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Autonomous Indoor Drone

Team Name : RuntimeTerror

Institute Name: Indian Institute of Technology(IIT), Kanpur

Team members details

Team Name	RuntimeTerror			
Institute Name	Indian Institute of Technology(IIT), Kanpur			
Team Members >	**1 (Leader)**	**2**	**3**	**4**
Name	Ashwin Shenai	Parivesh Choudhary	Amartya Dash	Kshitij Kabeer
Batch	2018	2018	2018	2018
Area of expertise	Software	Mechanical	Software	Software

Functionalities of the Robot

What all can the robot do? What all activities can it perform?

- ❑ Can detect gates using a novel ***Snake Gate Detection Algorithm***, which can detect overlapping gates in a very computationally efficient and robust manner.
- ❑ Uses ***Visual Inertial Odometry (VINS-MONO)*** with a single monocular camera and an IMU for localisation with respect to the indoor environment.
- ❑ Can also generate a *Dense* ***3D-Occupancy point cloud*** for obstacle avoidance, using the features detected by *VIO* and a *Map Enrichment algorithm*.
- ❑ Will use **PFM/VFH+** algorithms to generate setpoints for avoiding obstacles, on the basis of the generated local occupancy map.
- ❑ Being a **hexacopter**, it has a payload capacity of **2.5 Kg**, and a flight time of **8 - 15 minutes**. It will also have sufficient computational resources (**NVIDIA Jetson TX2**) to support the above software stack.
- ❑ The hexacopter runs on a **Pixhawk Cube** flight controller, which comes with inbuilt PID-based controllers and a failsafe coprocessor.

Functionalities of the Robot

Are there any things that the robot can do above and beyond the requirement? Are there any out of the box functionalities?

- ❑ It can perform autonomous landing/perching, based on ArUco marker detection, even on a moving platform.
- ❑ It has QR-code detection capabilities.
- ❑ It can accurately follow brightly-coloured lines on the warehouse floor.

Robot Specifications

Technical & physical specifications

Parameter	Values
Type	Hexacopter
Frame Material	PA66 & 30GF High strength plastic
Diagonal Wheelbase	550 mm
Weight (excluding payload)	4 Kg
Battery	10000 mAh LiPo 4S
Flight Controller	Pixhawk Cube
Vision system	oCam-5CRO-U
Computational unit	Jetson TX2
Payload capacity	2.5 kg

Robot/Solution Limitations

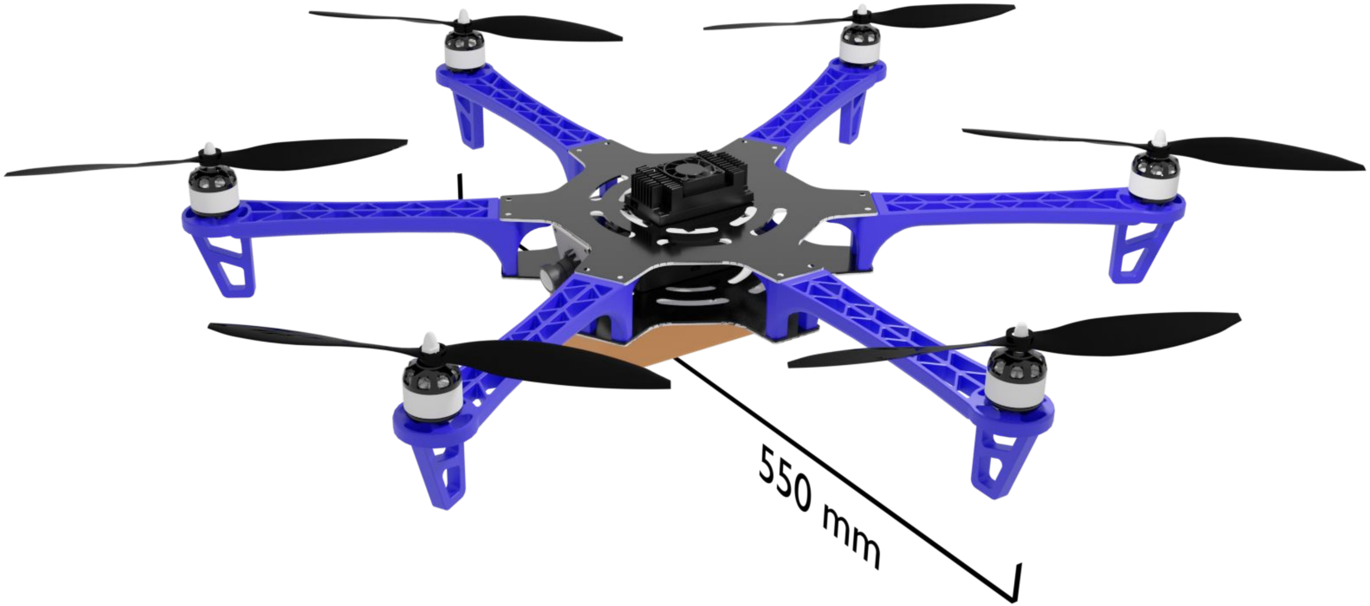
What can the robot not do?

- Due to the relatively small size of the hexacopter, we have approached an upper bound on the payload capacity and time of flight. (see Slide 11)
- It is relatively bulky and less agile as compared to an indoor FPV racing drone.

Are there any limitations compared to the requirements?

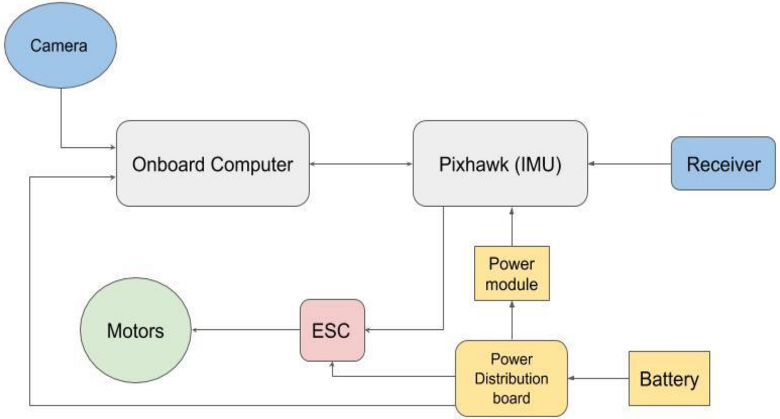
- The color detection of the gates may be affected by the lighting conditions.
- The VIO is sensitive to high accelerations, due to motion blur and the resulting high inaccuracies of the IMU.
- Obstacle detection and avoidance can fail for highly complicated objects, as the constructed dense point-cloud occupancy map will be inaccurate.

Robot Visualization -3D Diagram/Sketch



Architecture

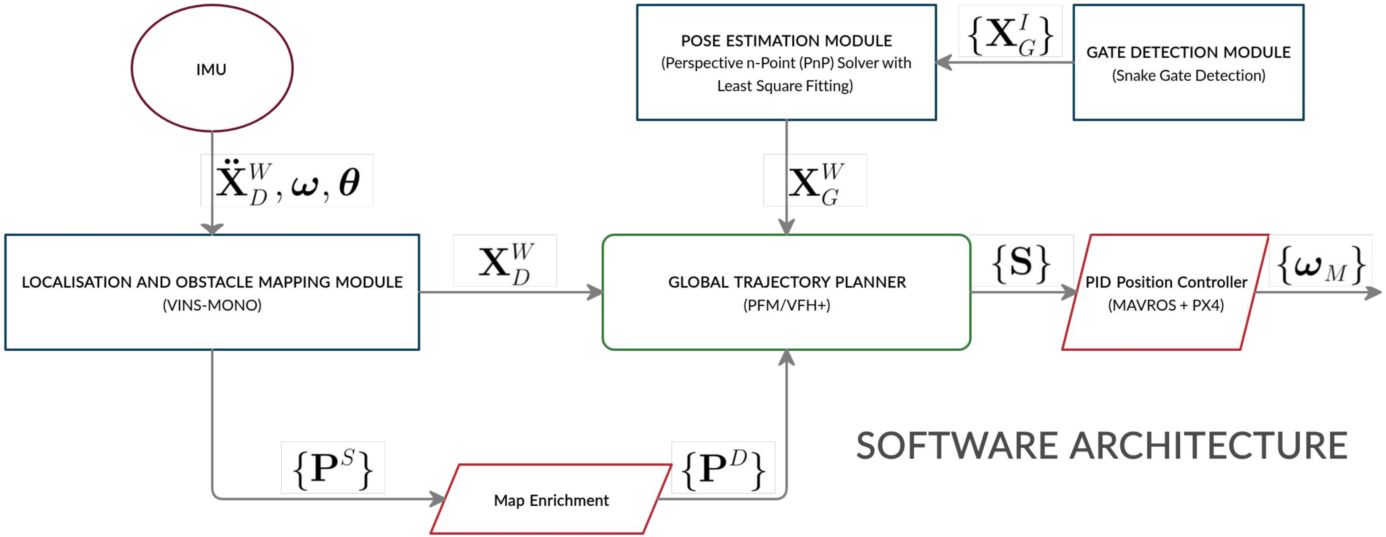
Tech/ Hardware Architecture



- DJI F550 lightweight frame made of high strength material.
- Pixhawk cube autopilot unit.
- NVIDIA TX2 power-efficient embedded AI computing device.
- oCam monocular 5MP camera with 65° Field Of View
- Industrial grade highly efficient KDE Motors and ESCs.
- Turnigy high energy density graphene LiPo battery.

Brief on Programming Module

- Modules will be written in a combination of Python/C++, and will be using ROS as a communication framework connecting individual nodes.



SOFTWARE ARCHITECTURE

$\{\mathbf{X}_G^I\}$: *Coordinates of Gate Corners, in Image Frame* $\mathbf{X}_G^W$: *Coordinates of Gate Center, in World Frame*

$\{\mathbf{P}^S\}$: *Sparse Obstacle 3D – Point Cloud* $\{\mathbf{P}^D\}$: *Dense Obstacle 3D – Point Cloud*

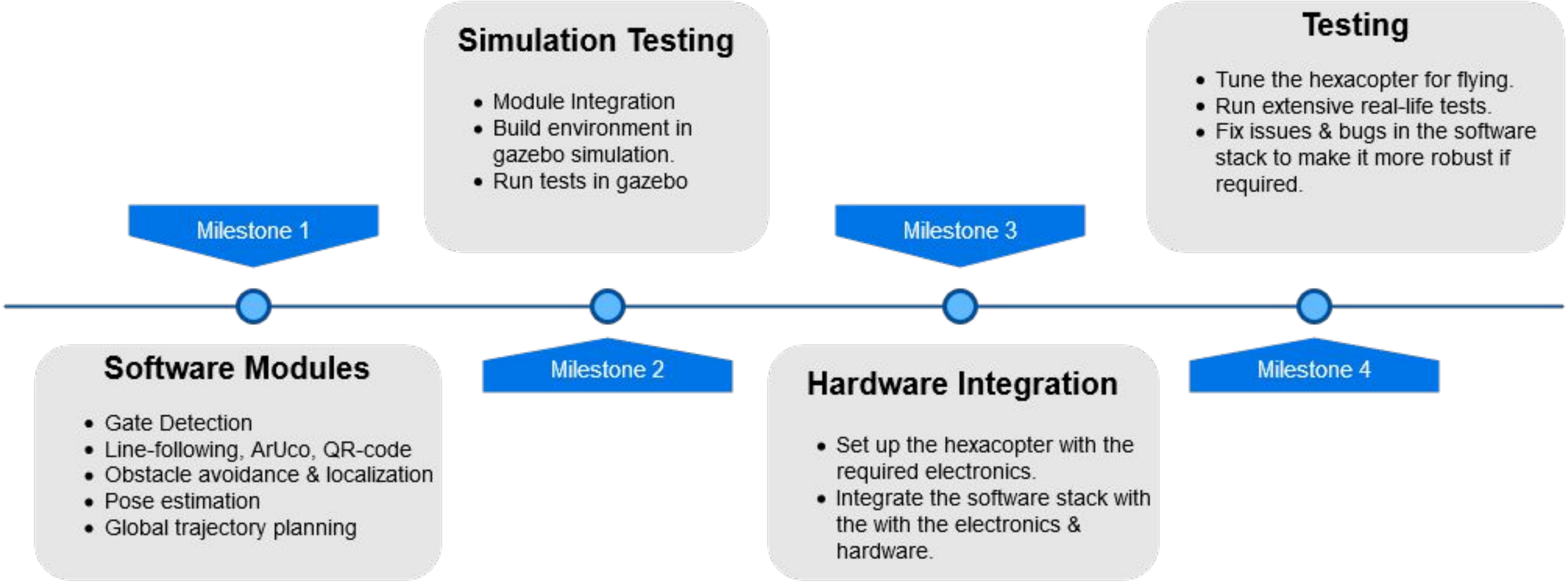
$\{\mathbf{S}\}$: *High Level Setpoint Commands* $\{\boldsymbol{\omega}_M\}$: *Low Level Motor Speed Commands*

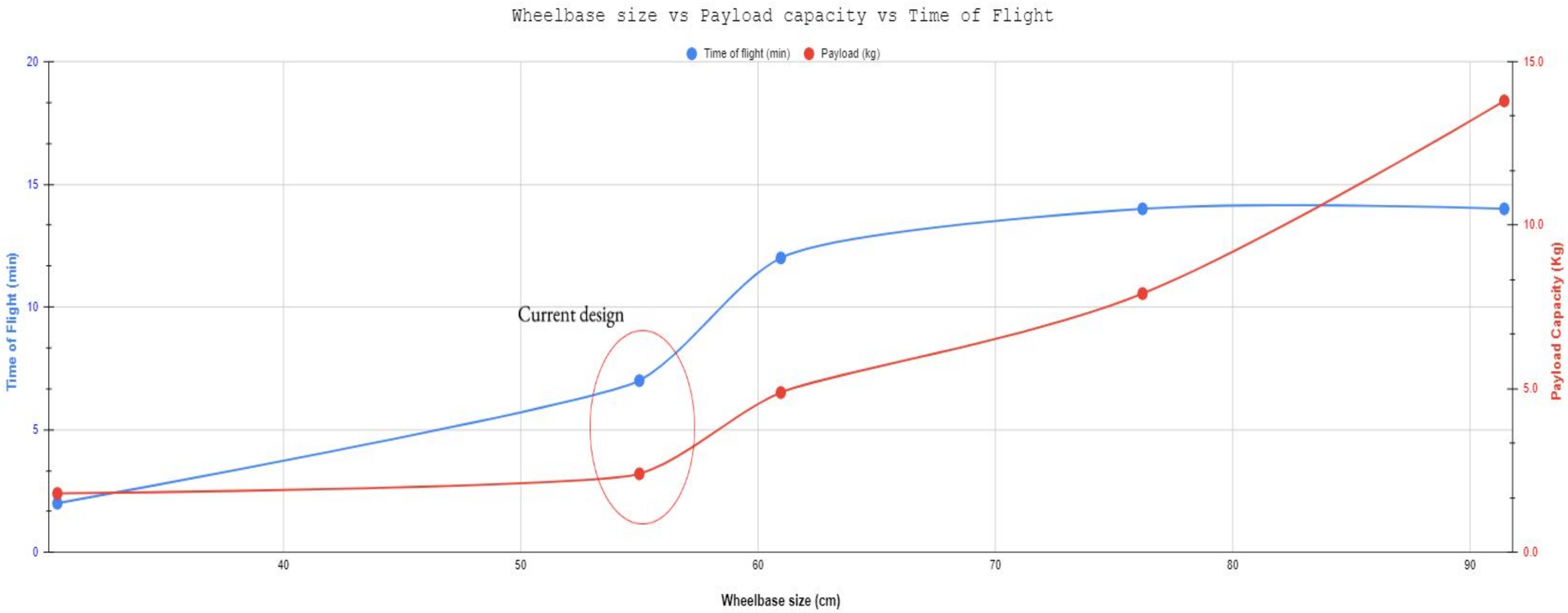
$\ddot{\mathbf{X}}_D^W, \boldsymbol{\omega}, \boldsymbol{\theta}$: *Linear Acceleration, Angular Velocity and Orientation of Drone, in World Frame*

$\mathbf{X}_D^W$: *Coordinates of Drone, in World Frame*

Execution Plan

High level action items in terms of what will be the steps from the drawing board to the actual prototype.





Wheelbase : Diagonal length of frame.

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3. Li, Shuo et al. “Autonomous drone race: A computationally efficient vision-based navigation and control strategy.” ArXiv abs/1809.05958 (2018): n. Pag.
4. Delmerico, Jeffrey A. and Davide Scaramuzza. “A Benchmark Comparison of Monocular Visual-Inertial Odometry Algorithms for Flying Robots.” 2018 IEEE International Conference on Robotics and Automation (ICRA) (2018): 2502-2509.
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