Flipkart

GRiD 2.0

Intelligent Picking - Round 3

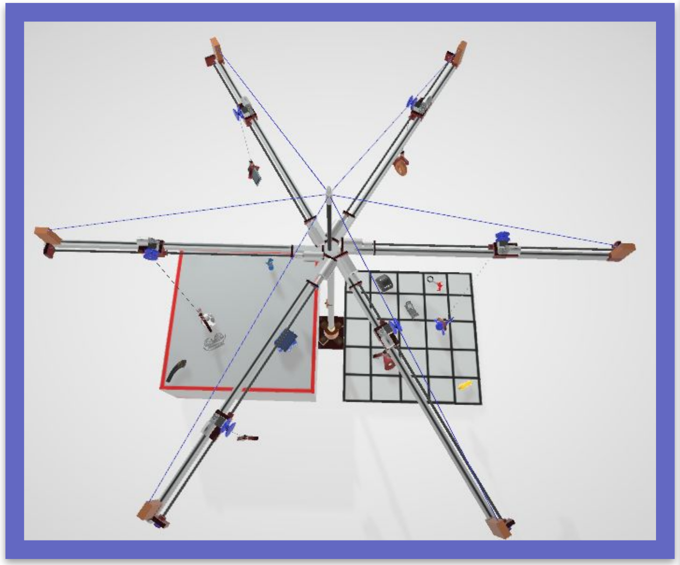
Team Name : XYZ

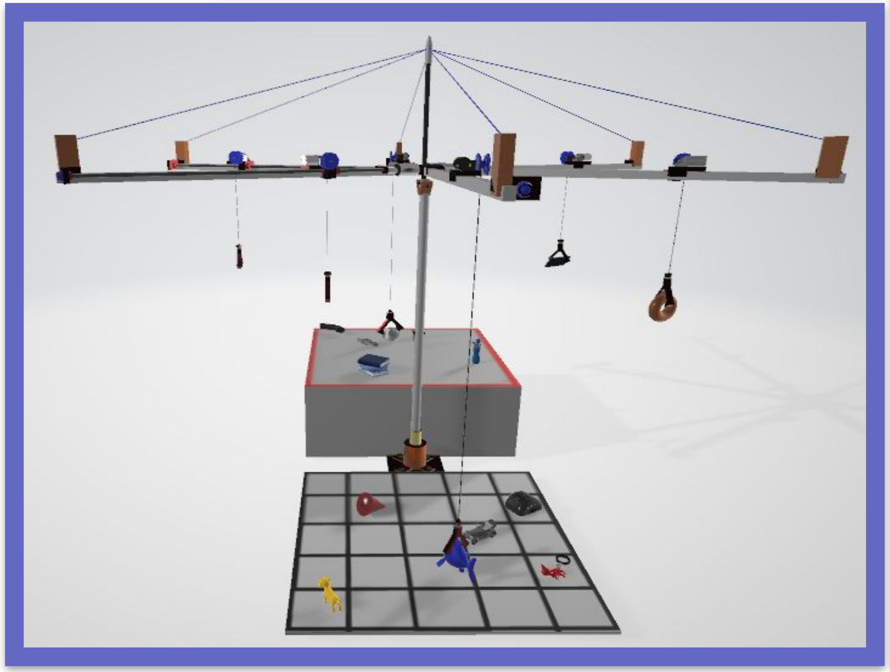
Institute Name : Indian Institute of Technology (IIT) (BHU), Varanasi

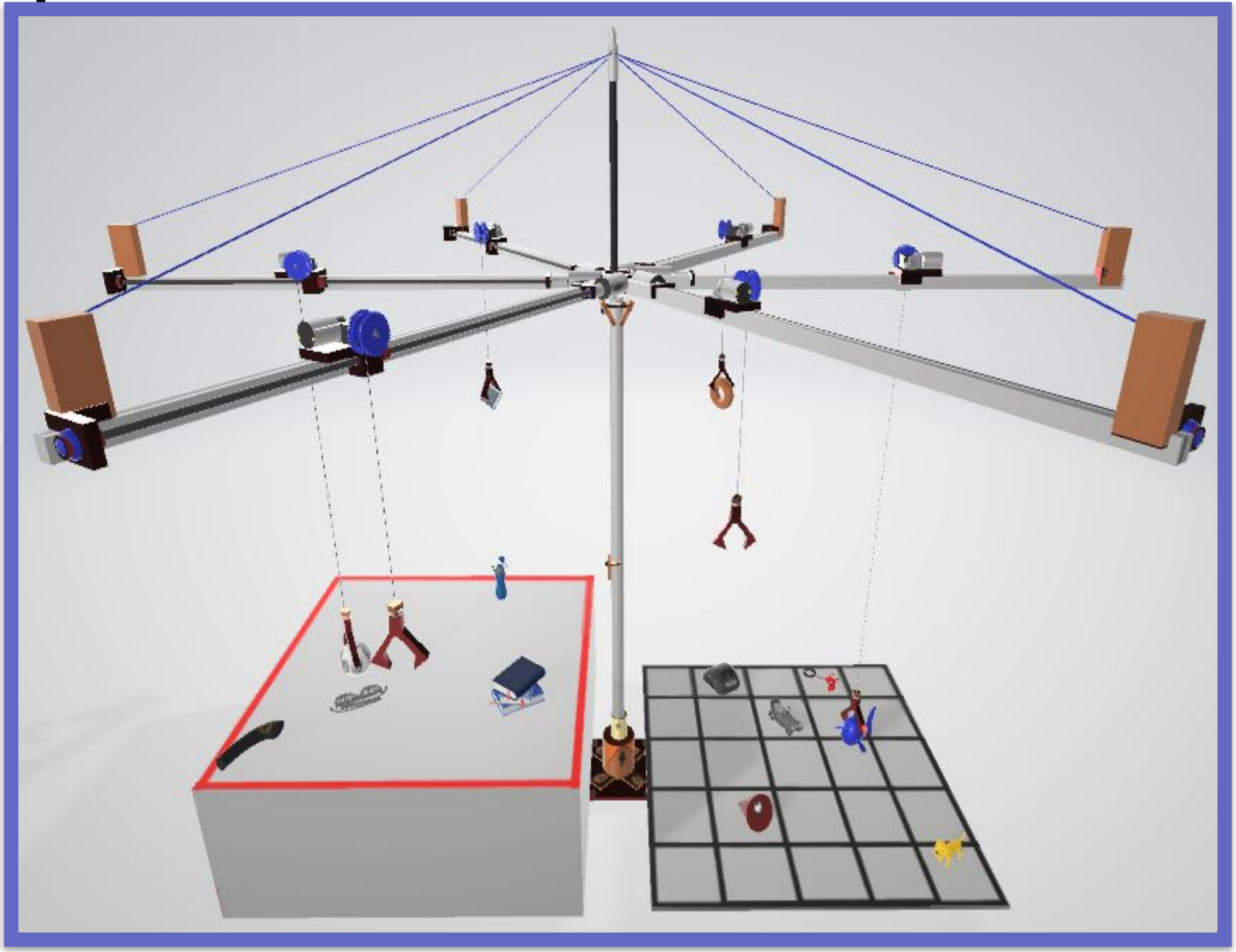
Team Member Details

1. Siddharth Anand Srivastav- Active member of Robotics club and participant in Pixelate and Hurdle Mania(Technex exclusive events), Robotics Summer Camp based on Robot Designing and PyBullet simulation.
2. Yash Upadhyay- Active member of Robotics and Aerodynamics clubs, Participant in Pixelate, Hurdle Mania, Dronetech, E-Yantra, Robotics Summer Camp based on Robot Designing and PyBullet simulation.
3. Vimal Kumar- Active member of Robotics and Aerodynamics club, participant in Pixelate, Hurdle Mania, Dronetech, Robotics Summer Camp based on Robot Designing and PyBullet simulation.
4. Vikhyath Venkatraman- Active member of Robotics and Programmer's clubs, participant in Pixelate, E-Yantra, Mosaic, Robotics Summer Camp based on Robot Designing and PyBullet simulation, 1st Place in Recognizance, Same stage in Flipkart GRiD SDC.
5. Aditi Agrawal- Active member of Robotics and Cine clubs, participant in Robotics Summer Camp based on Robot Designing and PyBullet simulation, Runners-Up in Robotryst.

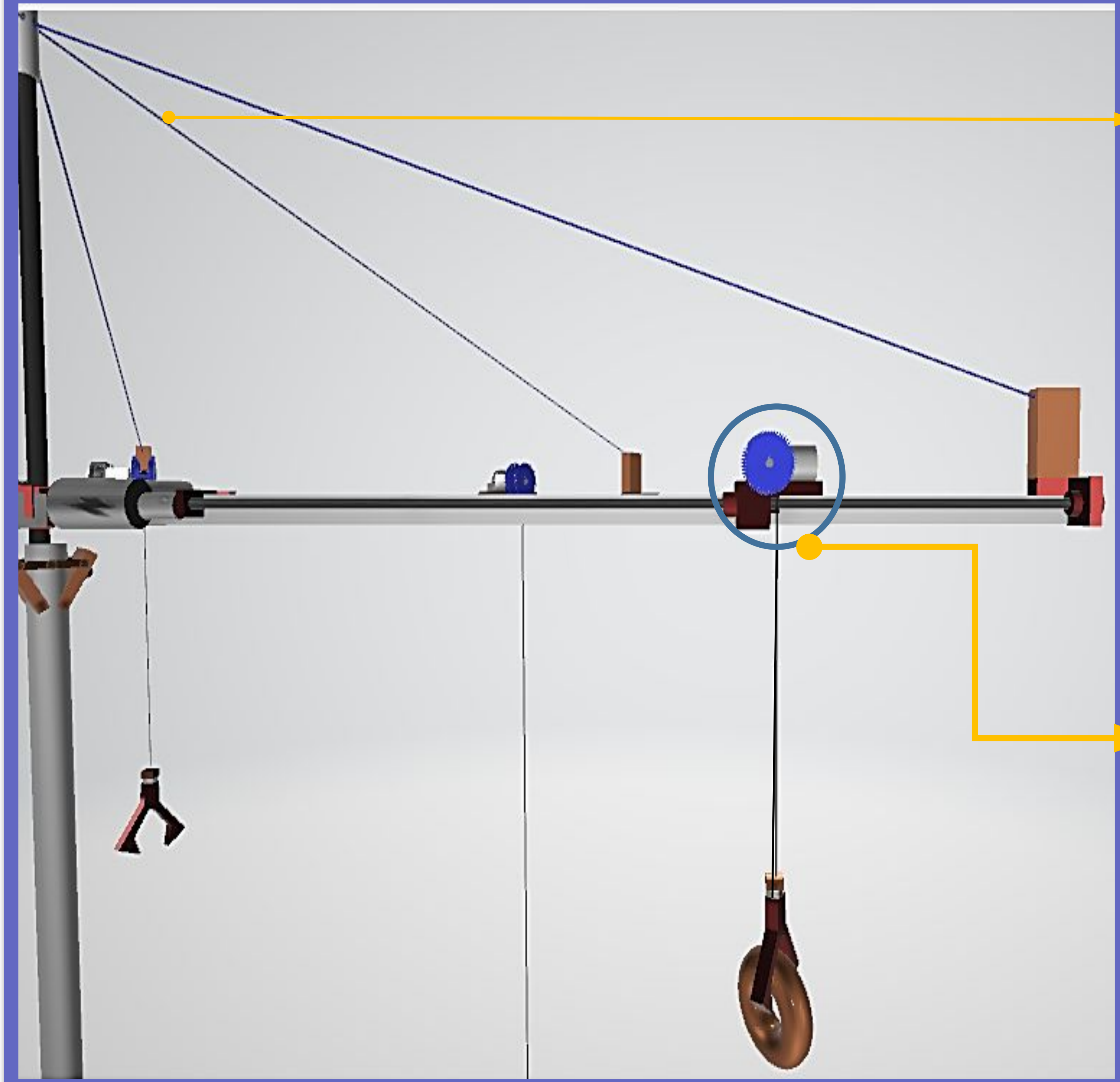
CAD Drawings for Robot and Components



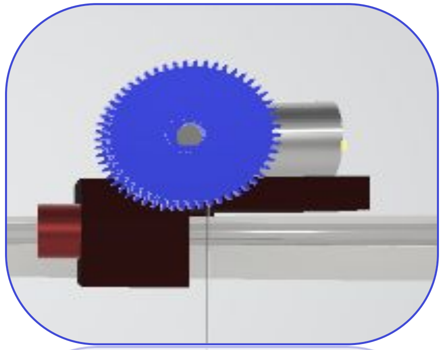


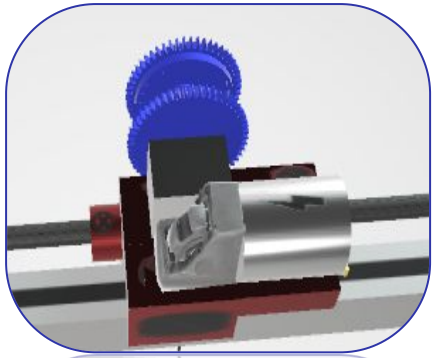



TECHNICAL
SPECIFICATION



Inspired by Suspension Bridges, the ends of the long arms are suspended from the rotating axle using wires for **Extra Stability**.

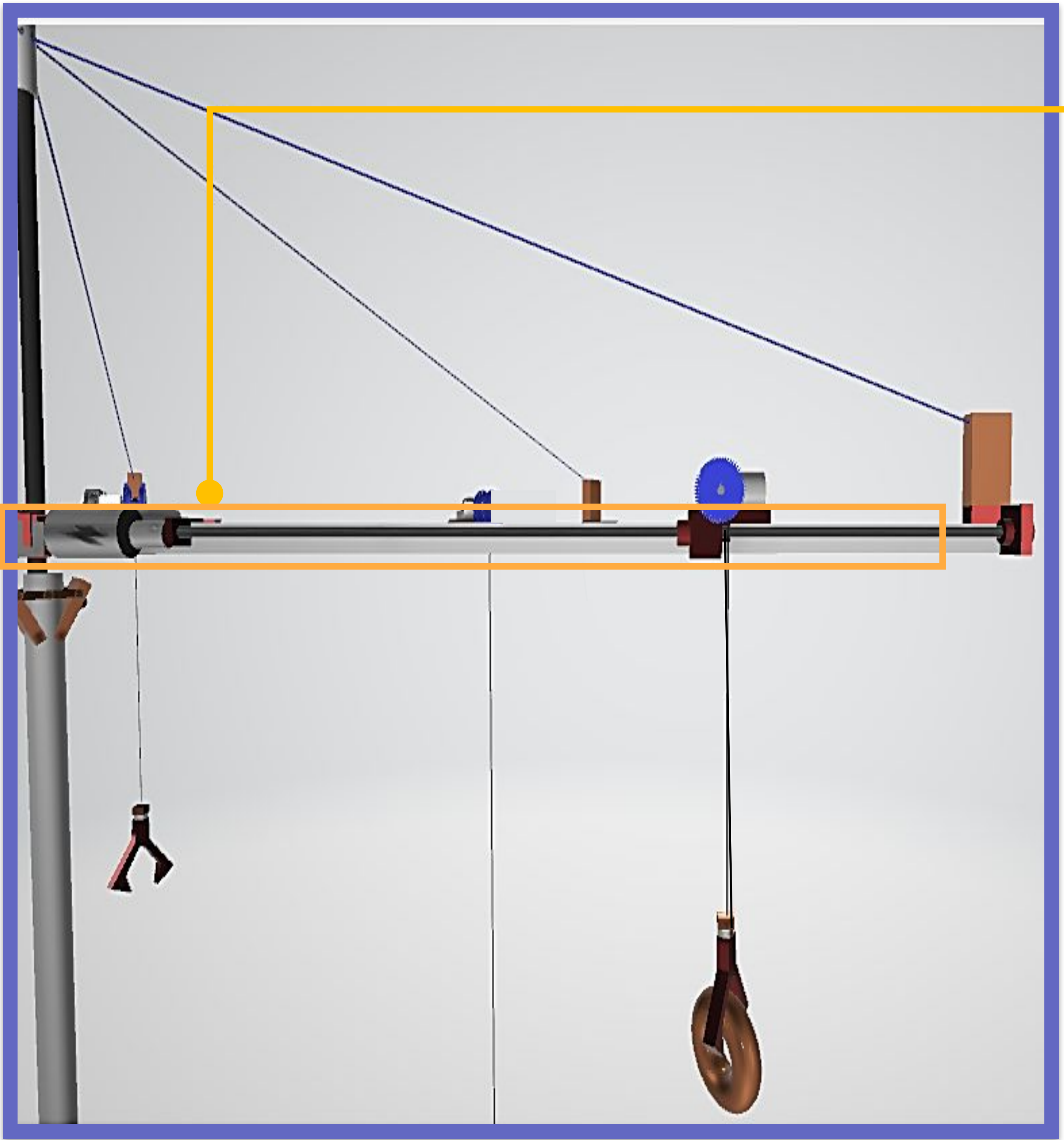


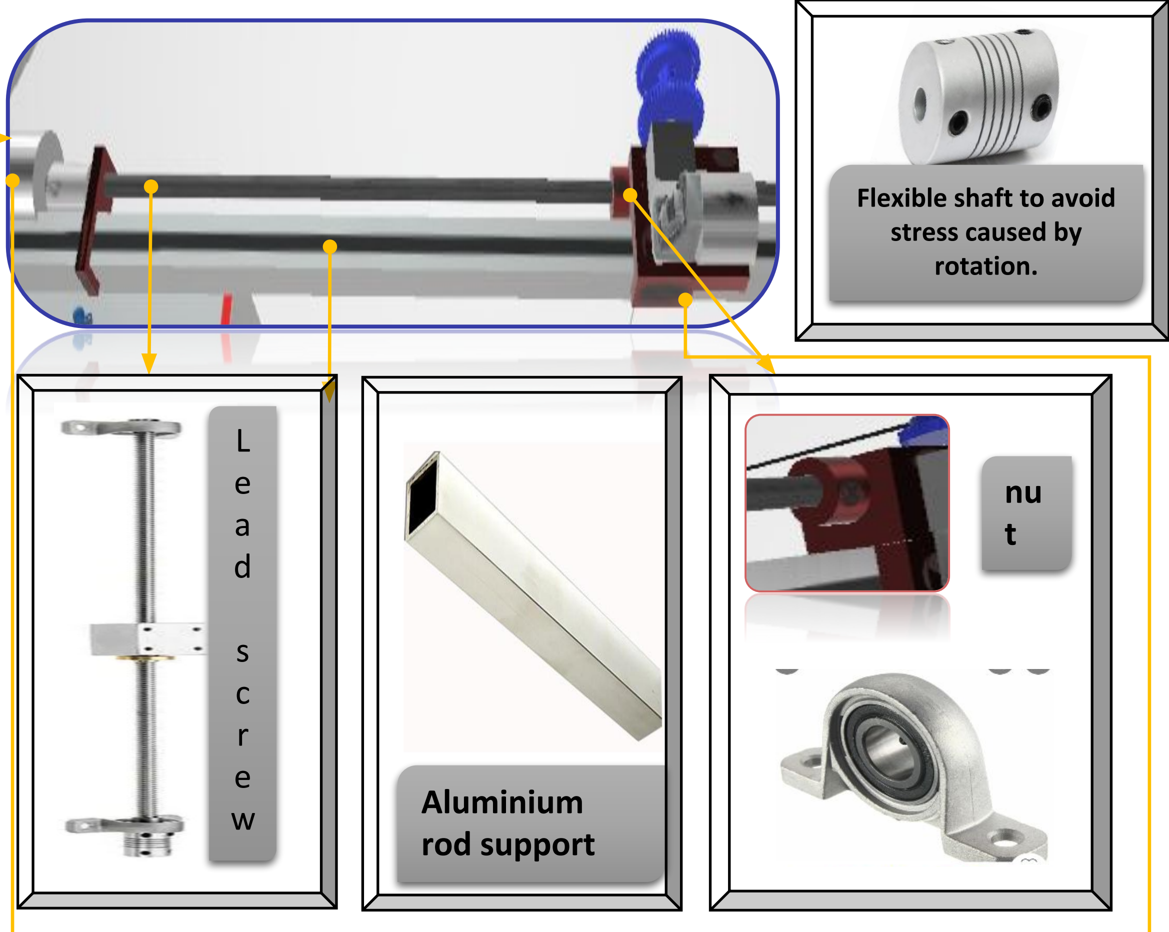


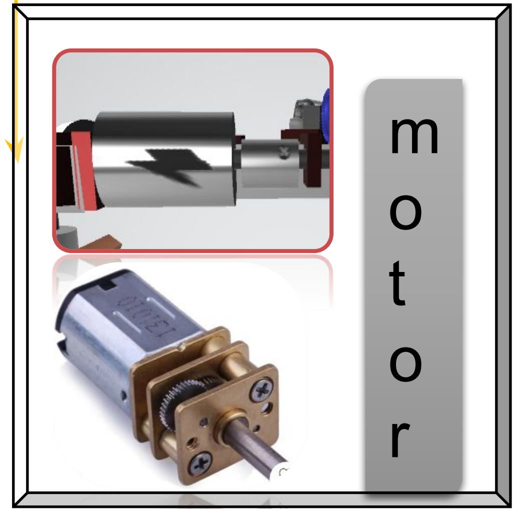
For vertical motion, **Worm Gear** will be used to avoid any reverse rotation that a load may cause. The gear will control motion of the pulley, which will control the vertical motion of the gripper via wires.

Pulley

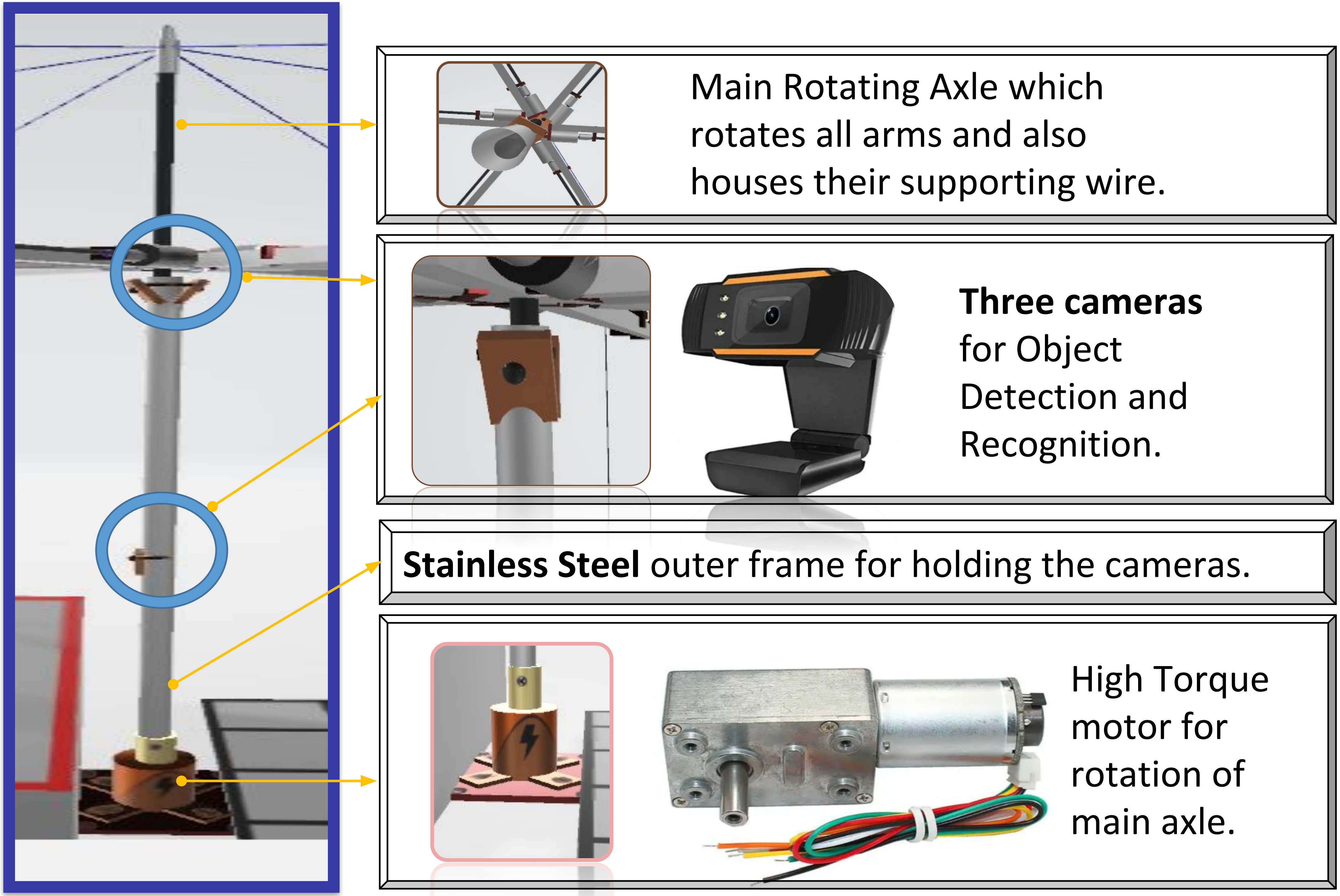
Right Angle Output Gear Motor







The motor rotates the lead screw causing linear motion of the nut on it. A housing bracket is attached to the nut to rest the worm gear motor. It is supported on an Aluminium rod.

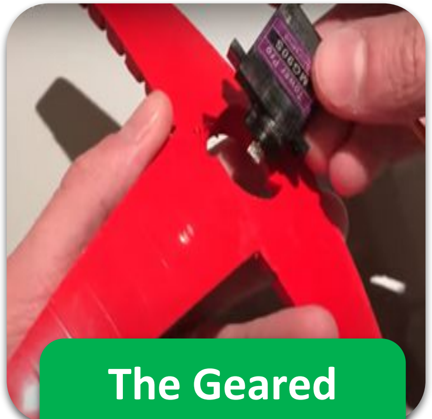

Main Rotating Axle which rotates all arms and also houses their supporting wire.
Three cameras for Object Detection and Recognition.
Stainless Steel outer frame for holding the cameras.
High Torque motor for rotation of main axle.

Making of The Gripper

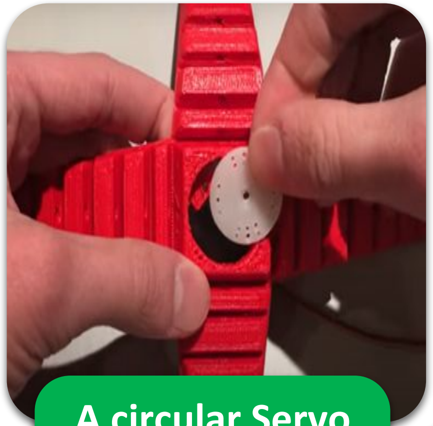
The robot will deal with objects of various size shape and texture. For delicate handling of this variety of objects we will be using **3D Printed Flexible Soft Grippers.**

The base of gripper is 3D Printed.

- Flexible materials like Ninja flex or Willow flex will have to be used for printing.



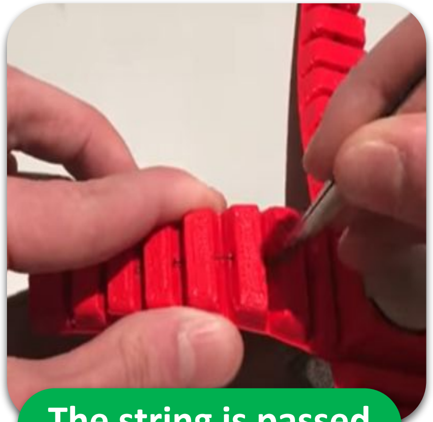
The Geared servo motor is fixed at the back of the gripper.



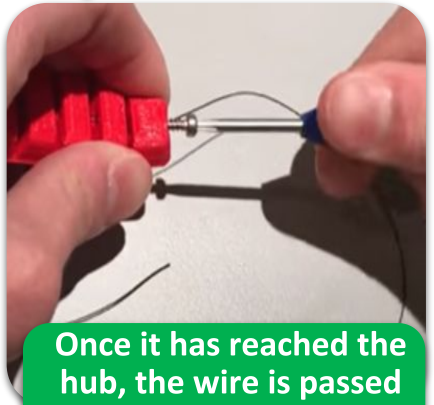
A circular Servo Horn is attached from the Front.

- The motor is twisted in such a way that there is a hole lined to each arm.

A Nylon String is threaded into each arm from the outside.



The string is passed through each semi-divided part of the arms, in which holes were intentionally left while printing, till the center.



Once it has reached the hub, the wire is passed through the hole of corresponding servo horn and then it is secured with screws on both ends.

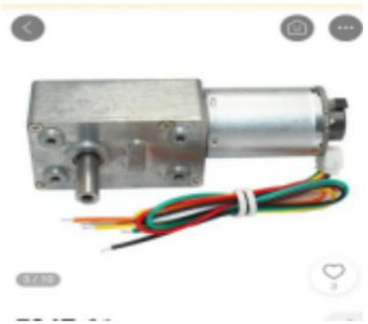
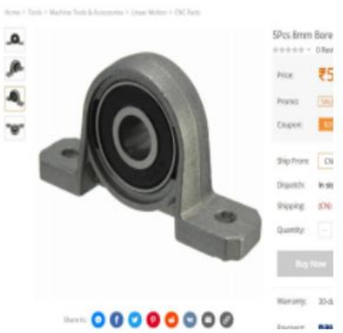
Gripping Mechanism

Fig. 1

Fig. 2

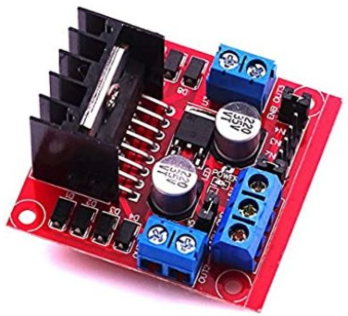
As the motor rotates from its initial orientation in Fig. 1 to that in Fig. 2 as instructed to by the Arduino, the string is wound around the servo horn, pulling the arms into gripping position as shown in Fig. 2.

Components Source & Price

	Links	Qty
	Motor at base for 360' rotation	1
	Camera	3
	Ball Bearings	2 Sets of 5 pieces each
	Motor for horizontal linear motion	6

	Links	Qty
	Motor for vertical motion	6
	Threaded axle	1
	Coupling	6
	Pulley	6

	Links	Qty
	Servo Motor for Gripper	6
	**SOFT GRIPPER** 3D file to print Flexible filament (WillowFlex, NinjaFlex, SemiFlex or similar)	6
	Housing Bracket	6
	Arduino UNO	6

	Links	Qty
	Motor Driver	7
	STEEL SHAFTS(2m) to be bought offline and manually threaded.	6
	ALUMINIUM RODS Have to buy offline as per frame requirement	**Approx 15m**

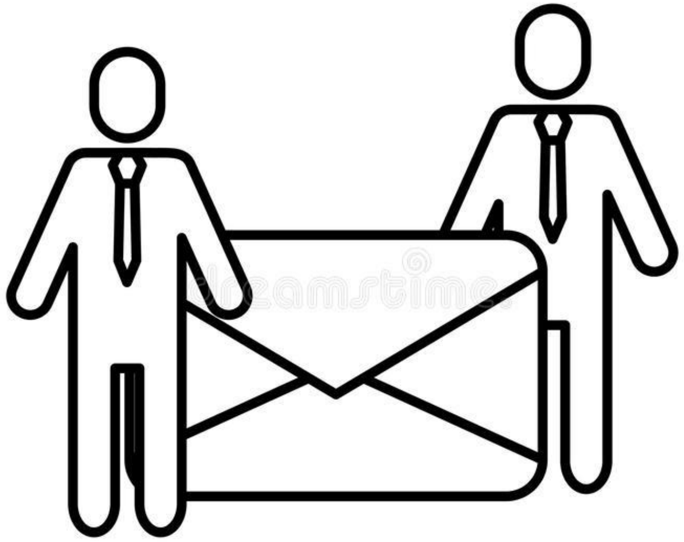
Bill

Shaft Coupling	80 x 6	= 480
Camera	1200 x 3	= 3600
Base Motor	950 x 1	= 950
Servo	360 x 6	= 2160
Pulley	175 x 6	= 1050
Shaft 1m + 2 Ball Bearing	1720 x 1	= 1720
Geared Motor For Pulley	750 x 6	= 4500
Geared Motor For Horizontal Linear Motion	275 x 6	= 1650
Ball Bearing (2 sets of 5 pcs)	555 x 2	= 1110
Housing Bracket	315 x 6	= 1890
Arduino Uno	504 x 6	= 3024
Motor Driver	250 x 7	= 1750

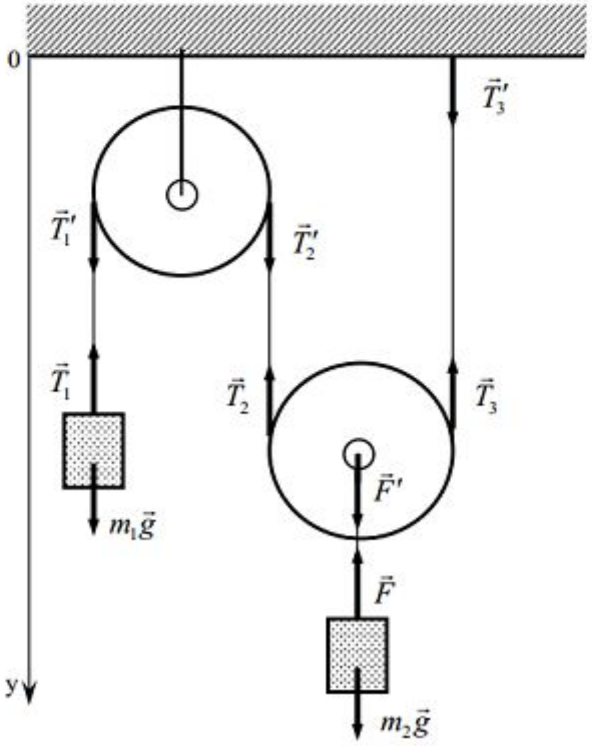
Rs 23,884 Excluding 1. Whole Frame
2. 2m threaded shaft x 6
3. 3D Printing

Expected cost: 23884 + 5000 + 4000

Rs 32,884 Excluding 3D Printing

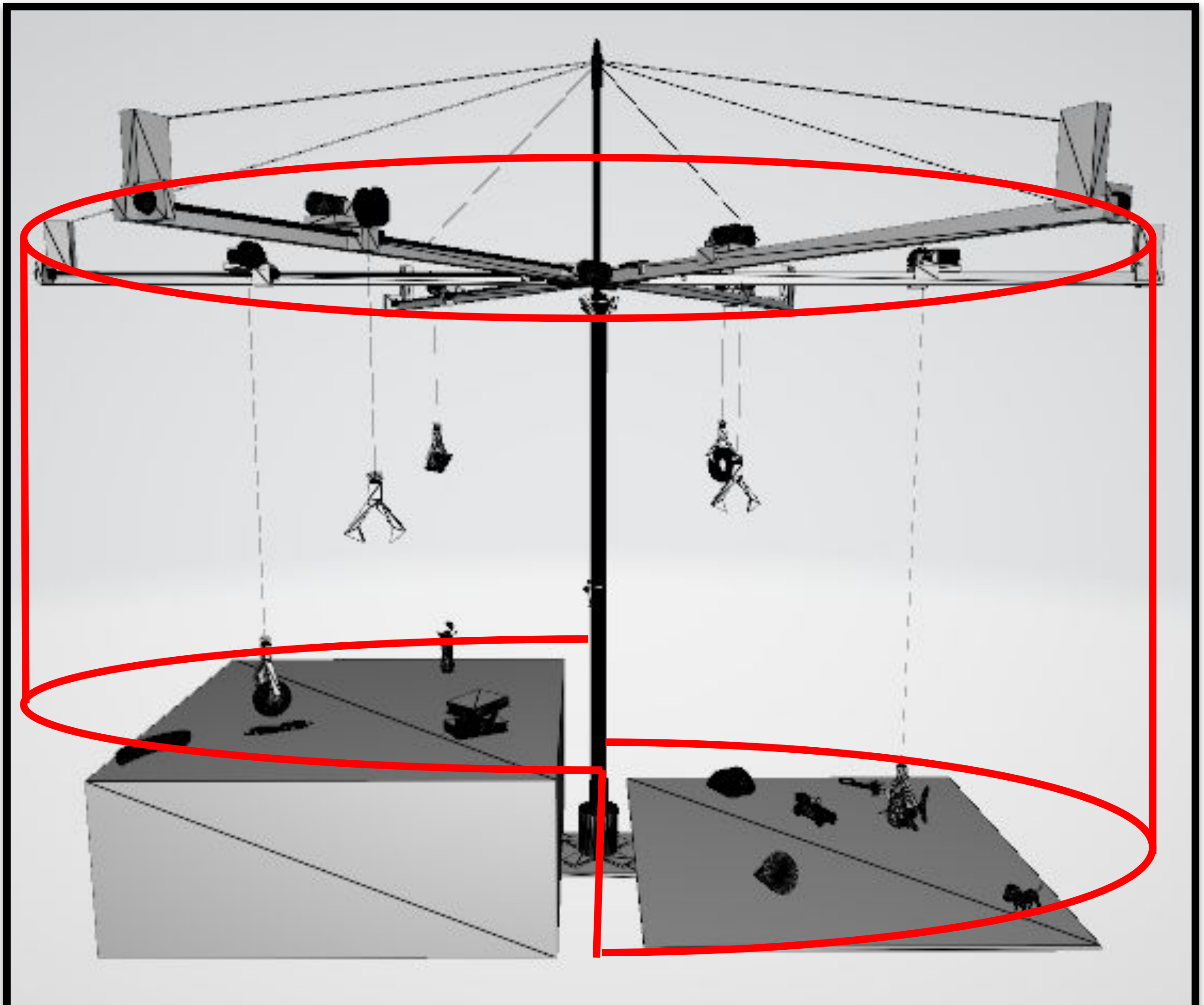


Work Envelope And Payload Calculations

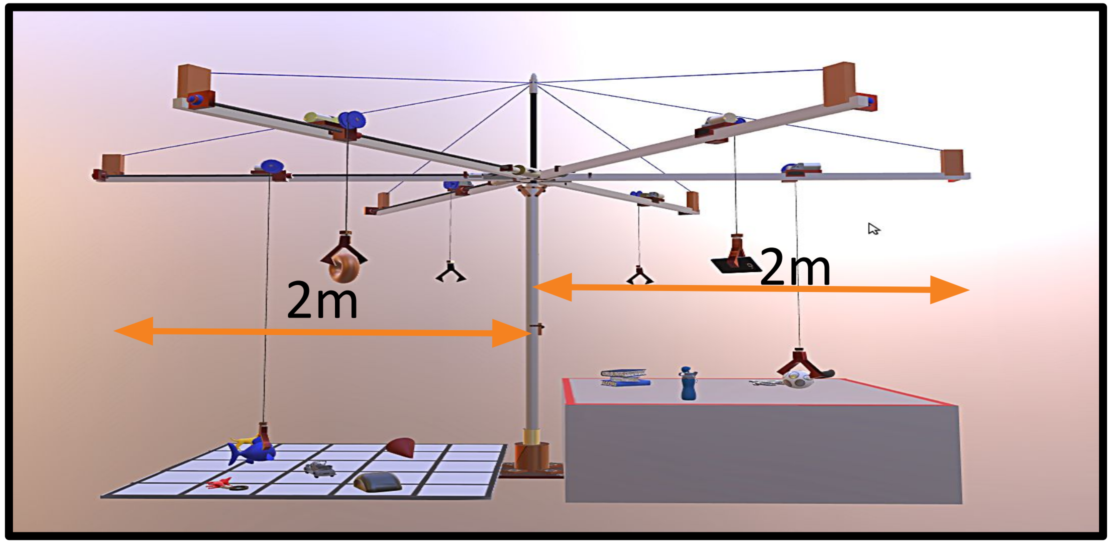


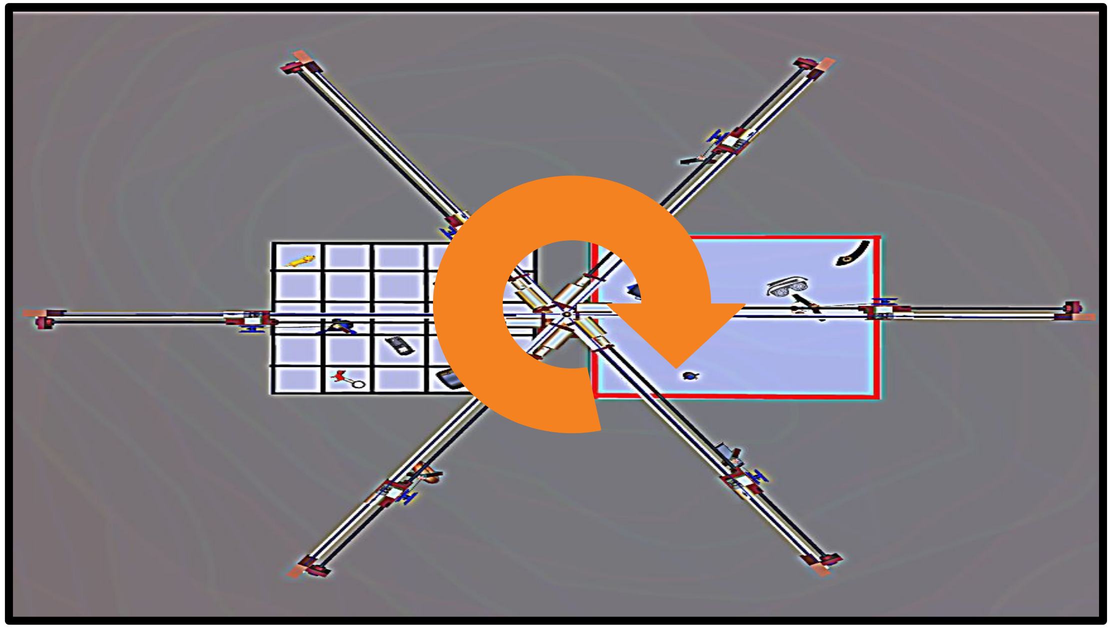
Work Envelope and Payload Calculation

1. **Reach Of The Robot Across The Pickup/Drop Area**



Work Envelope

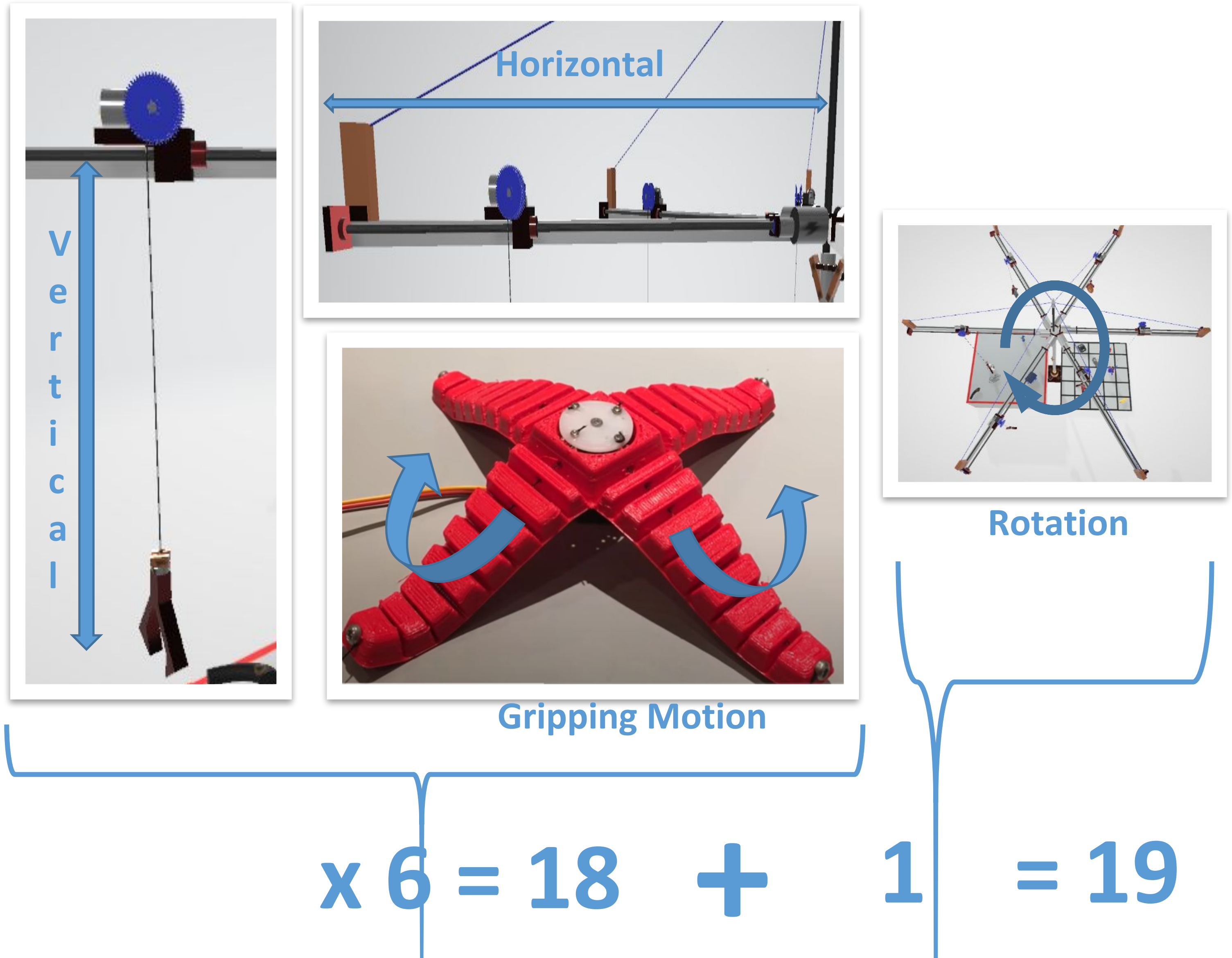




Work Envelope and Payload Calculation(cotd.)

2. **Degrees of Freedom = 19** (3 for each arm and one for the central axis rotation)

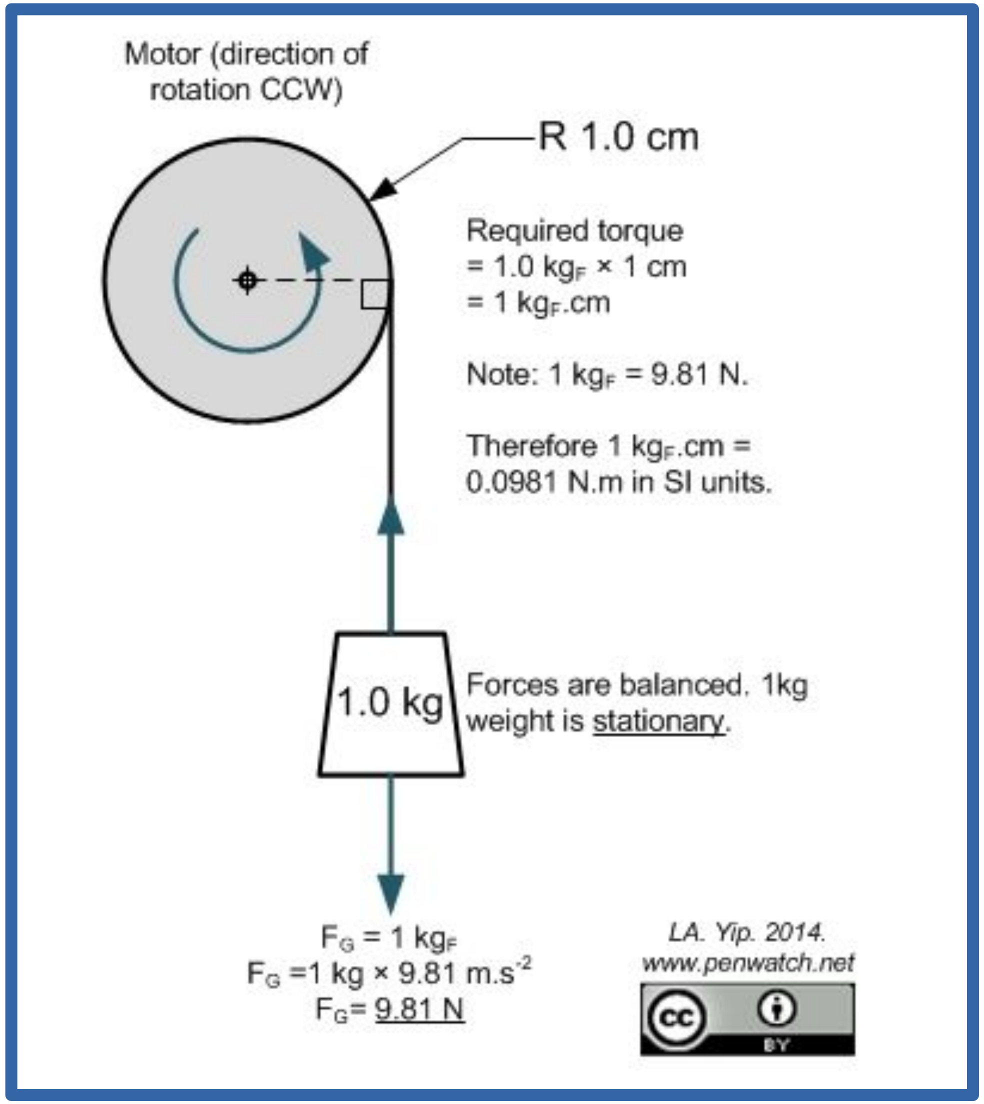
There is a total of three degrees of freedom for the movement of the arms which are the radial motion of the rod in the X-Y plane, the motion of the gripper in the vertical direction and the opening and closing of the gripper. So for each arm we have 3 DoF.



Work Envelope and Payload Calculation(cotd.)

3. Payload Calculation and Free Body Diagram

The motor for the vertical motion lifting the payload has a Torque Reading of 1 kg-cm. This means that the motor is capable of holding a 1 kg weight at a radial distance of 1 cm.

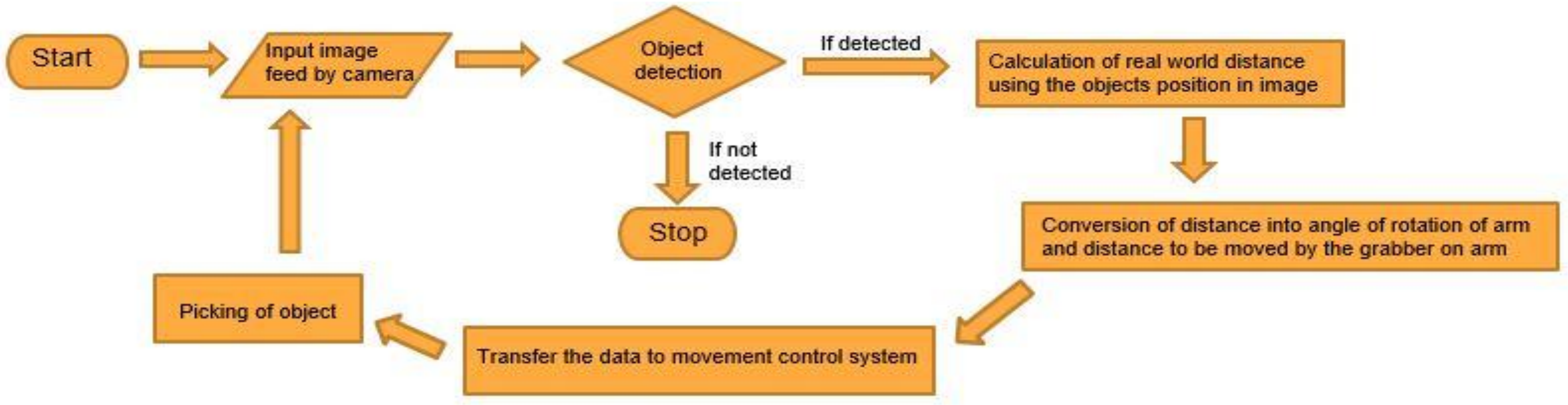


Work Envelope and Payload Calculation(cotd.)

4. Trajectory Computation Of Moving Components

The trajectory of the object after being picked up resembles the outline of a cylinder. The object picked would first move in the Z direction keeping X and Y constant. After that, a radial motion(r) and rotatory motion(θ) would take the object above the drop area, followed by a vertical motion in the Z direction and finally, the object is dropped from the gripper. Therefore, the complete trajectory would be a function of (r, θ, z).

Object Recognition Details



The Jupyter Notebook that we used to train the image detector is available here.

- Our object detection model will detect the position of object from the feed taken by the camera and then the position of objects is calculated in terms of the angle from the closest arm and its distance from axle.
- After the required calculation, the main axle rotates by the desired angle and when the arm is above the object, the grabber moves until it reaches the top of the object. After that the grabbers come down and pick the object from the top in the upright position as the object was placed. And this process continues.
- While dropping, the cameras detect the position where the object is to be placed and when it reaches the top of it, the grabber moves down and places the object.
- These picking and placing processes take place simultaneously and the model automatically chooses the more feasible process.
- When the count of initial objects on the picking area equals current objects in drop area, then the process

Simulation/Videos

1. Drive link for 3D file(Prototype). click here
2. Drive link for 3D Simulation video of Prototype. click here
3. Drive link for Object Recognition video. click here
4. Drive link for 3D file (Gripper). click here
5. Drive link for working Soft Grippers (Video Clip). click here

1. While the basic design has already been established and an animation of the bot in action already shown, we shall endeavour to better the design and simulation while we wait for the procurement and assembly of the bot.

2. We believe that the procurement of parts can be completed in 1-2 weeks if all works favourably, and even faster if there is some help.

3. We hope to be able to 3D Print our gripper arm and assemble the robot within 3-4 days if all goes according to plan.

4. The Software Development portion can run in parallel with the above points, and we do not believe much extra time shall be required for this portion.

5. The testing will require at least a week according to our estimates.

Current Progress

Our team has done quite a bit of research in different fields to make sure that the robot is build with max efficiency and as fast as possible even during this pandemic situation.

- We have made use of a fixed model in order to reduce the inevitable wear and tear that movable models are susceptible to.
- For the model structure, we have preferred aluminium due to its durability, strength, lightweight and low cost.
- To minimise object collection time, we made use of six arms in place of one.
- In order to imitate real life example of Suspension bridges, we have given additional support as detailed earlier.
- To prevent the reverse rotation of the load, we made use of the worm gears.
- For delicate yet effective gripping, we have made use of the soft grippers, which resembles the use in many real life applications as detailed in the previous presentation.

Current Progress(cotd.)

For the software side of things,

- For efficient and accurate classification and segmentation purposes, we have used the pretrained YoLO model, which is the current SoTA(State of The Art) model for efficient segmentation. If the segmentation itself is not suited to our purposes, we plan to further train the model according to our conditions by the principle of transfer learning.
- We have completed the motor configuration with arduino and L298N motor driver and we have also developed an efficient for optimal object picking and placing.

References

1. For Soft Grippers
https://www.youtube.com/watch?v=TyYW9BmMeSs

https://www.youtube.com/watch?v=8F8gctNCGyE&t=7s