Flipkart GRID 2.0

Autonomous Indoor Drone

Team Name : JAMIA MBD

Institute Name: JAMIA MILLIA ISLAMIA

Team members details

Team Name	JAMIA MBD				
Institute Name	JAMIA MILLIA ISLAMIA				
Team Members >	**1 (Leader)**	**2**	**3**	**4**	**5**
Name	SUHAIB UR REHMAN	INTEKHAB AZAM	SUHAIB AKHTAR	OSAMA MASOOD	
Batch	2017-21	2017-21	2017-21	2017-21	
Area of expertise	ROBOTICS SOFTWARE	MECHANICAL DESIGN	SIMULATION & MANUFACTURING	ELECTRONIC SYSTEM	

Functionalities of the Robot

- Autonomous indoor drone equipped with a pair of cameras, IMU sensors and onboard computational power can navigate through 3D structural environments, enter and exit building through windows and fly through other GPS denied environments.
- These aerial robot have great application in search and aid operation in remote and dense location, supply of goods in warehouses & factories and mapping of unknown constructed buildings.
- Surveillance, search and supply operation in missions in confined and complex indoor and outdoor environment that are inaccessible or dangerous for human or ground vehicle.

Robot Specifications

Technical & physical specifications

1. 6x Carbon fibre hexacopter arm & 6x glass fibre propellers
2. Mild steel centre plate for hardware support & payload box
3. 6x A2212 1800kv brushless motor
4. 6x 30A Plastic silicone bldc electronic speed controller
5. Pixhawk 2.4.8 PX4 32 Bit Flight Controller (inbuilt IMU & power management board)
6. Nvidia jetson nano development kit as a companion computer
   (Quad core A57 cpu @ 1.43 GHz,4gb ram, 128 CUDA core Maxwell GPU)
7. RTL 8188 Mini usb 150mbps wifi dongle.
8. 2x 5MP OV5647 Wide Angle Fish-eye Lens camera
9. 3S 3000mAh LiPo battery

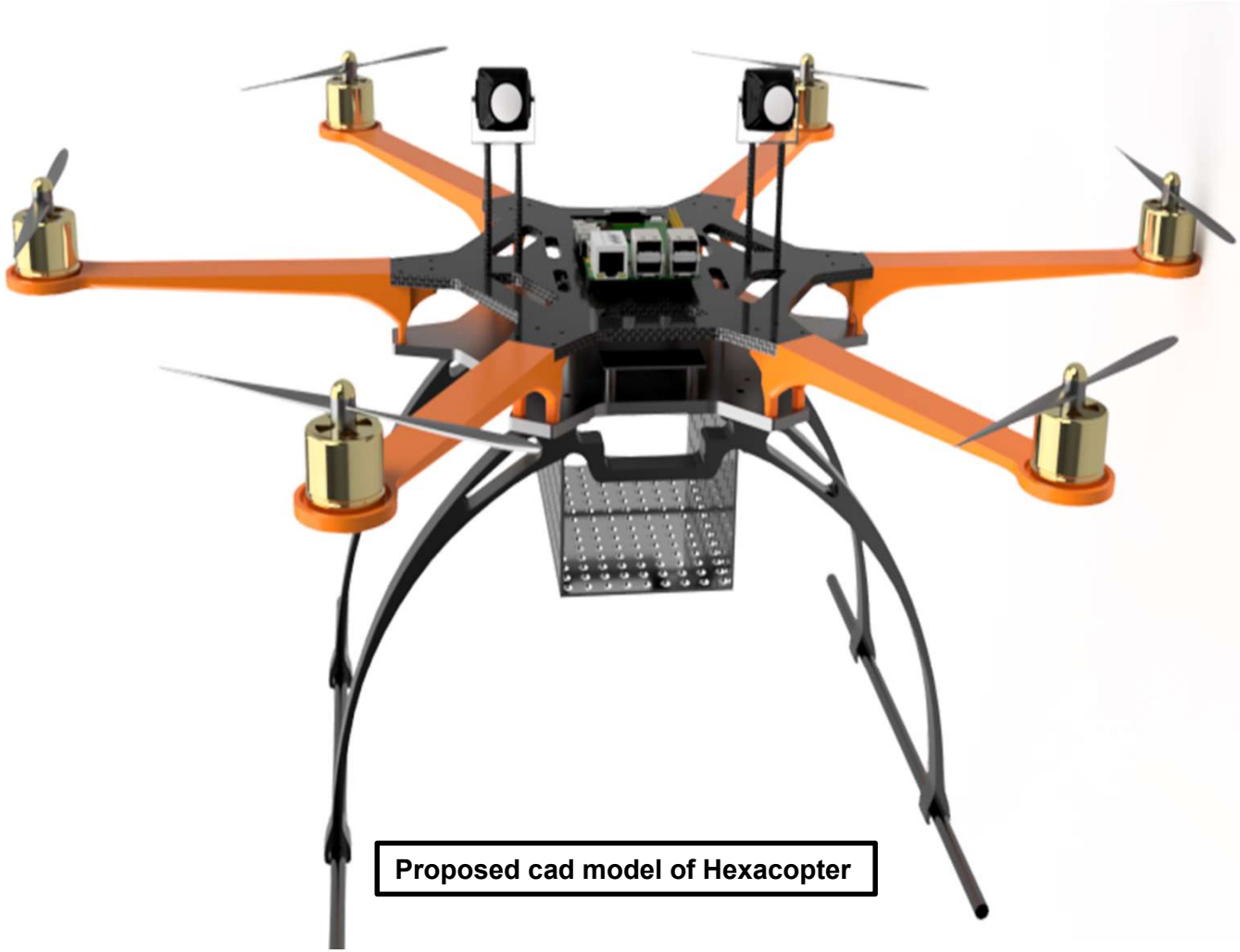
Robot/Solution Limitations

What can the robot not do ?

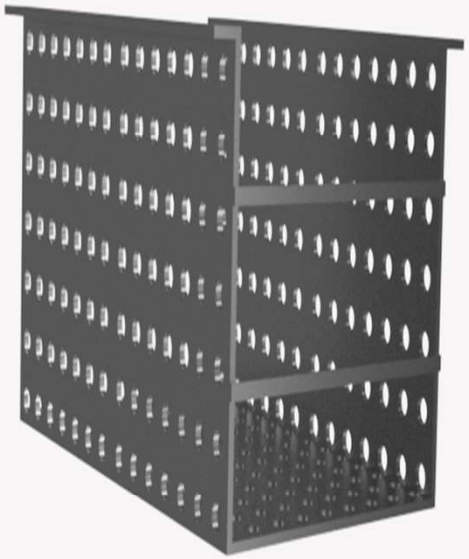
Although the Vision based approach that we are using is suitable for complex indoor based environment(multiple obstacles or objects to identify) where GPS is denied (like the one in flipkart problem statement) but it is not recommended for featureless environments such as room with only white walls.

Are there any limitations compared to the requirements?

Limited onboard computational power, intensive battery drainage , Weight & dimension constraints are some of the challenges. However, we will be overcoming these challenges using efficient algorithms, appropriate sensors, materials & electronic hardware.

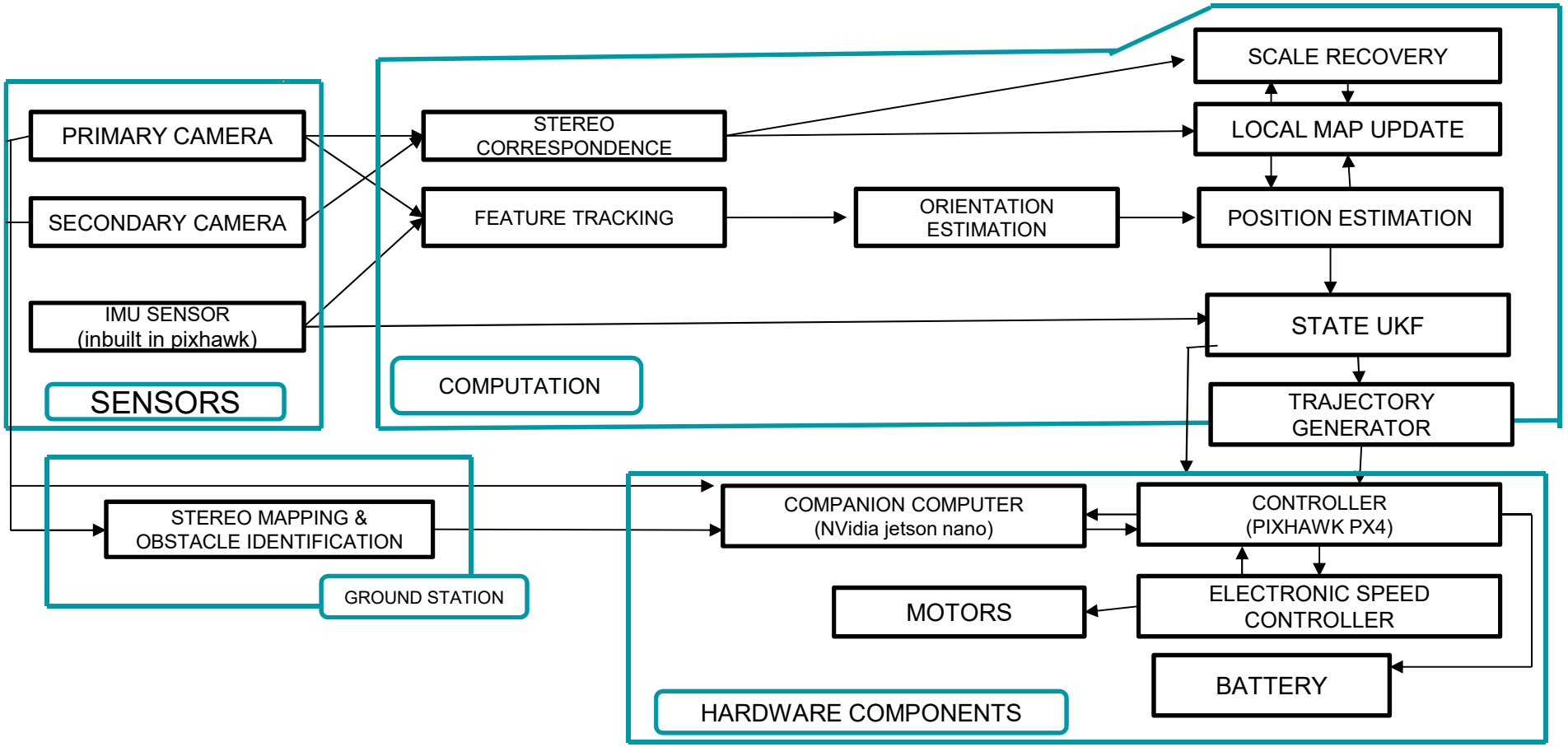


Proposed cad model of Hexacopter



DEATTACHABLE PAYLOAD CASE

Architecture



Brief on Programming Module

What programming language will be used?

We will be using **C++** for all algorithm development using **ROS** as the interfacing robotics middleware. **Python** will be used for utilizing **OpenCV library** for corner extraction and tracking and creating apps using dronekit.

What all software modules will be built?

Ardupilot software for controlling onboard flight controller instead of **px4**.
Dronekit-python for creating apps so to enhance autopilot.
Nvidia jetpack sdk for installing libraries and development tools.

Execution Plan

HARDWARE IMPLEMENTATION

1. In order for drone to navigate in GPS denied environments autonomously, We are presenting a **vision based approach** hexacopter system that uses a pair of **cameras** and **IMU** sensors (inbuilt in PX4 flight controller).
2. Two forward facing fish eye camera will develop a combined monocular stereo approach. The **primary camera** will work at a high rate and will support **pose estimation**, local **mapping** and **obstacle identification**. **Secondary camera** will operate at a low rate and will compensate for **limitation** of **monocular vision based approaches**.
3. The proposed hexacopter consists an **autopilot board(pixhawk4 flight controller).**This flight controller has a **inbuilt power distribution module** which will be connected to battery. Apart from this, it also houses **IMU sensor**(gyroscope,accelerometer,barometric) to enhance stability and control of drone. Flight controller will take input from onboard **companion computer(Nvidia Jetson nano)** and adjust the motor rpm via **electronic speed controller**.
4. While **flight controller** is able to perform autonomous function to some extent, but due to limited onboard computation power it will not be able to perform intensive task like **computer vision** for **obstacle identification** and **mapping** of given room. That is why we will be using a companion computer, **Nvidia Jetson nano**.

ALGORITHM AND SOFTWARE TOOL IMPLEMENTATION

1. As per the **given problem statement**, the hexacopter need to pass through the all the windows and avoid obstacle as fast as possible while at the same time maintaining high quality state estimate. For this purpose we will use certain **computer vision algorithm** for **obstacle avoidance**, **corner detection** and **feature tracking**. While suitable **state estimator** , **trajectory control algorithm** will enable us a smooth **autonomous navigation**. Generally visual based approach enable full 6-DOF to pursue high speed flight but it works on limited update rates due to computational complexity and limited onboard processing.
2. We will be using **visual inertial slam** for state estimation that will allow us **high speed flight** with linear velocities. The proposed estimator will be fusing information from **camera for vision processing** and from **IMU sensor for state estimation**.
3. As there is a possibility that the number of **window** and **obstacle** in a **single line** can be **more than one**, there is a very much possibility of **image jitter** due to **excessive angular velocities**. To **minimize** this we will try to generate to smooth **polynomial trajectories** by integrating our estimator with a **non linear tracking controller**. Virtual inertial state estimator will help in accurately tracking the position and velocity of hexacopter in the given 3D environments.
4. Cameras will be calibrated using **omnidirectional calibration toolbox** (modules available on **OpenCV**). The **primary camera** will be used for **detecting edges of windows** by implementing **Shi-Tomasi corner** method (computer vision) and track them using **KLT feature tracker** (computer vision).
5. The speedup robust feature "**SURF**" method (computer vision) will be used in **object recognition** in path of craft and **feature detection**.
6. As we are not aware with the complete demography of hall in given problem statement , we will be using **non linear controller** for safe side due to its **superior performance** in highly **dynamical motion**. While in non linear transitions ,**extended Kalman filter** can give particular poor performance , we will be using **unscented Kalman filter** framework with delayed measurement compensation to measure the pose and velocity of robot.

MECHANICAL DESIGN AND MANUFACTURING

1. Due to increased weight of drone because of **weight of payload** to be carried , the amount of **thrust** required to hover our craft **increased** substantially. As we could not increased the power of motor after a certain extent due to problems like **overheating** & **esc failure**, we decided to go with a **hexacopter** capable of producing minimum 7N thrust(exact thrust will depend on final dimensions).
2. The proposed **cad model** of our hexacopter is displayed in **previous slide**. The **exact dimension** of our hexacopter will be subjected **final hardware** used but we have made sure that in any case the **drone dimension** fall **within** the **dimension** of **windows** given.
3. Once the dimension are fully finalized, we will be performing various mechanical analysis like **aerodynamic** simulation, **dynamic** & **vibrational** simulation, **structural** simulation to ensure the safety our design before fabrication.
4. We are planning to use **carbon fibre** material for **frame** arm of our hexacopter while **perforated steel** sheet will be used for making **box** to carry **payload**. We are looking forward to **fabricate** the **arm** of hexacopter using **3D printer** available in our **university.** **CNC** machining will be use for **steel** centre **plate** of frame.
5. Once we are done with the fabrication, we will **test** our drone in our **university project room** by creating a somewhat **similar environment** as given in problem statement.


Flipkart
GRID 2.0