


# The Granny Copter

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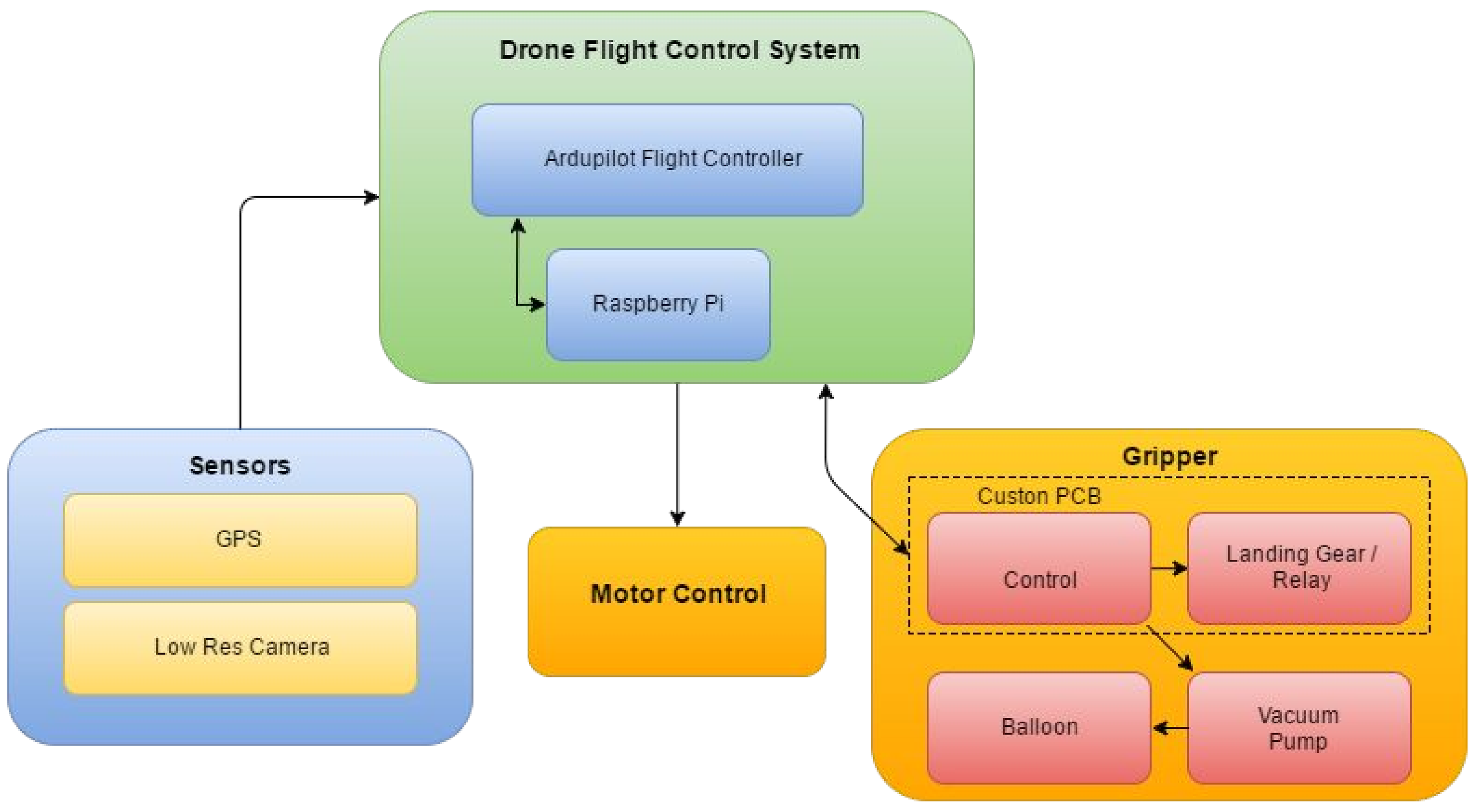
## Abstract

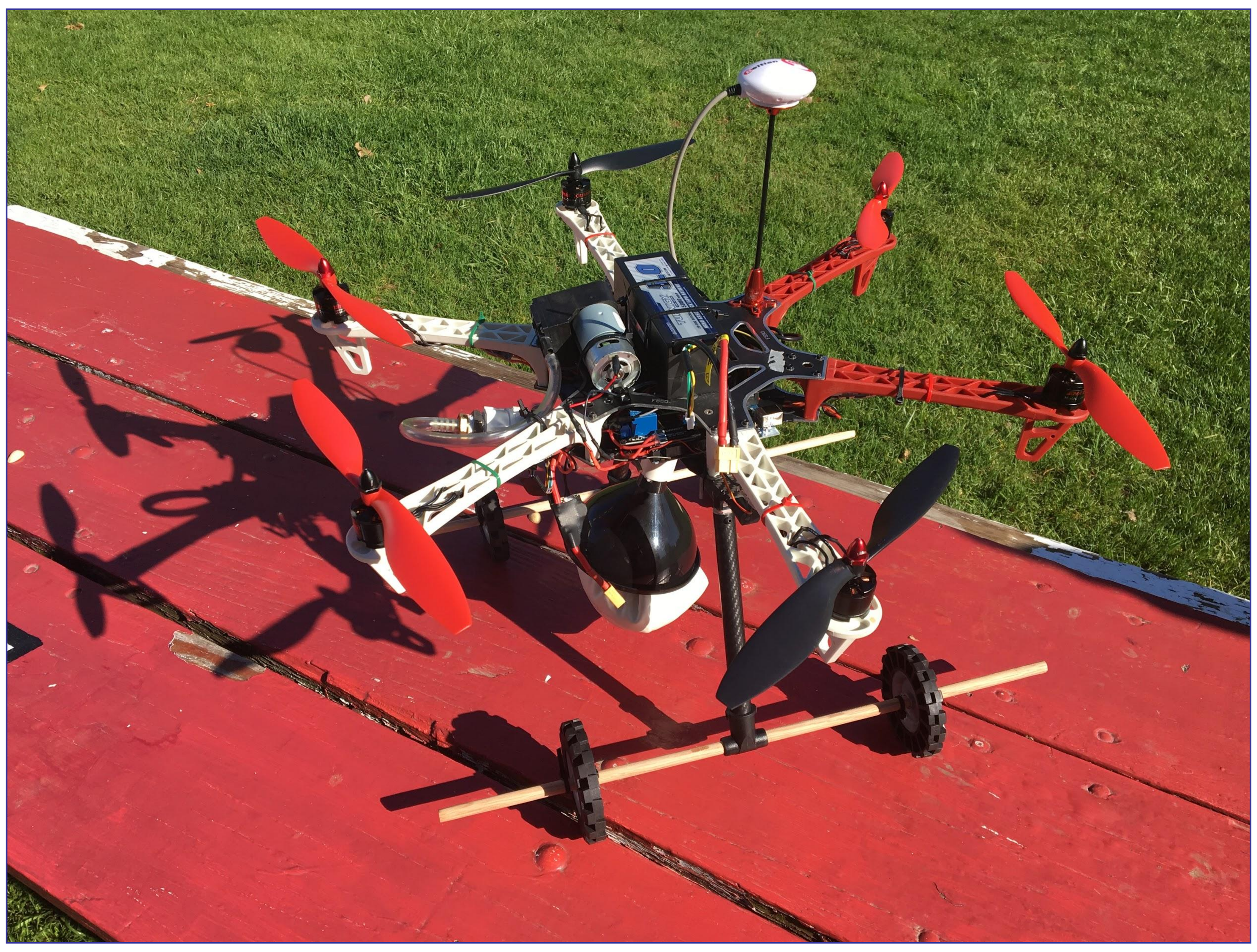
The Flying Universal Gripper is a novel way of retrieving objects with a UAV. This is achieved by outfitting a hexacopter drone with an advanced gripping system that is capable of picking up small objects of virtually any shape. The system is designed to utilize camera tracking software in real time to locate and navigate to desired objects from the the air. After identifying an object, the system autonomously lands above it, lowers to pick it up off the ground, and then flies to a predetermined location.

## Block Diagram




## Specifications

| | |
|---|---|
| Average Flight Time | 20 minutes |
| Cost | <$500 |
| Lifting Capacity | 5lbs |
| Frame | Durable |
| Takeoff, Flight, Landing, Return | Fully Autonomous |
| Type of Objects Obtainable | Variety of Complex Shapes |



## System Overview

**Drone System**

★ Used hexa-copter frame for robustness.
★ 6 motors provide 5.1kg of total thrust.
★ Pixhawk flight controller controls the motors and communicates with the Raspberry Pi for autonomous flight.
★ Used Raspberry Pi as a companion computer for offboard processing

**Sensors**

★ GPS module with <2m accuracy enables the drone to fly in search patterns set by the user as well as allow the drone to return home.
★ Low resolution downward facing Logitech webcam. Outputs video to Raspberry Pi for analysis.

**Autonomous Flight**

★ Used camera tracking techniques and GPS aided flight patterns to guide the drone.
★ While in the air camera is used to detect rings on the ground.

**PCB**

★ PCB houses the 12V voltage regulator, microcontroller, and vacuum switch.

**Gripper**

★ Made from balloon, funnel, and coffee grounds.

## Results

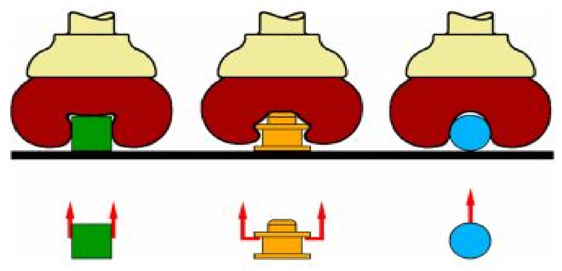
Our UAV achieves full autonomy by taking off, flying a waypoint guided search pattern, detecting and landing on a target, and returning to its launch location all without user control. The gripper system can also successfully claim many objects of different sizes and shapes. However, the drone lacks the precision to land on an object by about six inches due to outside influences such as wind. Also the vision system only recognizes a target, not specific objects.

## Acknowledgements

We would like to thank our advisor, Weibo Gong for his support and advice. Thank you to our evaluators, Israel Koren and Robert Jackson for their indispensable feedback. We would also like to thank Christopher Hollot and Fran Caron for facilitating this year's SDP.

# Granular Jamming

The gripper subcomponent of our project employs the phenomenon of granular jamming. The concept of granular jamming uses a mass of granular material (e.g. coffee grains) enclosed in an elastic membrane to form a gripper. Applying a negative pressure to the gripper hardens the granular material enabling it to pick up a variety of objects. This type of gripper provides high reliability with very low overhead.



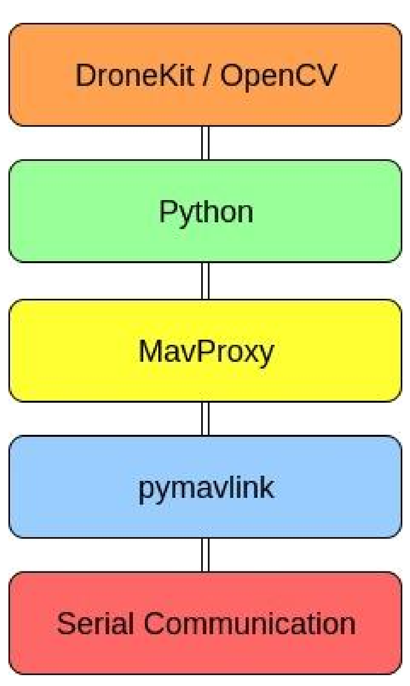
https://www.eng.yale.edu/brown/ABRJL12.pdf

# Gripper System

- ★ Balloon
- ★ Funnel
- ★ Coffee Grounds
- ★ Filter
- ★ PVC pipe
- ★ Plastic Tubing
- ★ 12V Vacuum

# Companion Computer

The Raspberry Pi is responsible for all high level computations. It processes image frames from the webcam and returns precise velocity adjustments to the flight controller. The Pi also maintains GPS waypoints and runs the master script that embodies the drone's flight mission.



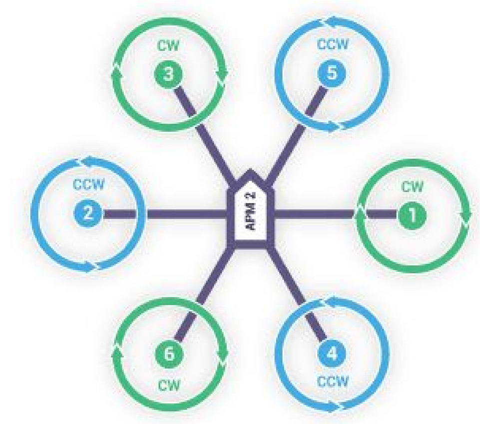

**Communication Stack**

# Cost

| Part | Development | Production(1000) |
|---|---|---|
| Drone<br>-Motors<br>-Hexa-copter Frame<br>-Speed Controller<br>-Propellers | $223.23 | $167 |
| Gripper | $13.34 | $5 |
| Raspberry Pi 3 Model B | $39.99 | $37 |
| PCB | $70.00 | $10 |
| Pixhawk Flight Controller | Donated | $70 |
| Landing Gear | $35.34 | $24 |
| 12V Vacuum | $21.95 | $16 |
| 14V Battery(4s Lipo) | $33.44 | $26 |
| GPS | Donated | $30 |
| Kingmak Mini HD Camera | $16.99 | $12 |
| Relay Switch | $12.65 | $9 |
| Total | $466.93 | $406 |

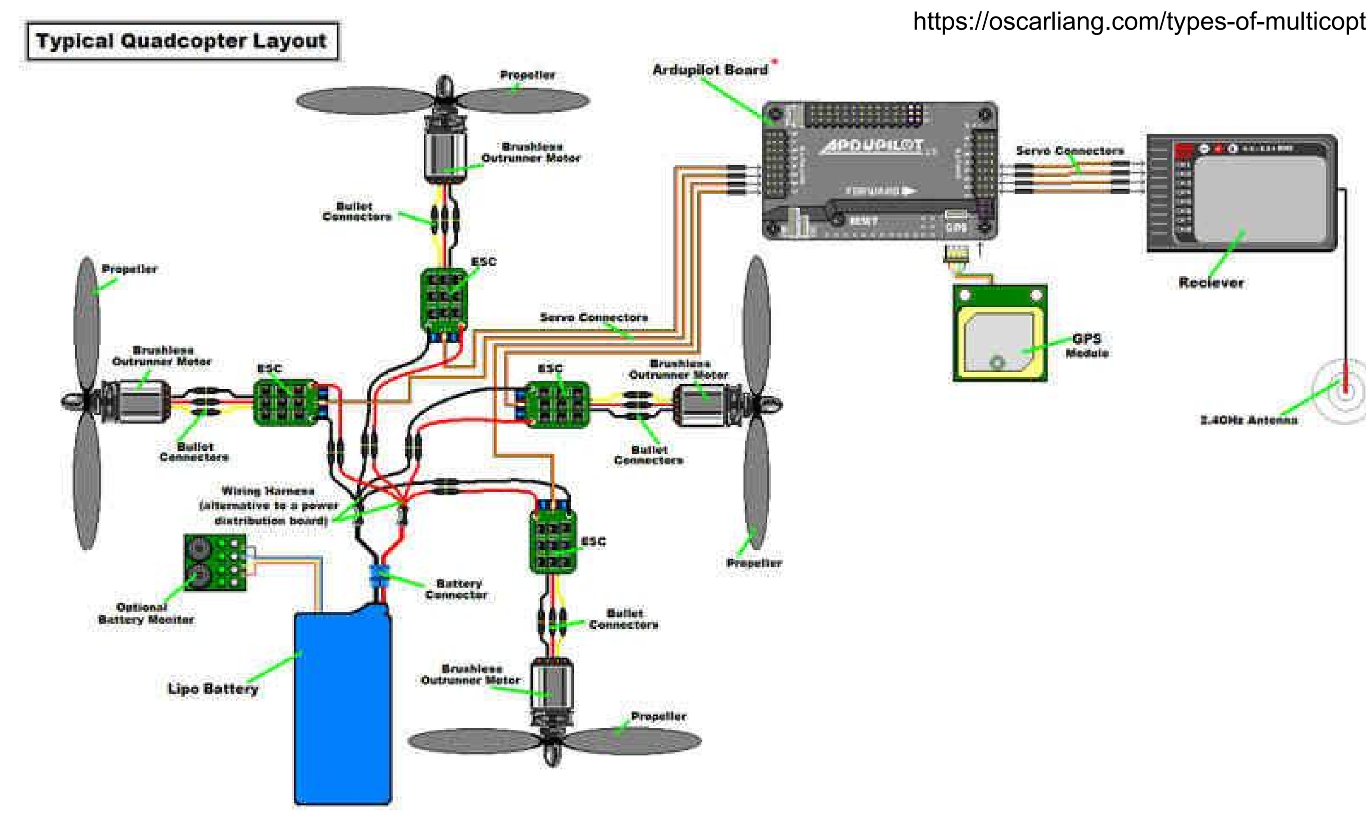
# Drone Body

- ★ Hexa-copter frame
- ★ Pixhawk flight controller
- ★ 5000mAh 14.8V battery
- ★ 6 ESCs
- ★ 935kV motors
- ★ 10'' diameter propellers



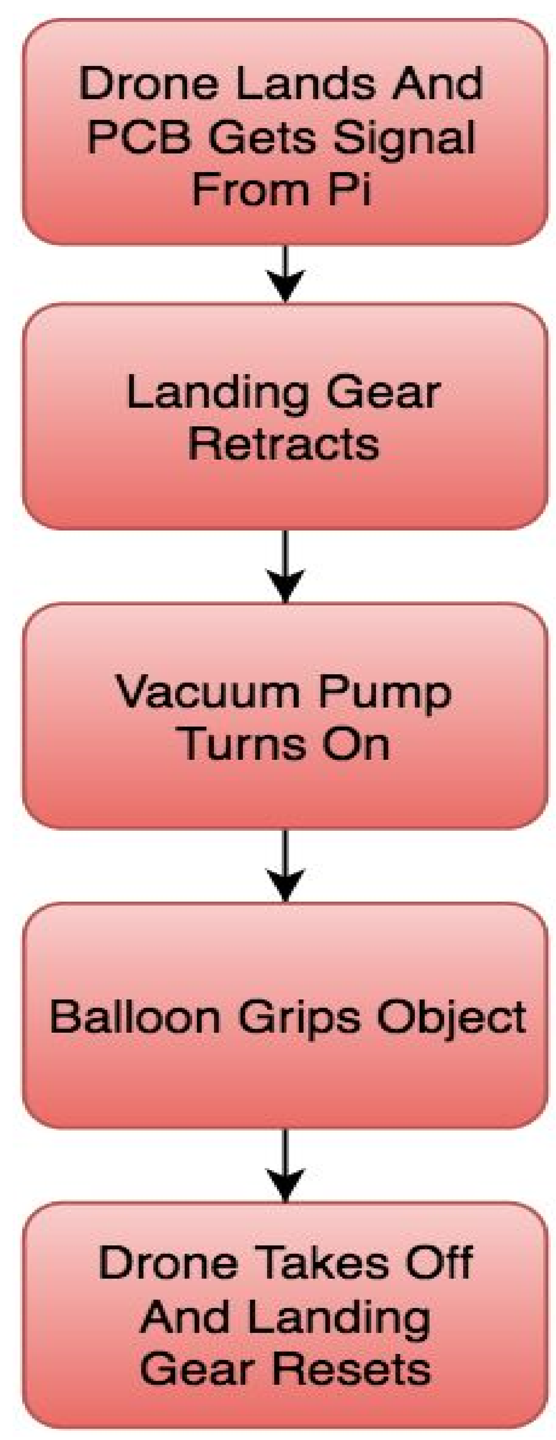
*HEXA X*

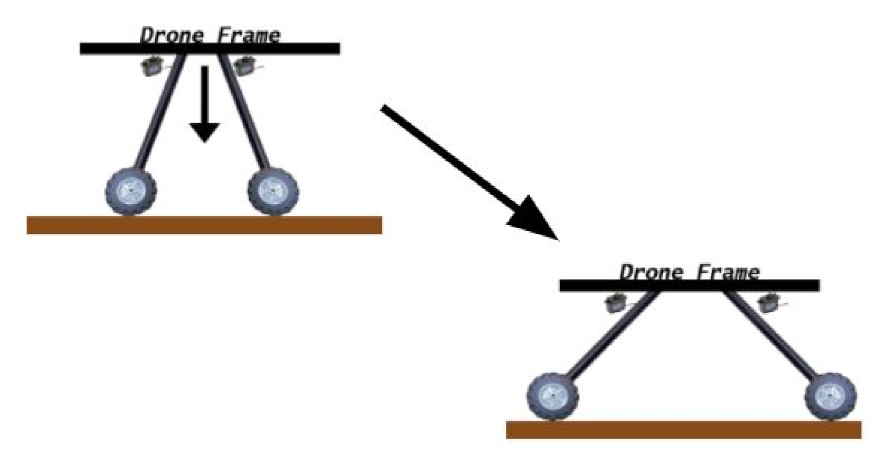
https://oscarliang.com/types-of-multicopter/




http://ardupilot.org/copter/docs/connecting-the-apm2.html

# Landing Sequence

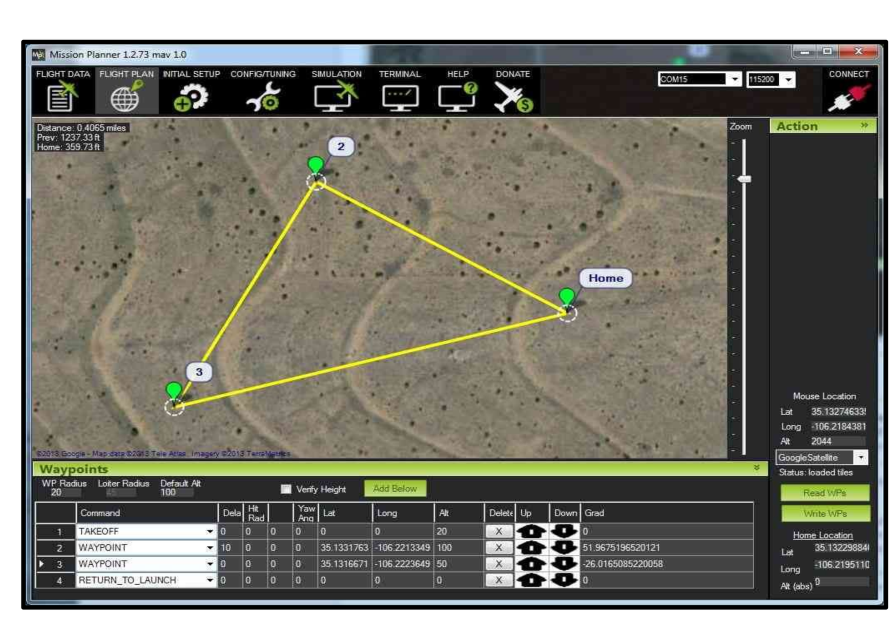



The landing sequence is necessary so that the gripper can come into contact with an object. After landing, the drone body lowers slightly before engaging the gripper. Then the drone lifts off holding the object.

# Autonomous Flight

To achieve autonomous flight we employ GPS aided flight patterns and camera tracking techniques to guide the drone. The target is identified through a ring detector algorithm using OpenCV, a computer vision API. When the target has been identified a path planning algorithm is used to land the drone on top of the object. The flight path to the object is calculated by the object's relative pixel location in the video feed and the drone's altitude. These inputs continuously update the algorithm in a feedback loop. The output of the algorithm is velocity commands to the motors.



**GPS Waypoints**

**Target**