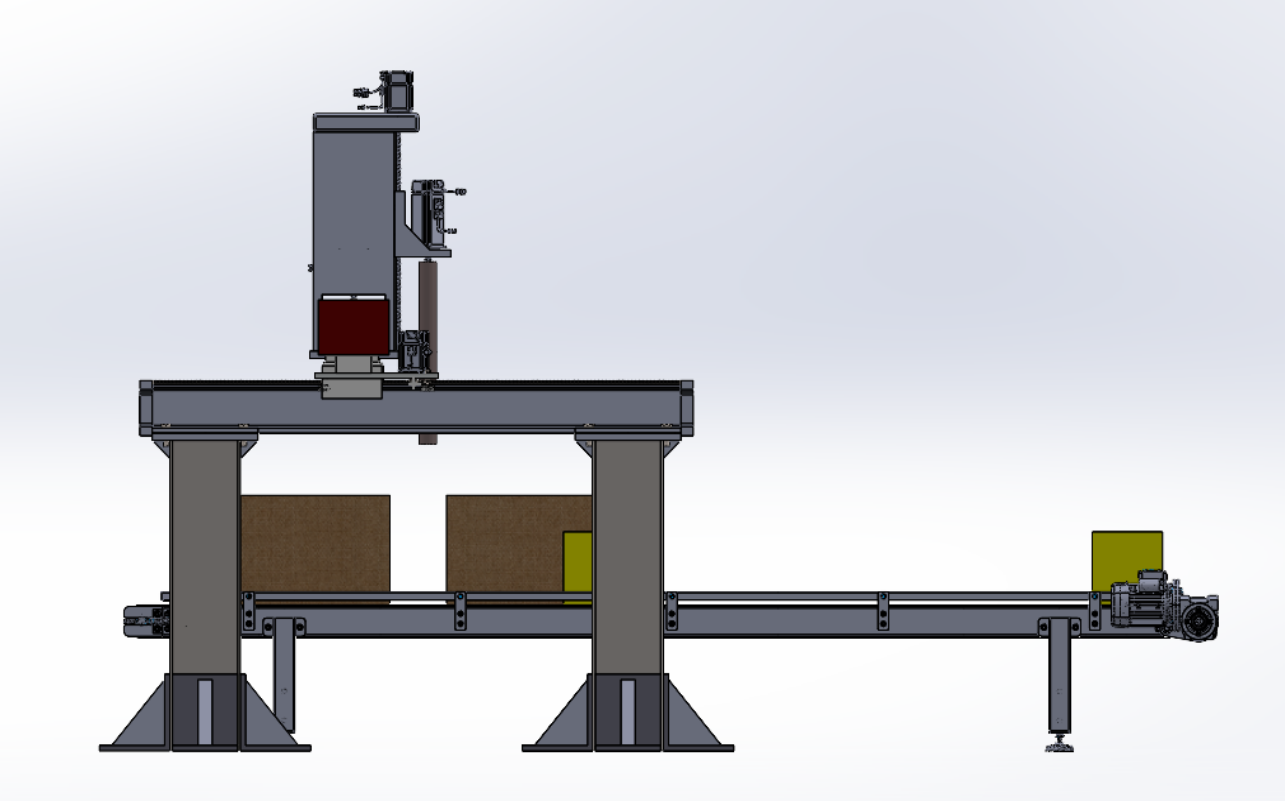
Front View



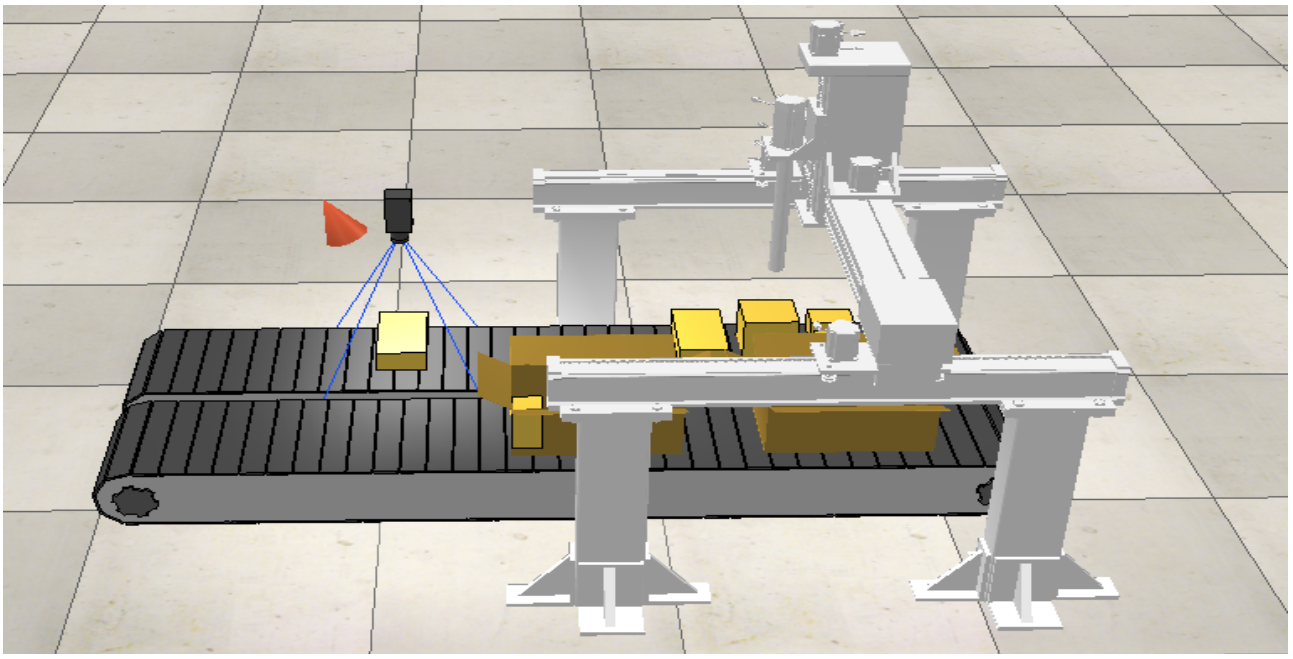
Isometric View



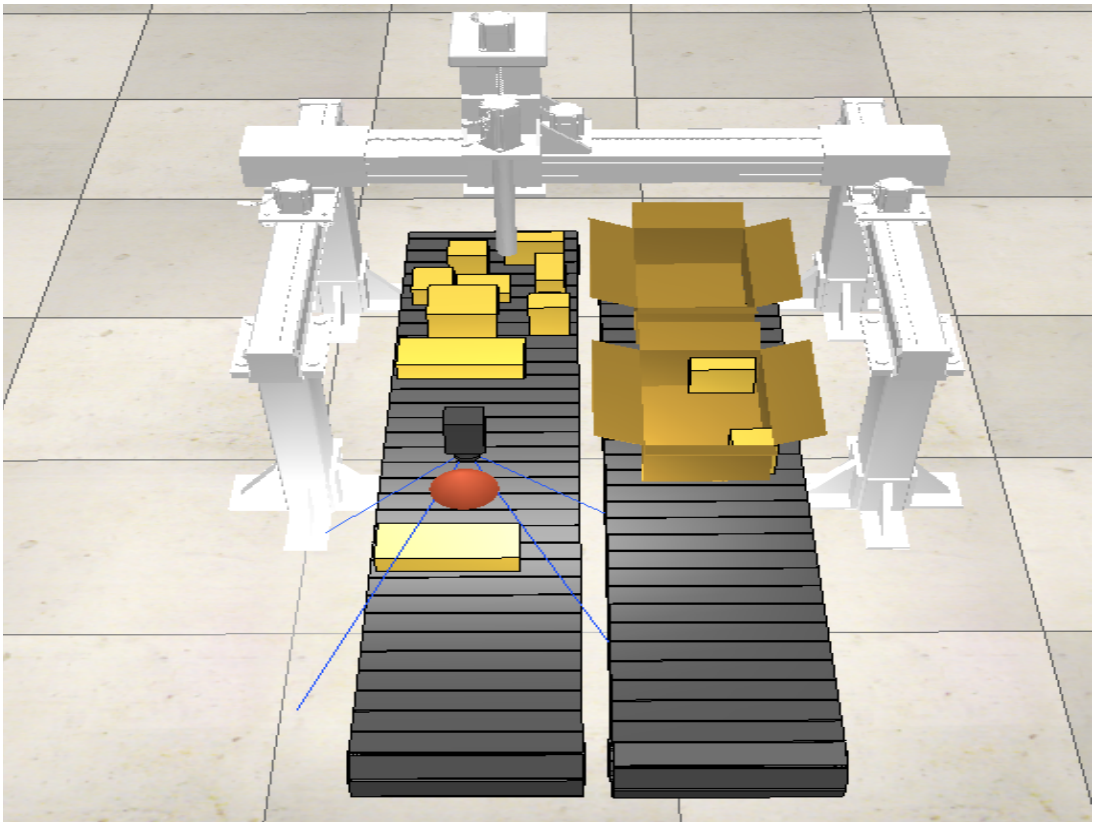
Top View



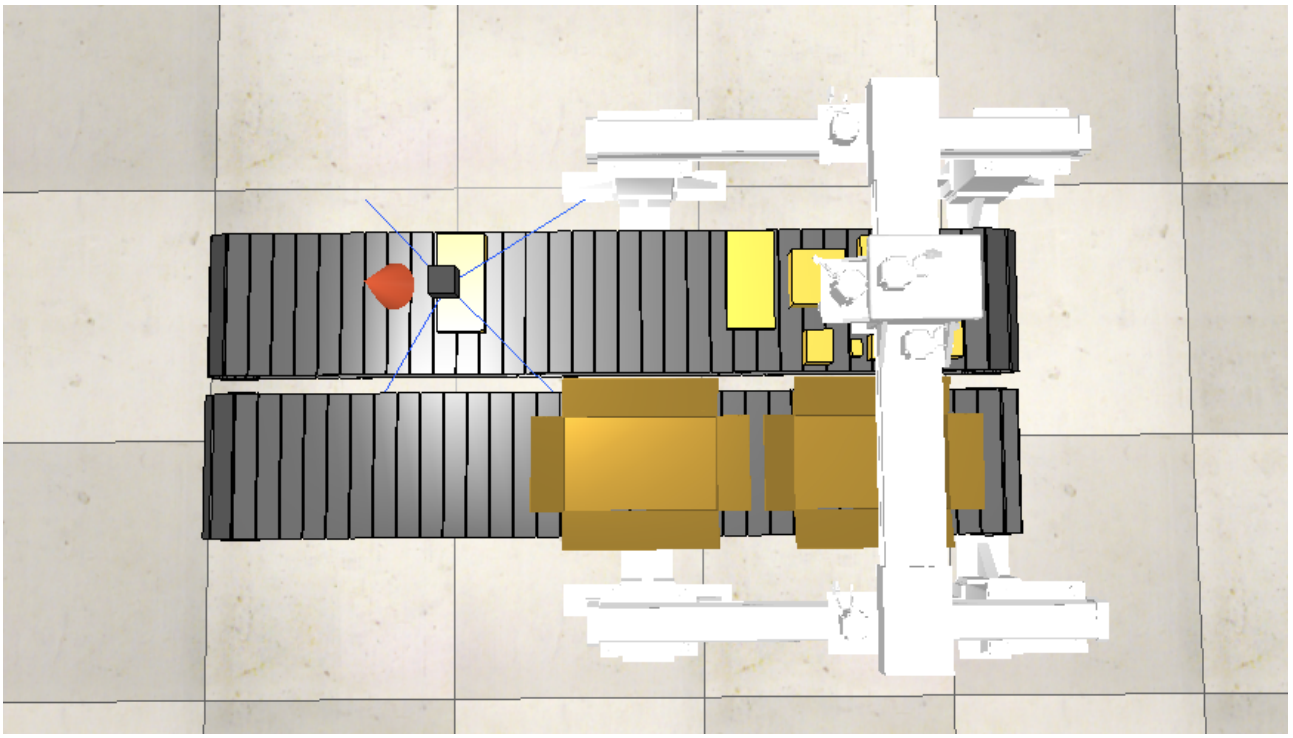
Side View



Top-Side View



Top-Front View



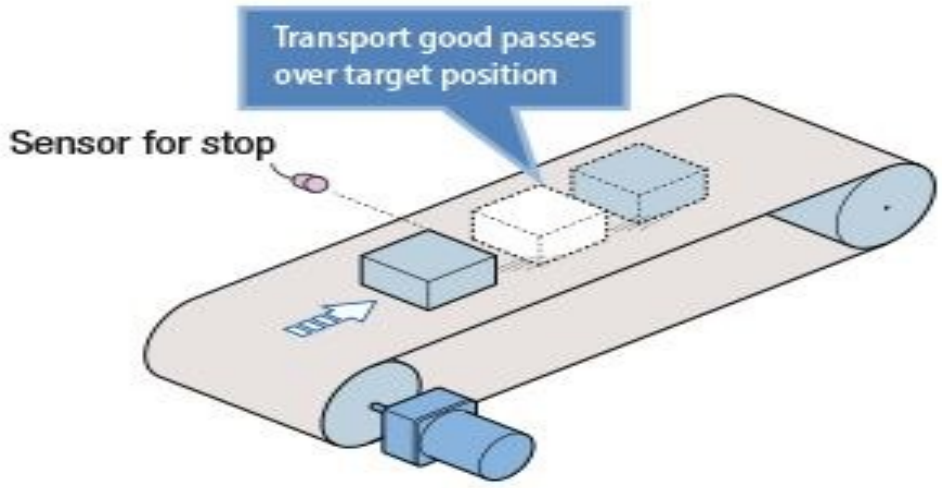
Before Operation

After completion of two iterations: 2 boxes placed

Conveyor Tracking:

When any production process needs to be scaled, an assembly line is installed. With humans operating the assembly line, they are able to make decisions about when the next item will reach them for improvements. They do this by using their eyes and process how much time it will take to reach them by approximating the distance of the item from them and the speed at which the conveyor belt is running.

We need to automate this process using machines. In a similar fashion to how humans operate, we need eyes i.e. a machine vision sensor to capture the arrival of the item on a preset point. As an added advantage, this sensor will also capture the dimensions and the orientation of the item, which will be utilised later in our sorting algorithm. As the conveyor speed is known to us, we will be able to track that package/item's location by updating the coordinates of that package using the time traversed since the detection and the speed the conveyor is operating at.



Motion Control:

In the PSP bot, we will be using servo motors to control the linear guide rails for each axis of the ganty bot:

1. **The two Parallel Guide rails:** The bridge is shifted on the parallel guide rails using **2 servos**. Both the motion on both the rails will be in the same direction. We will term this as the **X-axis.**
2. **The effector on the bridge:** For the movement of the effector on the bridge. We will be using **1 servo**. This movement is aimed at helping us reach at different depths into the conveyor belt. We will term this the **Y-axis.**
3. **The effector linear motion vertically:** The PSP Bot has to work with items

of varying heights. For this we need controlled motion in the vertical axis. We will be using **1 servo** for this purpose. We will term this as the **Z-axis.**

4. **The end effector tool :** To **orient** the tool with the box properly, we will use **1 servo** for rotation. When the effector tool is oriented with the object we need to apply a grip to pick it up and at the box, release it to place it. For a **gripper based tool**, it will be controlled using 1 servo or an actuator. While for unsymmetrical objects the **claw based tool** can be used which is controlled using 2 servos for complex system applications. This will give us controlled movement, grip strength and span over each pick and place.
5. **Conveyor: One servo** to drive and run the conveyor.

The PSP bot will require **6-7 servo motors** which will be controlled using the PLC motion controller.

Central Monitoring System:

When working on a huge machine floor with a lot of such packaging bots, it is vital that there is a system implemented which can provide smart reports to a central coordinator.

Instead of a HMI being attached to each PSP bot, requiring a human, we will be interfacing our PLC with the cloud. Many such PSP bots will be uploading their data to the cloud. In general case it will be at least one PSP bot connected to the cloud via Delta's IOT solution. The HMI will take the information down from the cloud and display it to the coordinator operator, who will take actions based on the data. This system requires a Wireless module to connect with the PLC and then to provide the interface, a HMI.

For instance, let's consider a case in which a factory floor consists of 12 PSP bots. Bot number 7 encounters a malfunction. Currently, no one is situated at the location. The coordinator is monitoring all the bots from the HMI in his office. He is made aware of the production halt through the screen. He notices that there has been a snag. He is able to fix it by rebooting the system. He is able to do that through the interface without even getting out of his chair to go inspect the bot.

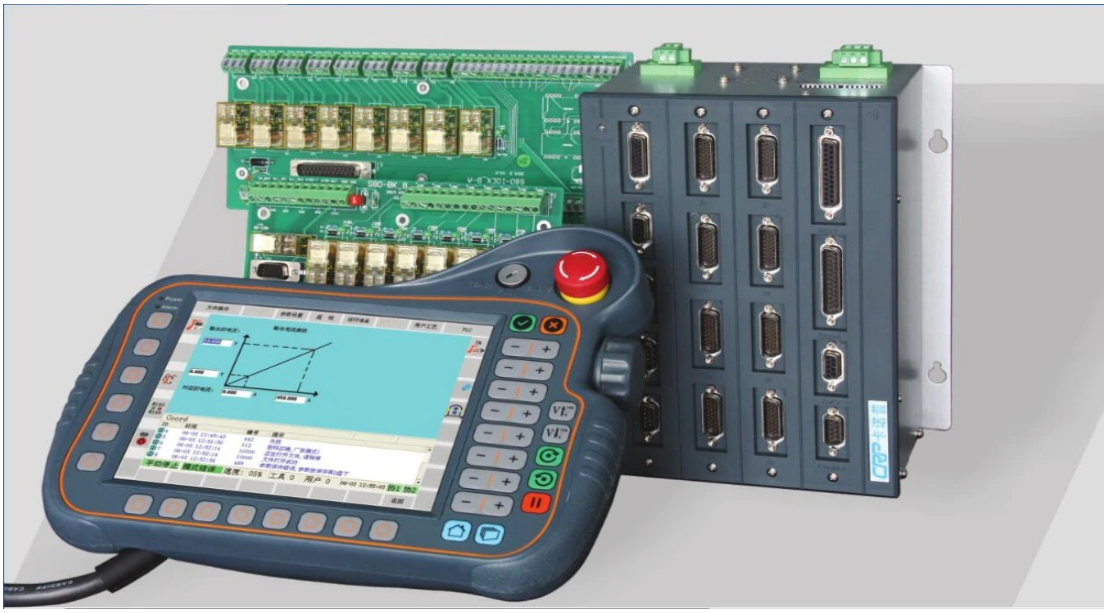
Hence the central monitoring system will monitor and manage the process of execution, error detection and deployment of the PSP Bot.

Human Machine Interface (HMI):

Human-machine interface (HMI) is a component of certain devices that are capable of handling human-machine interactions. The interface consists of hardware and software that allow user inputs to be translated as signals for machines that, in turn, provide the required result to the user.

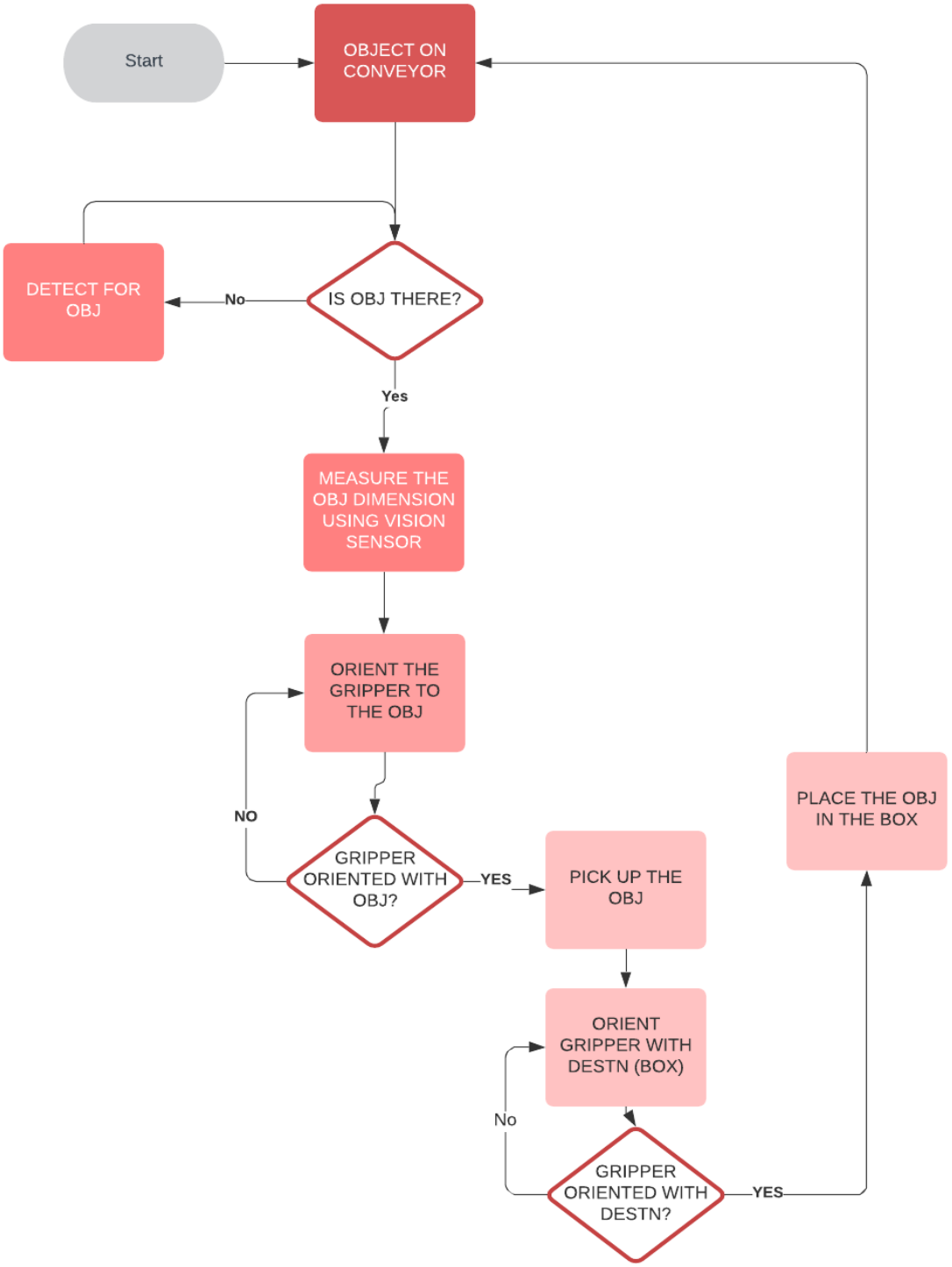
PSP bot will use a Delta HMI, 7 inch screen to display the signals and the results to the operator. The HMI receives its information from the PLC. It will display real-time-data to the operator so he can schedule Jobs and override the operation in case an error occurs in the systems.

Delta HMI



User Interface to set parameters

Workflow of the PSP Bot:



: ***Figure:*** **Flowchart of PSP bot processes.**

Design Analysis:

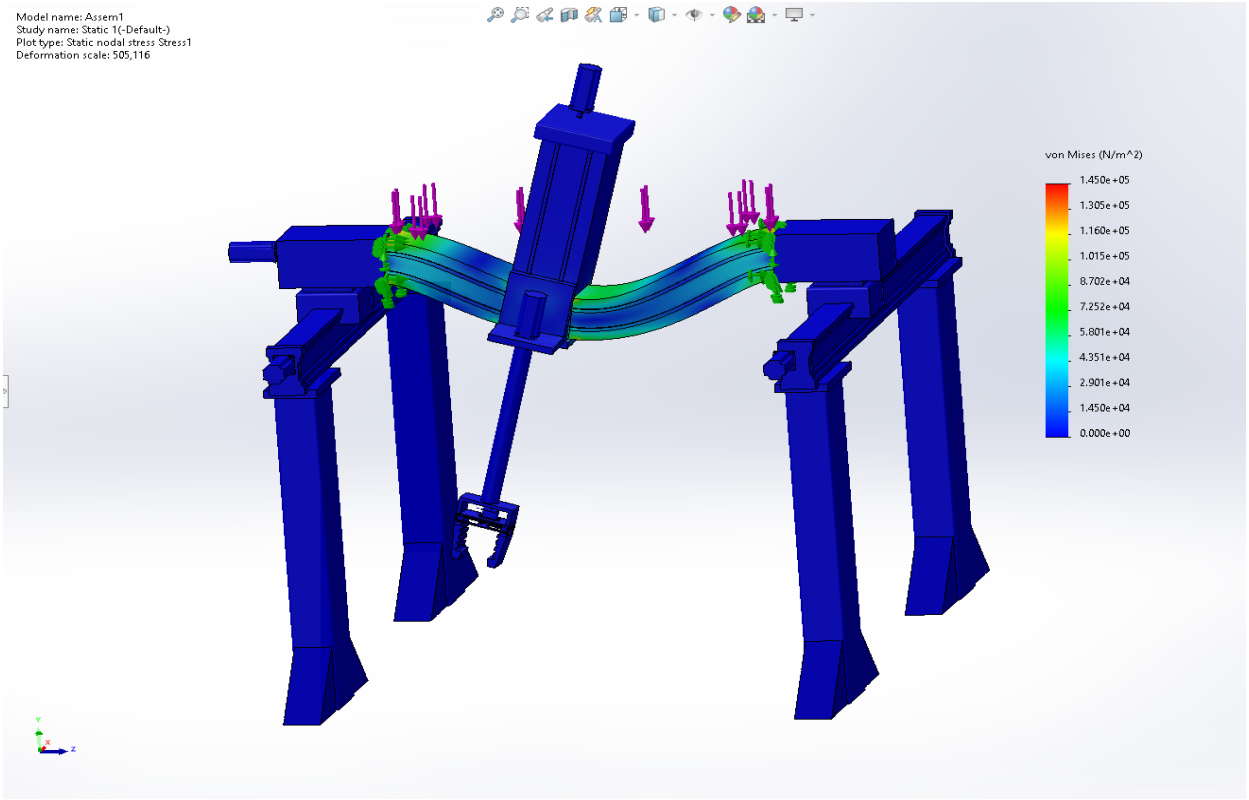


Figure: **Von Mises Stress Analysis**

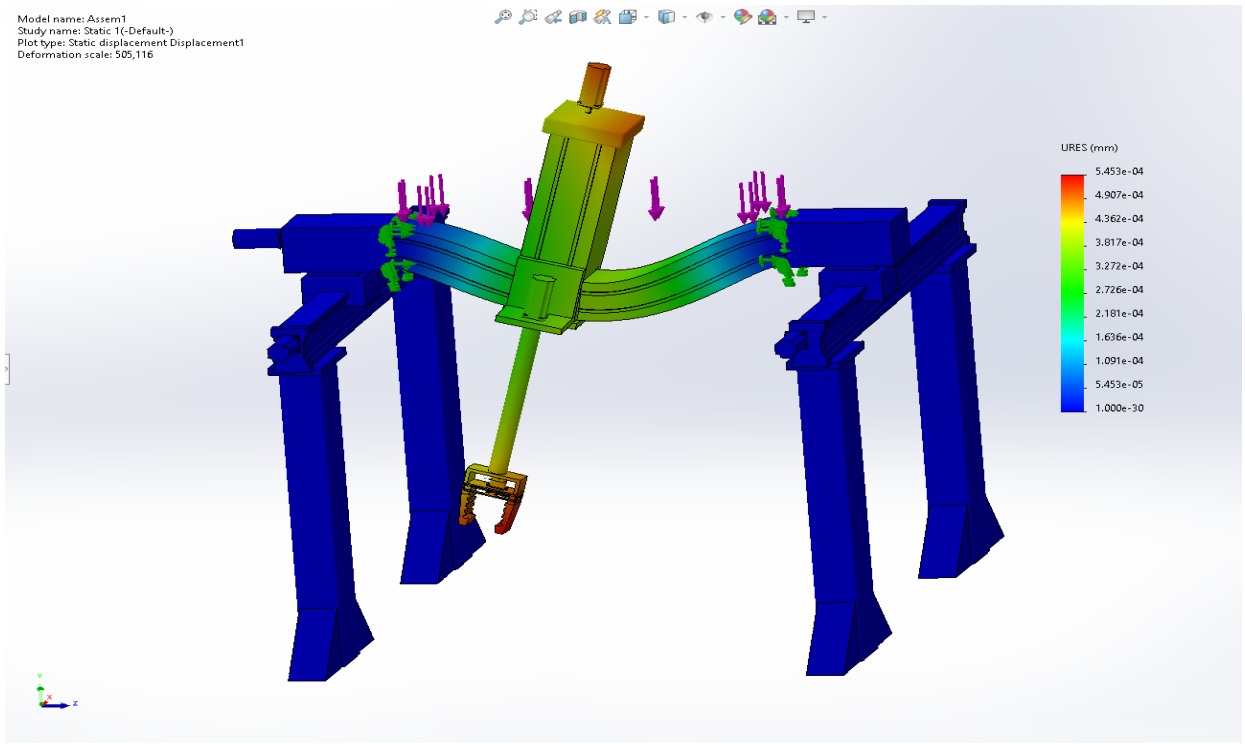


Figure: **URES displacement Analysis**

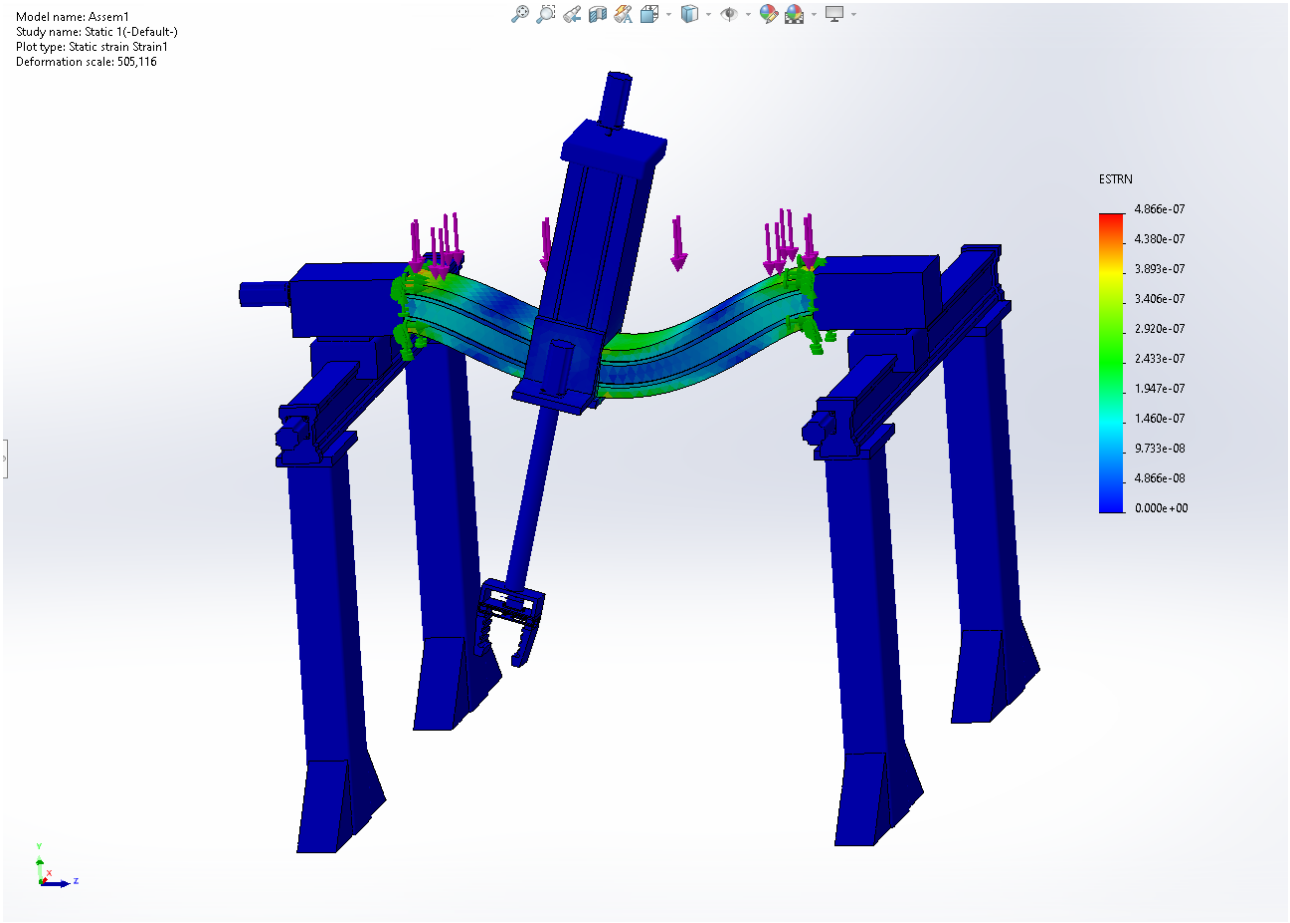


Figure: **Strain Analysis**

Stress(min-max)	0 - 0.145 MPa
Displacement(min-max)	0 - 0.00054 mm
Strain(min-max)	0 - 0.00000048

NOTE: We are working with an **exaggerated deformation display**. The product wouldn't actually deform like this under that load, SolidWorks is just showing you an amplified version so you understand where your biggest stresses are.

Algorithm

Overview:

The major implementation of the PSP Bot revolves around the Bin Packing Algorithm. The objects/ packages coming from the conveyor are detected using the vision sensor. They are placed some definite distance away from the gantry mechanism. The sensor records and processes this data. It comprehends and then accordingly gives commands to the PLCs which give commands to the servo motors and their associated drives. Conveyor tracking which incorporates the size and data of the orientation, weight and size of the boxes/items will be implemented to timely track the position of items on the conveyor.

Bin Packing Algorithm:

Problem: Pack different sizes of boxes/ items in a container in the most efficient way. It can be cost based, space efficient or weight efficient as suited by the user.

In the bin packing problem, items of different volumes must be packed into a finite number of bins or containers each of a fixed given volume in a way that minimizes the number of bins used. In computational complexity theory, it is a combinatorial NP-hard problem. The decision problem (deciding if items will fit into a specified number of bins) is NP-complete.

Workflow:

1. Each input box/ item which passes through the conveyor will be detected by the vision sensor and its snapshot will be taken.
2. After applying Image Processing Techniques on it, object details will be extracted such as the orientation, size and dimensions of the input box.
3. Binary Packing Algorithm will be runned and If the input item fits in the remaining capacity of the output container box, it will be selected, else it will be rejected (placed in another container).
4. Making use of Conveyor tracking the gripper of the gantry setup will pick up the selected box and place it in the current filling container.
5. It will be placed in the output container as per the orientation calculated by the algorithm.
6. After maximum capacity of the output box is achieved, that box is sent for

sealing, barcode scanning and further pre-shipping processes.

7. Repeat for another boxes

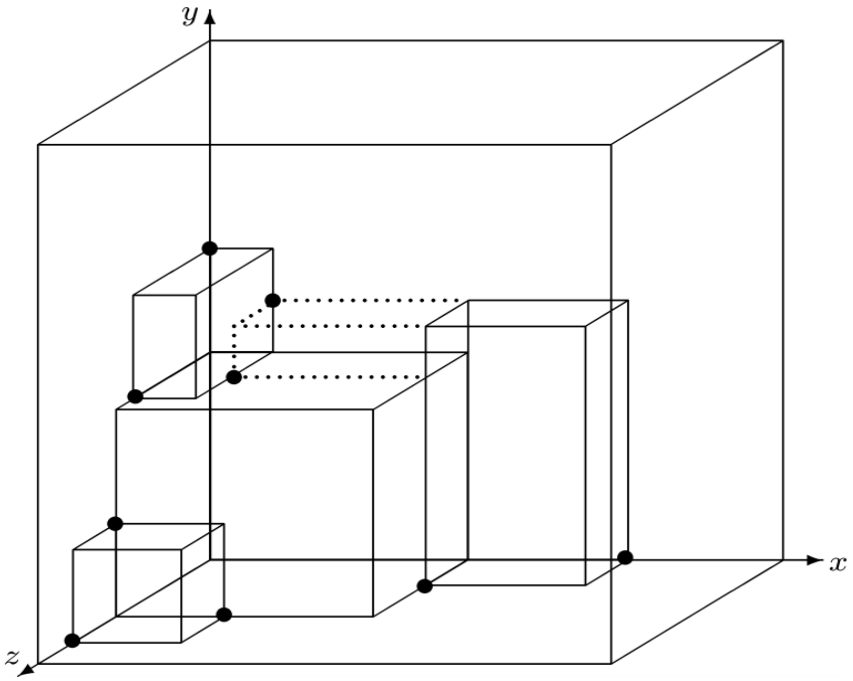


Illustration of Placement of items

The Bin Packing Algorithm has various versions to solve the packaging problem:

Two of them are:

1. **First Fit Algorithm:**

   When packing an item, start with the earliest bin. For instance, if you have a row of boxes partially filled with various items, check to see if it fits in the very first box you packed (Bin 1). If it doesn't move on to Bin 2, and down the row until you find one that works.

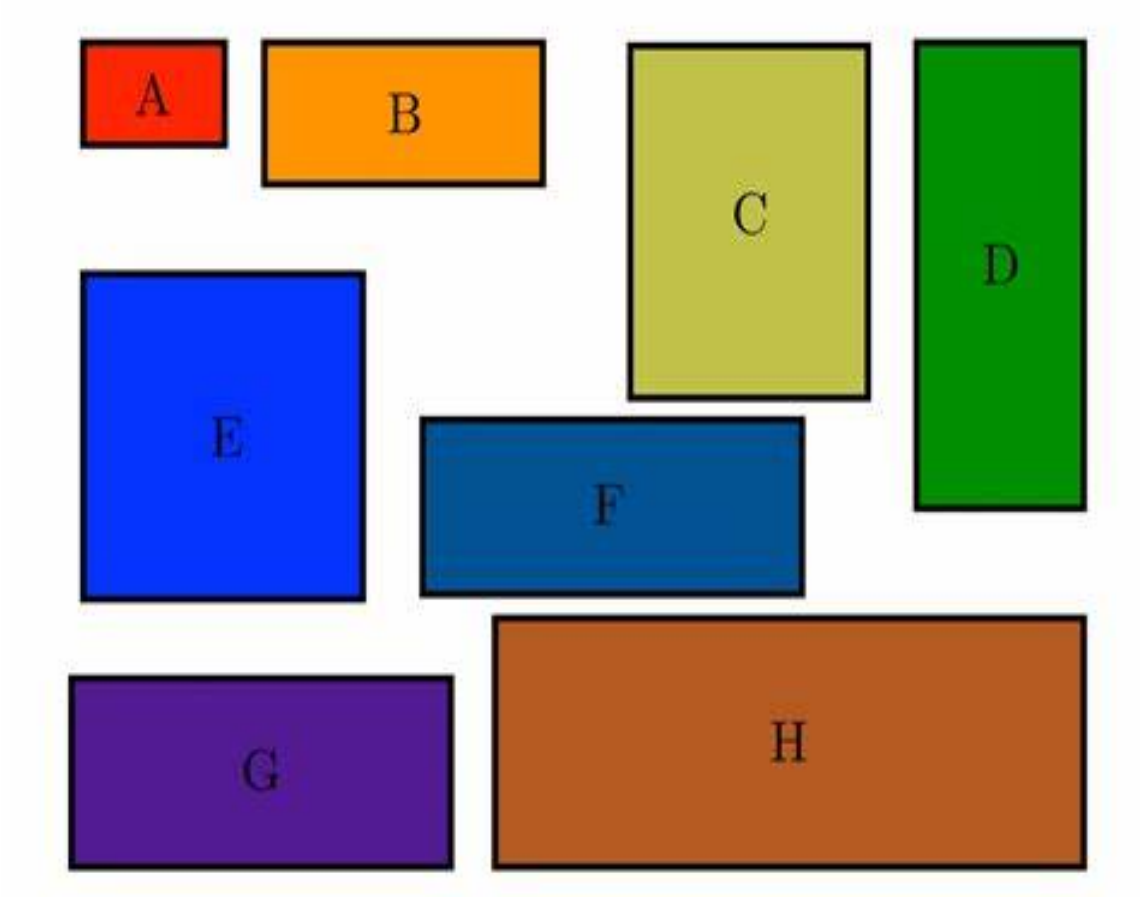
2. **Best Fit Algorithm:**

   With this approach, the bot looks for the bin with just enough room to pack an item. The goal is to use as much of that bin's space as possible and get the bin shipped out as quickly as possible.

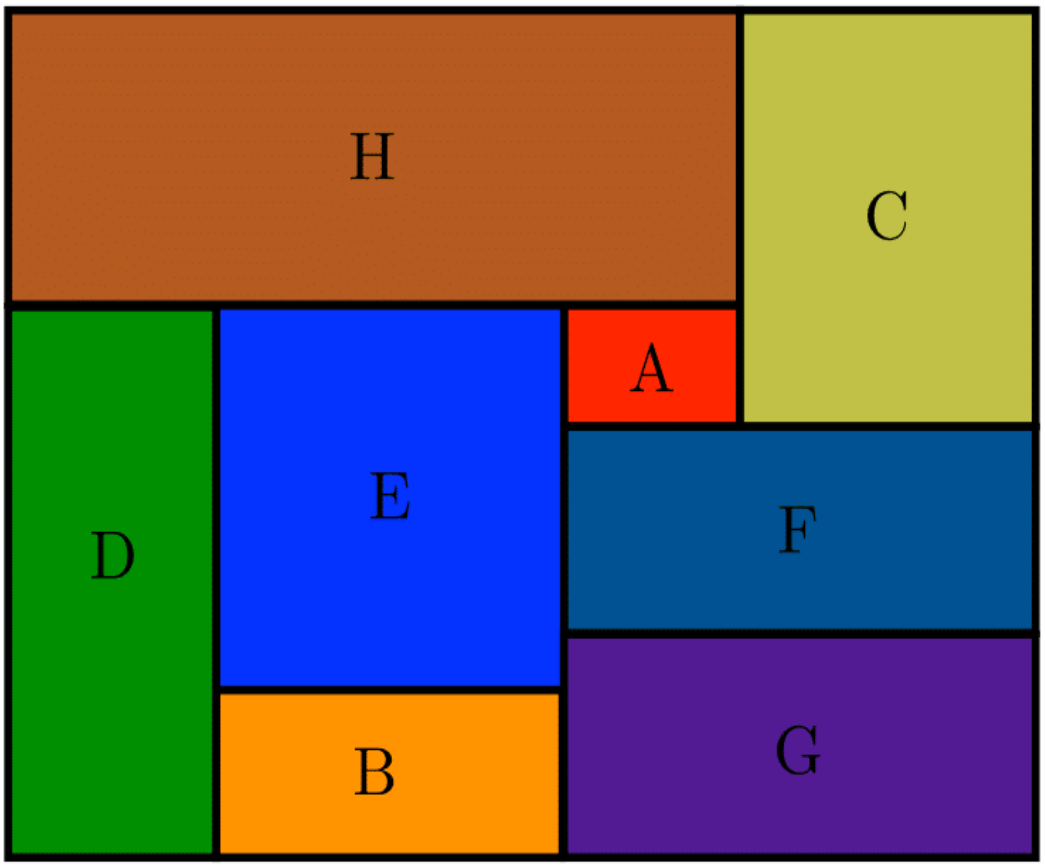
The **Best Fit - Bin Packing Algorithm** proves to be more efficient considering our use case of filling one box to the fullest. We intend to use this version of the Bin Packing Algorithm.

Advantages of Best fit over First Fit :

- Less time Complexity.
- Matches the purpose well.
- Utilizes the smallest available free space for efficient fill.
- Reduces occurrences of possible leftover unallocated large free spaces as compared to first fit.



Loosely placed items in random fashion: Inefficient



Items placed tightly as per Bin Algorithm : Efficient

Uncertain Error Handling:

- In case of an error occurring during the workflow, the PSP bot will stop its current operation and report to the main system along with the bot ID using IIOT.
- After stopping the workflow, it sounds an error indication beep sound and blink a red LED.
- Through the HMI it will also try to provide its operator with the highest level of information about the occurred mishap.
- The operator will be able to resume the operation manually after the problem has been resolved.

Cost Analysis, Feasibility and Reasonability:

- Using parts as per industry standards makes the overall project cost effective.
- PSP Bot is a multi-purpose robot in different packaging scenarios and hence improves the value for money.
- As compared to costly industrial robotic arms, our system is less complex, easy to use and more economical.
- The project is quite feasible and an upgrade over existing pick and place robots including the features of custom sorting.

Component Block Diagram:

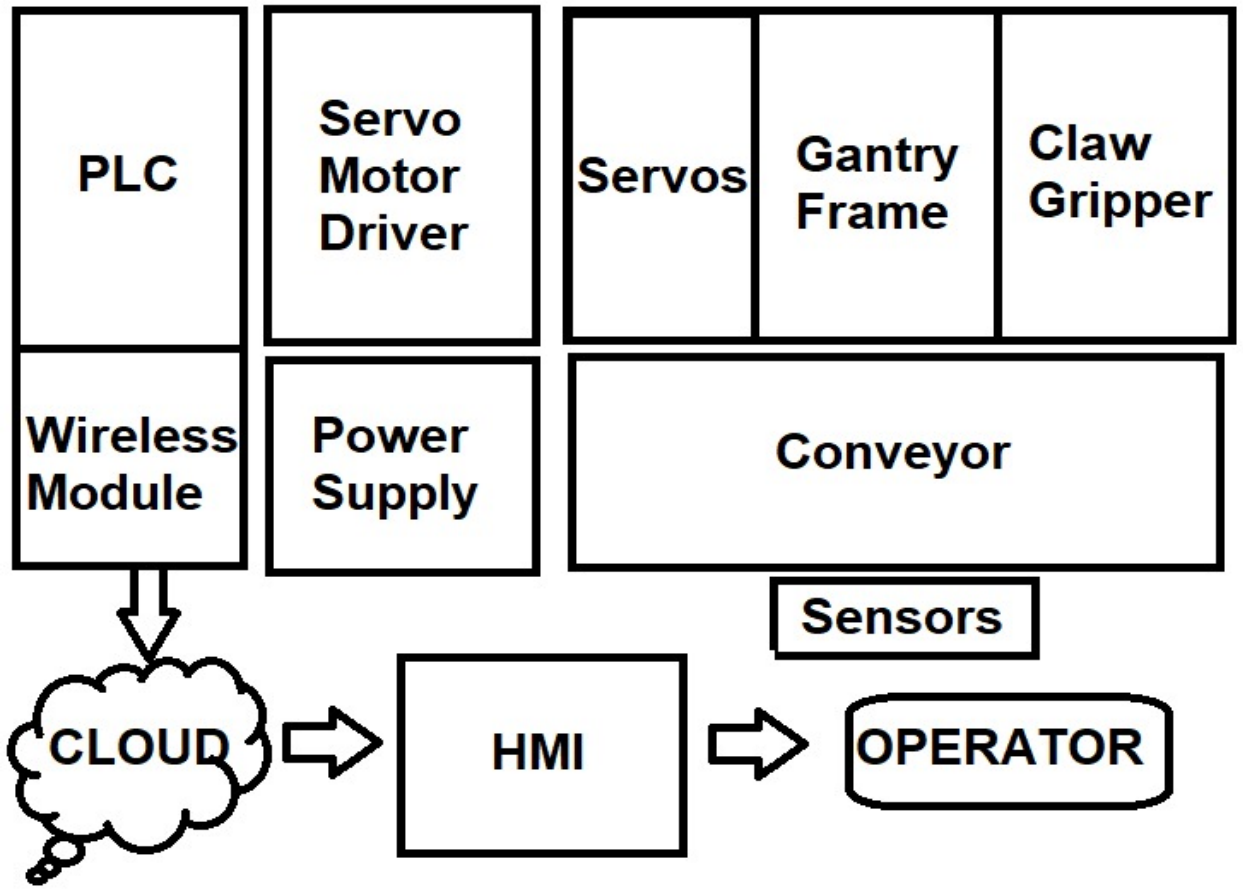


Figure: **Block Diagram for the PSP bot showing the major components**

Proposal Configuration

Delta Industrial Automation Products Applied

Sr No	Product Name	Model	Quantity	Description
1	PLC: Motion Controller	DVP50MC-06	1	Main controller which accepts the input through HMI and cloud server and controls according to ladder logic.
2	Expansion Module	DVP16SP11T	1	8 in 8 out
3	Expansion Module	DVP04ADS	1	Analog 4in
4	HMI	DOP107EV	1	To observe the status of the robot on the field and to control it. 7 Inch Color touch hmi
5	Machine Vision System Controller	DMV3000-GE2-VL (24VDC supply\4CH\Gig-E)	1	For object detection of items/packages and positioning.
	Camera 1	DMV-CM2MCGE-D (2.0mp,CMOS,color)	1	
	Lens 1	DMV-LN12M (12mm,2mp)	1	
	Camera to Controller Interface cable	DMV-CAF5MGE (Gig-E, camera interface , 5mtr)	1	
	Light	DMV-LDBR300030P (300mmx30mm BAR light, 24V)	2	
	Light Controller	DMV-P1024D (24V, 2CH)	1	

6	Laser Displacement Sensor	LD-150	1	To measure depth or distance in the z axis for object (90~210 mm)
7	Proximity Sensor	IS-N1208-BPOB3: NO 8mm Sensing Proxy (Servo Home)	4	To ensure that the item has been picked up by the end effector and mapping the entry and exit of input objects for the vision setup.
		IS-N1208-BPCB3: NC 8mm Proxy (Limit Sensor)	8	
8	Product Sensor	PS-RR3-PS12	1	300mm Sensor
9	Switch	DVS-005-I00	1	Ethernet Hub
10	SMPS	DRP024V240W1AA	1	24V 10 A SMPS
11	IOT	DX-3021L9	1	IOT with Cloud License
12	Motor Driver	ASD-B3A-0721-E (x - axis)	2	For driving the motors
		ASD-B3A-0721-E (y - axis)	1	
		ASD-B3A-0721-E (z axis)	1	
		ASD-B3A-0721-E (z rotation)	1	
		ASD-B3A-0721-E (conveyor)	1	
13.	Servo Motors	ECM-A3H-C20807RS 1 (X - Axis)	2	For moving the components of the gantry bot and for the gripping action of the end effector along respective axes. And 1 for the conveyor belt.
		ECM-A3H-C20807RS 1 (y - axis)	1	
		ECM-A3H-C20807RS 1 (z axis)	1	
		ECM-A3H-C20807RS 1 (z rotation)	1	
		ECM-A3H-C20807RS 1 (conveyor)	1	

14.	Planetary Gearbox	PL90-10-C108 (X - Axis)	2	Gearbox to provide more torque.
		PL90-05-C108 (y - axis)	1	
		PL90-10-C108 (z rotation)	1	
		PL90-15-C108 (conveyor)	1	
		Provider/Name/ Model	**Quantity**	**Description**
11.	Microcontroller	Jetson Nano	1	ForIOT, vision sensor interfacing backup
12.	SMPS	Third Party	1	24V, 5A
13.	LED Display	Third Party	1	1024x768 resolution
14.	VGA cable	Third Party	1	10 mtr
15.	Generic USB, Ethernet cables	Third Party	Multiple	For connections
16.	MCBs	Third Party	Multiple	For connections
17.	Relays	Third Party	Multiple	For connections
18.	Panel Mount, Miscellaneous electrical wires and components	Third Party	Multiple	For connections and mounting devices
15.	Steel Frame Elements	Third Party	Multiple	To make the bot
16.	Mechanical Joiners (Bolts, Nuts, Rack and Pinion, Ball screws,	Third Party	Multiple	To join various parts together

	etc)			
17.	Aluminium, Frame Elements	Third Party	Multiple	To make the bot
18.	Conveyor belt and Conveyor setup	Third Party	1	For input boxes
19.	Air compressor	Third Party	1	For operating the vacuum based end effector

Future Scope:

This project can be taken a lot further than its current telling. The concept of customised pick and place is a vast challenge faced in the packaging industry. Some other possibilities we looked into for the PSP bot was using a delta bot, and robotic arm (palletizer bot). Though the implementation will be different, we will achieve different results.

For instance, with the use of a delta bot, the speed will get a boost and the payloads will be smaller in weight and size. An implementation for hamper packaging can be tried out with this.

Another aspect we want to explore in the algorithm and their performance measures. After considerable research we have settled down on the best fit bin packing algorithm. However, there are many other algorithms that can be a better selection for other use cases, such as the knapsack packing algorithm, the first fit bin packing and worst fit bin packing algorithm, strip packing algorithm. Each algorithm has a certain benefit and drawback and remaking the PSP bot for different purposes, it will be essential to redo the algorithm by matching the pros and cons with the new processes.

Summary:

PSP Bot in short is a pick, place, packaging bot which detects the boxes and places the smaller boxes in a bigger box with maximizing the space used. As E-commerce businesses are running to their full potential which is expected to grow even more in coming years, there should be speed and efficiency in the packaging sector of the company as maximum deliveries in a day equals maximum profits("Time is Money"). Now maximizing the space means less amount of bigger boxes which means less spending for raw materials which in turn increases profit and also good for the environment.
Keeping the above in mind, we believe that given a chance PSP Bot will surely contribute towards providing economic solutions in the industry.