Intelligent Picking

Team Name : X Ash A-12

Institute Name: Indian Institute of Technology (BHU) Varanasi

Team members details

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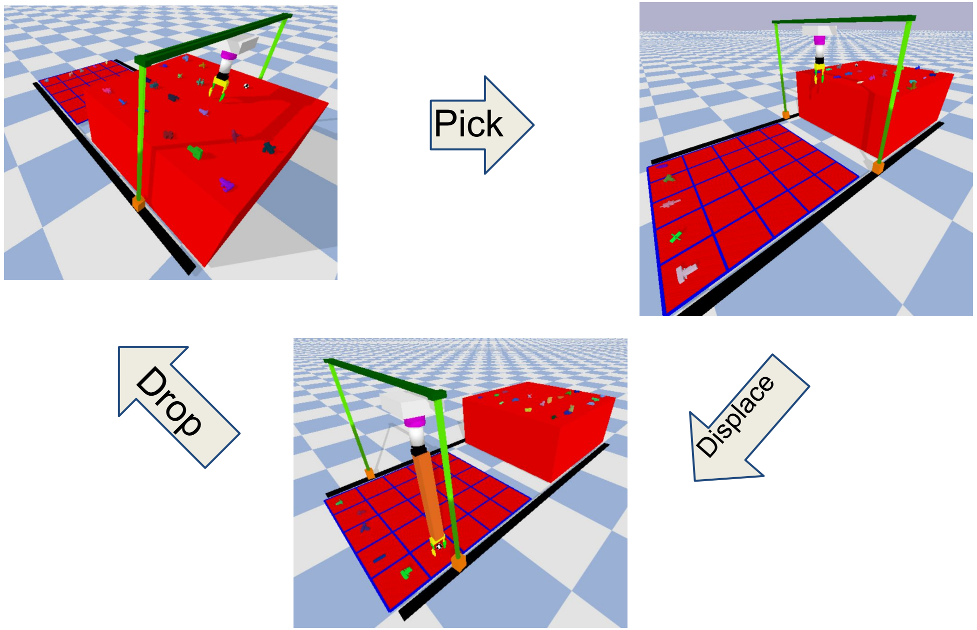
Institute Name	Indian Institute of Technology (BHU) Varanasi				
Team Members >	1 (Leader)	2	3	4	5
Name	Sirusala Niranth Sai	R.Lokesh Krishna	Nishant Kumar	Ayush Kumar Shaw	Raghav Soni
Batch	2022	2022	2022	2023	2023
Area of expertise	Hardware design and simulation, Deep Learning	Hardware design and Optimal Control development, Robot Learning			

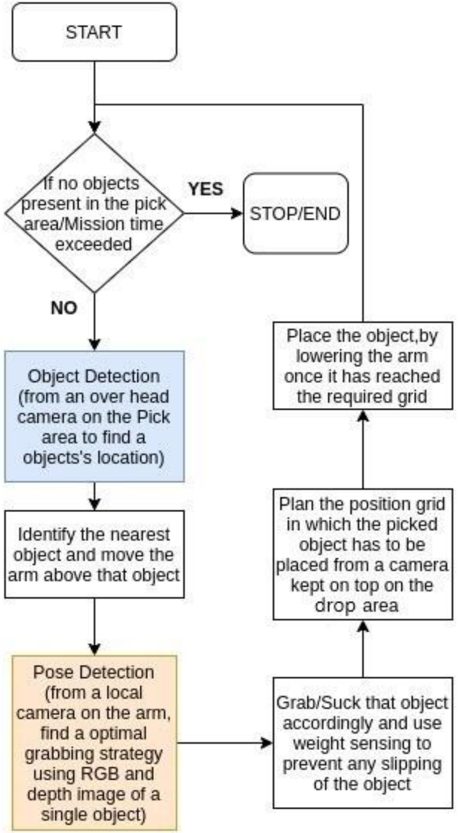
Our Solution Design:



Ab har wish hogi poori...

VIDEO VISUALIZATION : OVERALL WORKING PLAN

Our Approach:



Robot Specifications:

Software:High-level:

- **Custom trained** Deep Learning models to carry out the **Identification**, **Segmentation**, **Pose prediction**, etc.
- Owing to the versatility of **Python** and its **support for Deep Learning-based implementations** we set up the high-level control in it, as it is a very small trade-off for the speed as compared to the complexity in other languages.

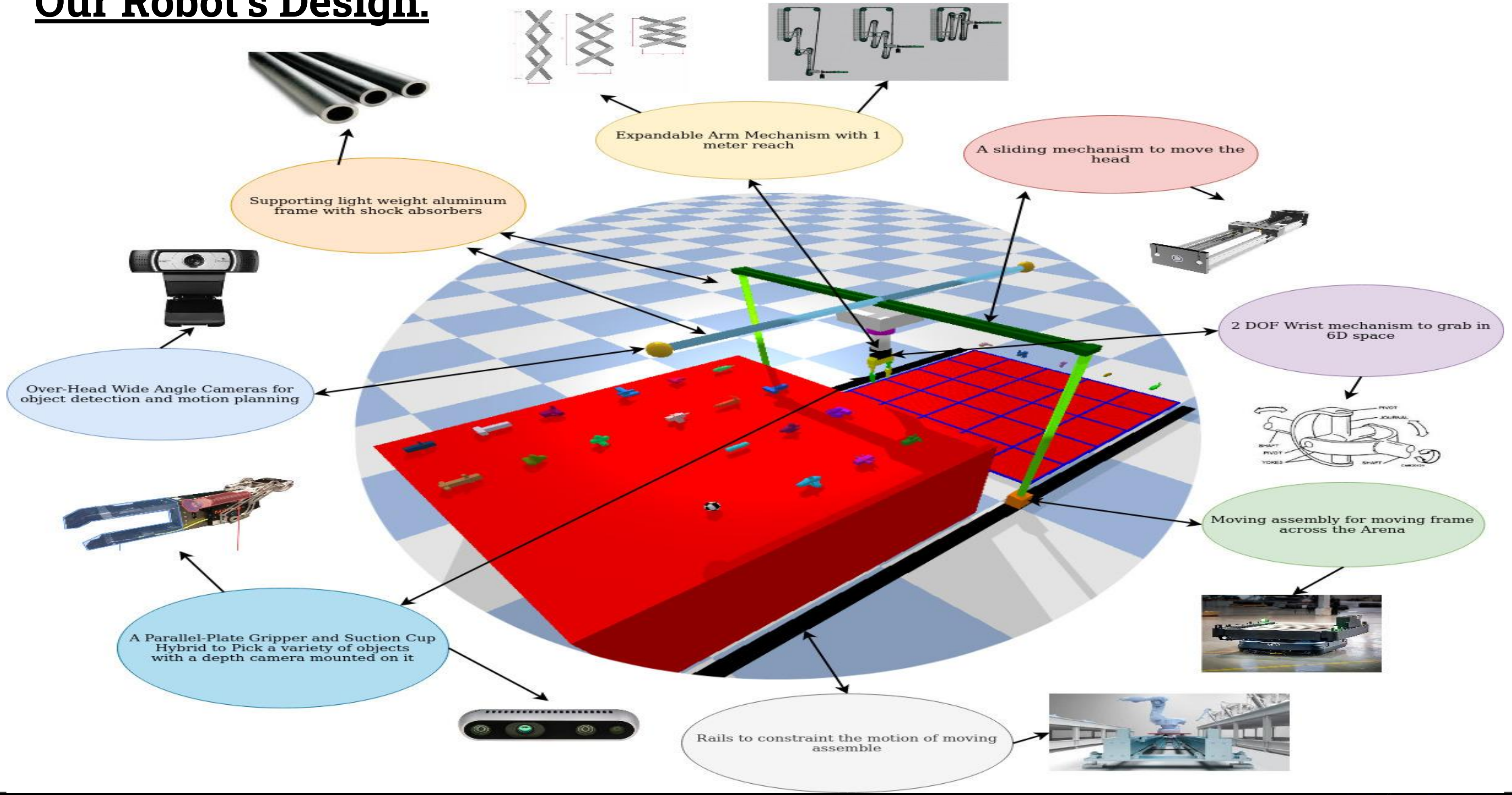
Electronics & Low-level Software:

- We define the low-level software to be the one that **interacts with the robot hardware** and thereby converting the robot plans to **low-level joint commands**. Thus, it ranges from the code that sends **image-based feedback** to the off board computer to that which gives commands to the motor controller.
- The **onboard computation** is to be run by a microprocessor with decent image handling capabilities and the ability to run troubleshooting/backup safety plans to bring back the robot to the safe configuration, during a loss of connection with the off board system. Ideally Raspberry Pi suits this purpose..
- We propose to switch to C++, to ensure **greater bandwidth** of operation so as to ensure a **higher control loop frequency** for agile and robust maneuvers of the robot.
- The **off-board computation** runs our **deep learning models**, to give out high-level commands sent to a motion planner.

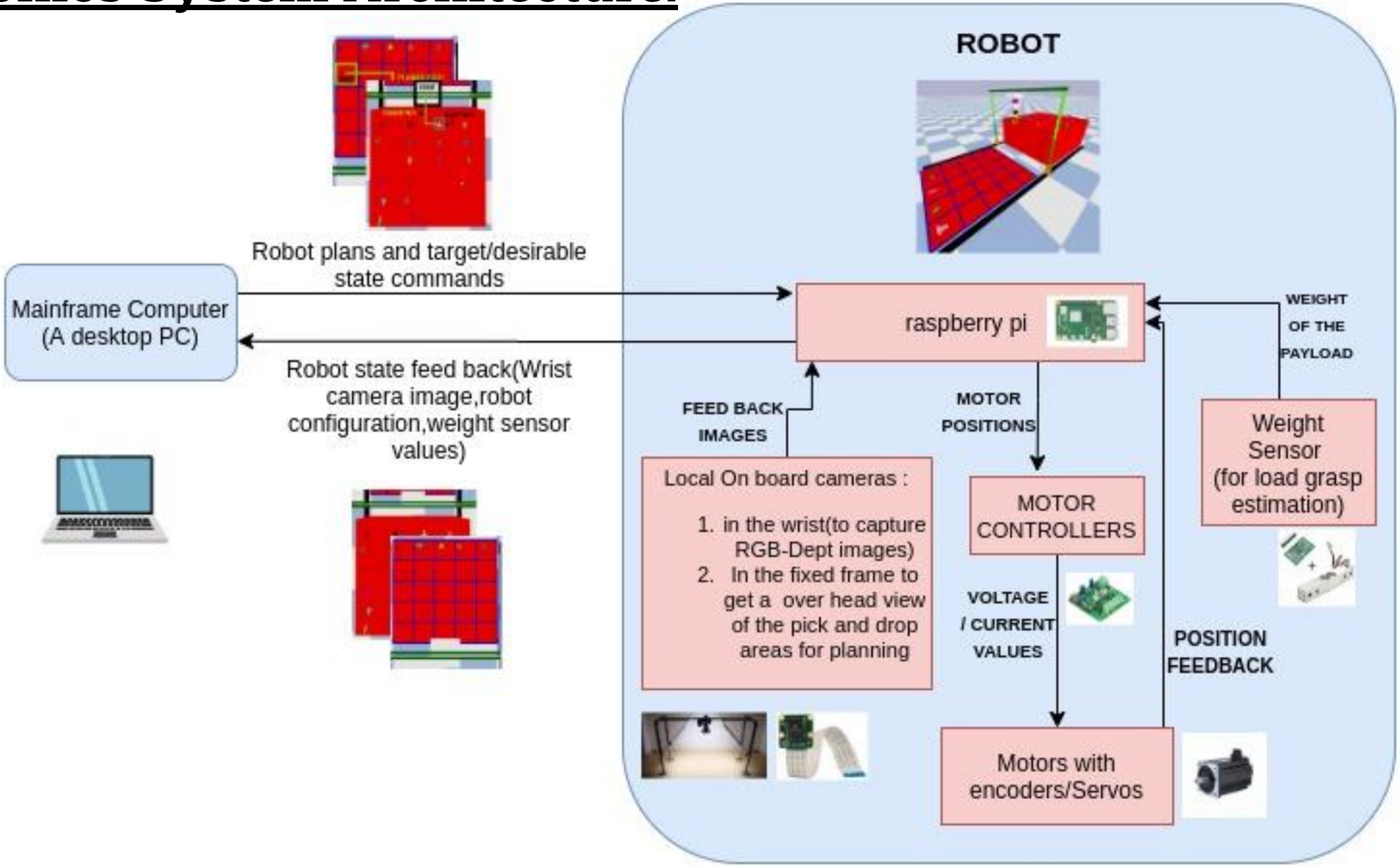
Mechanical:

- After a thorough analysis of available industrial solutions, we propose a **novel design**. It is almost **impossible** to build a **single robot arm** capable of reaching the lengths and breadths of the arena as it requires motor **torques of unrealistic magnitudes** and **links with superior mechanical properties**.
- Our mechanical structure is a **hybrid design** to ensure a great amount of **static stability** during operation while keeping the **cost of construction and maintenance low**.

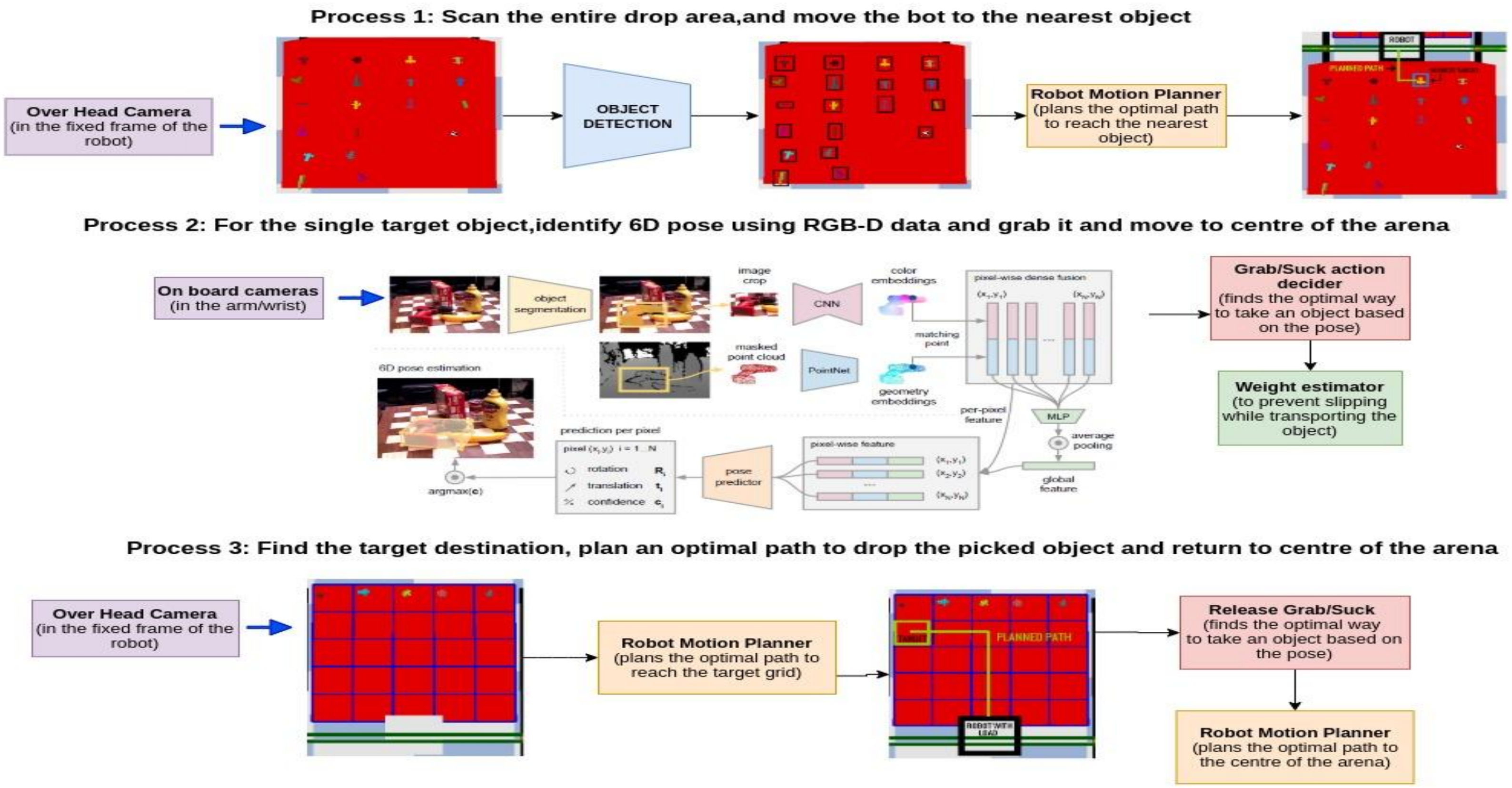
Our Robot's Design:



Electronics System Architecture:



Software Pipeline:

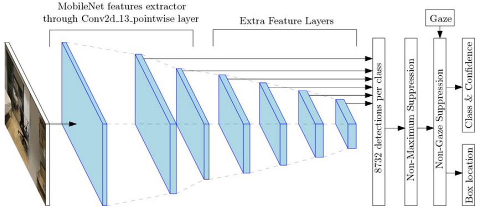


Programming Modules

- Due to its **clean** and **straightforward** syntax, **Python** will be the main programming language used, with the prospect of introducing **C++** so as to ensure **faster real-time inference** while carrying out the task.

- For carrying out tasks like object detection, segmentation and pose estimation for grasp planning, **deep learning based neural networks** will have to be built with each neural network focusing on a different part of the software pipeline.

- These networks include the implementation of algorithms like **YOLO**(for object detection), **Mask R-CNN**(for instance segmentation) and **DenseFusion**(for 6D pose estimation). We can shift to **lightweight models** such as **MobileNet** in order to decrease the computational cost required, thereby increasing the efficiency of our model.



- We also plan to bring in **ROS(Robot Operating System)** for **efficient robot planning** as it is the state-of-the-art software used in the development of sophisticated robots. **PointClouds** will be necessary for the **visualization of depth data** from the RGB-D cameras so as to efficiently plan our grasping techniques and ROS can help us in doing so.

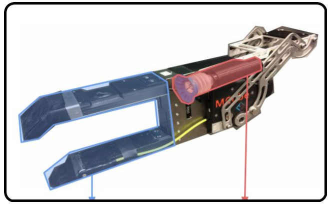
- **Pybullet**, an open-source **simulation software**, will be while implementing the different parts of the pipeline and validating the results in simulated hardware, so as to continuously improve our model without using real world hardware.

Features and functionalities of the Robot:

The robot is expected to **recognize and displace** warehouse grade objects from the given pick area to the drop area as quickly and reliably as possible.

Apart from the primary functionalities to recognize, grab, move, and place we are planning to add the following additional functionalities:

- An accurate estimate of the pose for optimal grasping, implementing **6D pose estimation** using an **RGB-D (Depth) camera** as opposed to the relatively inaccurate 2D based methods.



- Enhancing robot planning by **object detection** techniques.
- Usage of a **hybrid, gripper and suction cup-based design** to efficiently pick wide array of payload objects.

- Radically **simplified mechanical design** and a sophisticated vision-based control strategy to **minimize** the possible **system failure conditions** and develop a fully automated product.
- **Cost-efficient architecture** on both the hardware and software, to ensure **replaceability and greater profit margin**.
- The Software framework is general enough to be **easily customizable** for a different warehouse scenario with possibilities of adding additional features like **voice commands, auto-recovery**, etc

Limitations:

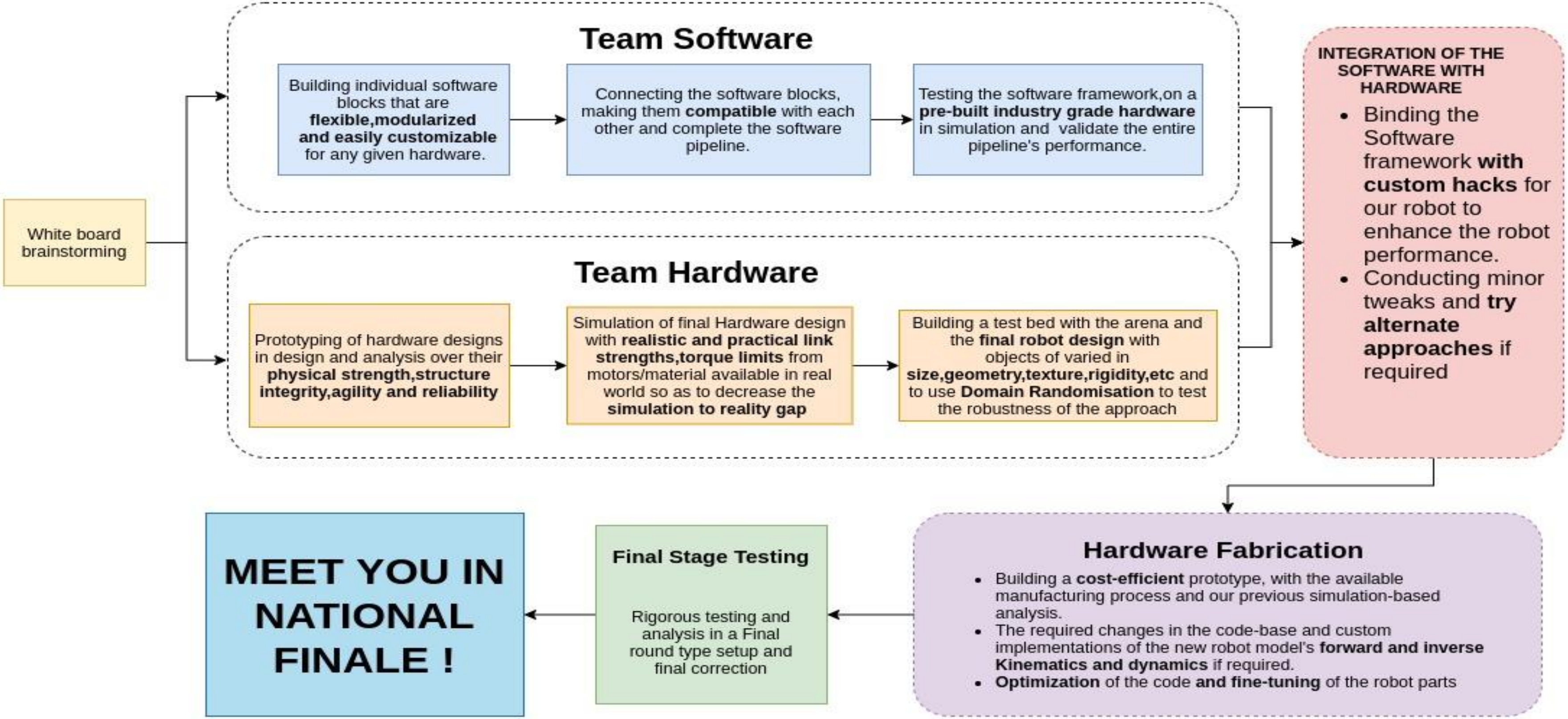
- One of the key limitations of our hardware design is the amount of **overfitting we did for solving the given problem statements**. Owing to the dimensions of the current task, solving it in the most **simplistic and cost-efficient way leads to a trade-off in its generalization capabilities**.

- The frame of our robot essentially consumes a considerable amount of space around the work area which might be uneasy to place in **human prone warehouse scenario.**

References:

- Robotic Pick-and-Place of Novel Objects in Clutter with Multi-Affordance Grasping and Cross-Domain Image Matching
- Vision-based Robotic Grasp Detection From Object Localization, Object Pose Estimation To Grasp Estimation: A Review
- DenseFusion: 6D Object Pose Estimation by Iterative Dense Fusion
- DPOD: 6D Pose Object Detector and Refiner
- Cartman: The low-cost Cartesian Manipulator that won the Amazon Robotics Challenge

Execution Plan:



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