Laser-Assisted Guidance Landing Technology for Drones

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Motivation

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1. In recent years, **drone** flight has been widely applied across various fields, and how to accurately **land autonomously** at **designated locations** has become a popular research topic.

2. Existing vision-based methods can achieve precise landings, but they rely on **camera** systems, which are **high payload**, **high-power consumption**.

3. Another motivation for the research is to apply this landing technology to **various practical scenarios**, such as **delivering supplies** or **parcels in adverse environments**.

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Introduction

Introduction

1. The purpose of this study is to create an algorithm that will enable drones to **land** with precision **despite the inherent positioning errors** that are customary in **GPS** technology.

2. Using **laser guidance** to improve the accuracy of UAVs during landing.

3. This technique can provide the most **cost-effective solution** for this problem due to its **low payload**, **low power consumption** and even **low costs**.

Introduction - Laser

- Our work make use of laser **coherence**, ensuring **accurate direction** and **sharpness** of the measurement.
- Drones will **no longer require bright environments** for landing.
- **Operating costs** for drones can be **reduced**.
- The **recognition distance** for drones to locate the landing point can be **extended**.

Specification	Details
Output wavelength	650 ± 5nm
Laser shape	Dot (Oval)
Spot size	<18mm at 10m
Size	$\phi 3.6 \times 9$mm

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Methodology

Methodology - Framework

Drone

Landing base

Methodology - Hardware development

Fig. 3. Pixhawk 4

Equipment	Function
Pixhawk 4	Flight controller
Raspberry Pi 4B	Onboard computer
5V Laser Beam Receiver Module	Detect the laser beam
GT-38 Wireless Serial Communication Module	Communicate

Methodology - Hardware development

Fig. 4. Raspberry Pi 4B

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Pixhawk 4	Flight controller
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Methodology - Hardware development

Fig.5. 5V Laser Beam Receiver Module

Fig. 6. GT-38 Wireless Serial Communication Module

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Methodology - Hardware development

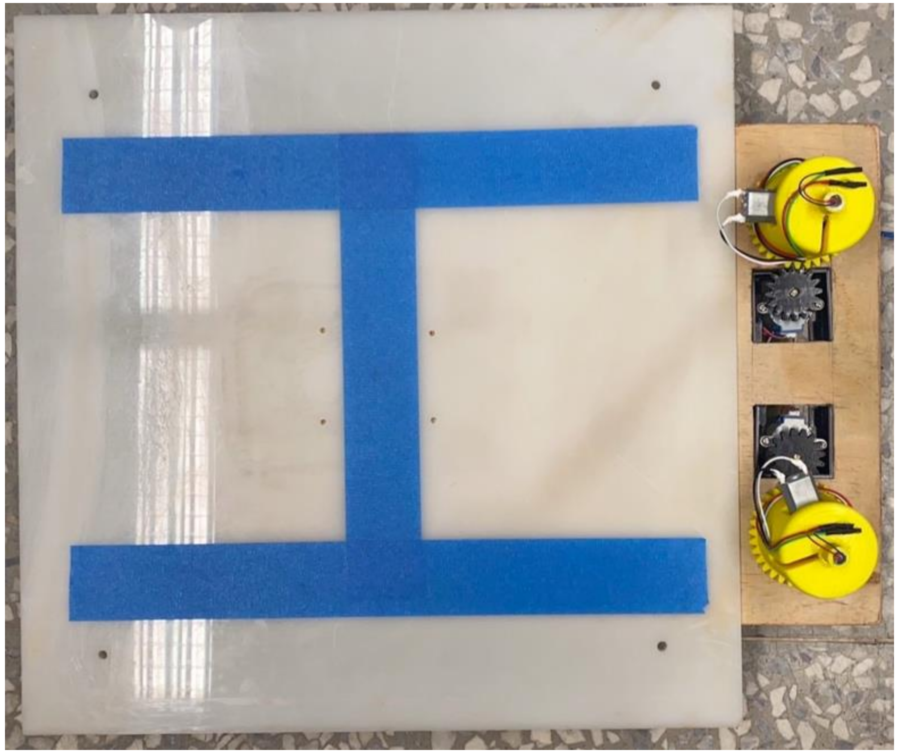


Fig. 1-1. Landing Base

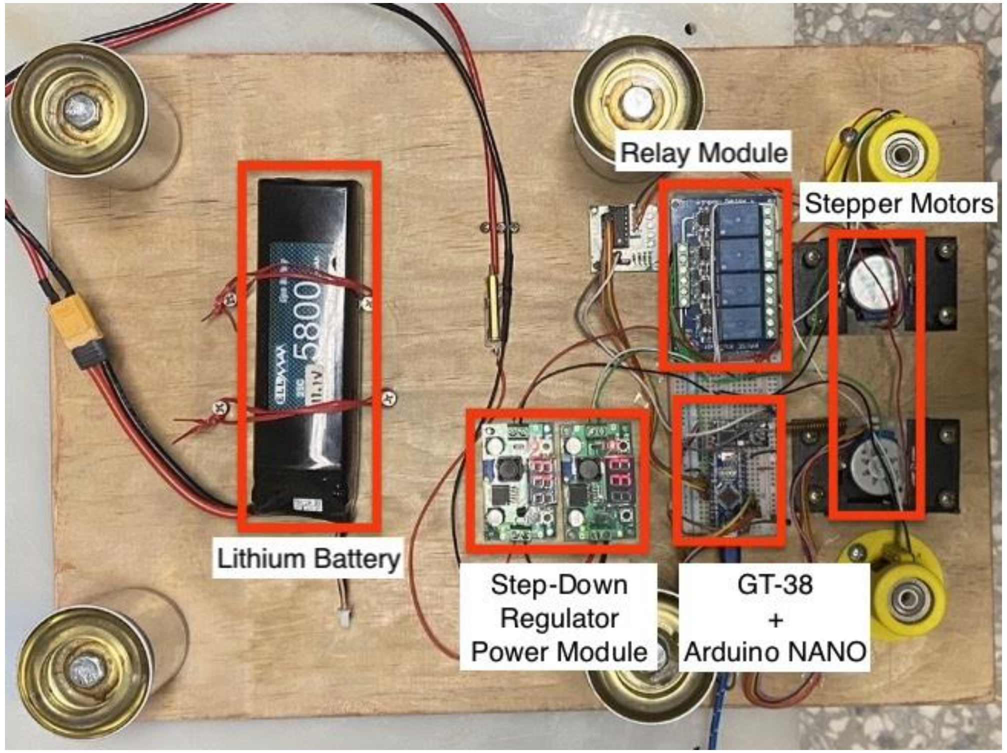


Fig. 1-2. Landing Base

Methodology - Hardware development

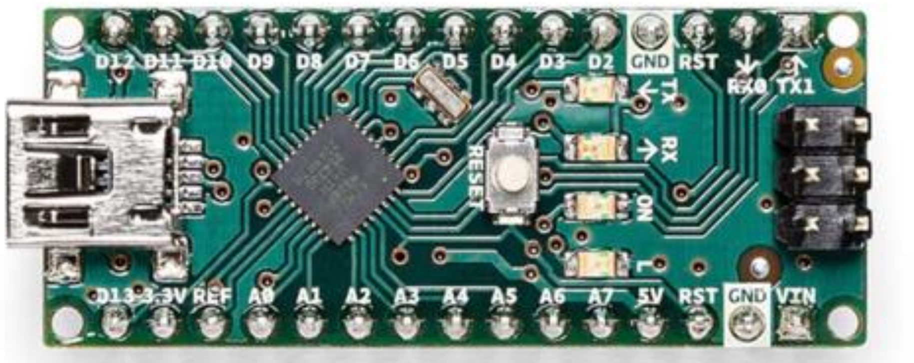
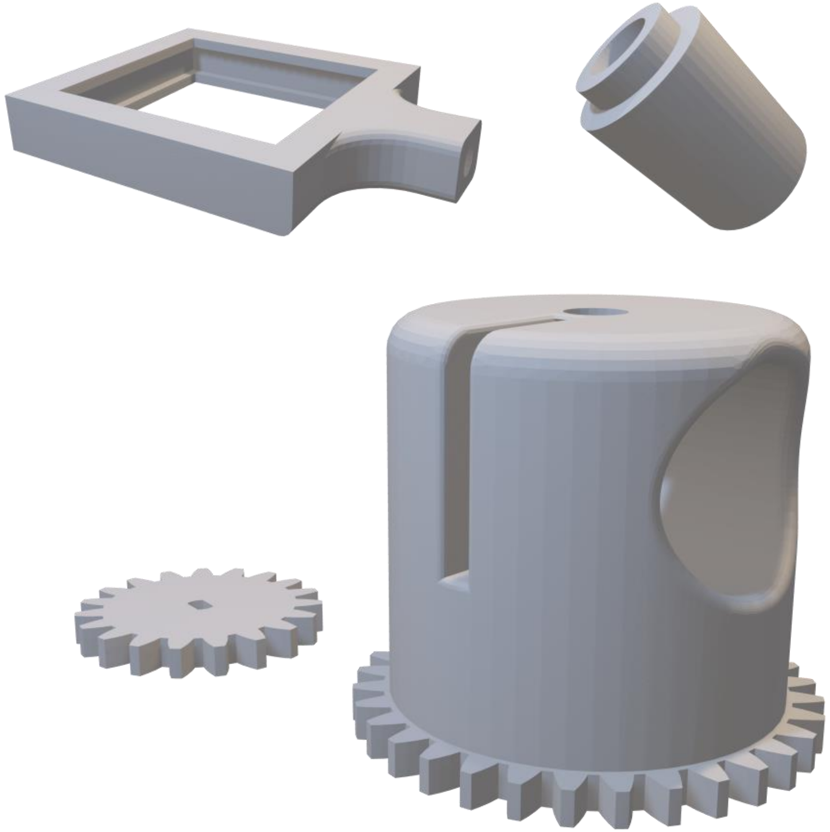


Fig. 7. Arduino NANO

Equipment	Function
Arduino NANO	Base computer
5V DC motor	Generate fan shaped laser
5V Laser Beam Transmitter Module	Emit laser beams
28BYJ-48-5V Stepper Motor	Rotate laser projecting module
GT-38 Wireless Serial Communication Module	Communicate
Laser-Projecting Module	Enable fan shaped laser beam scan 360°

Methodology - Hardware development



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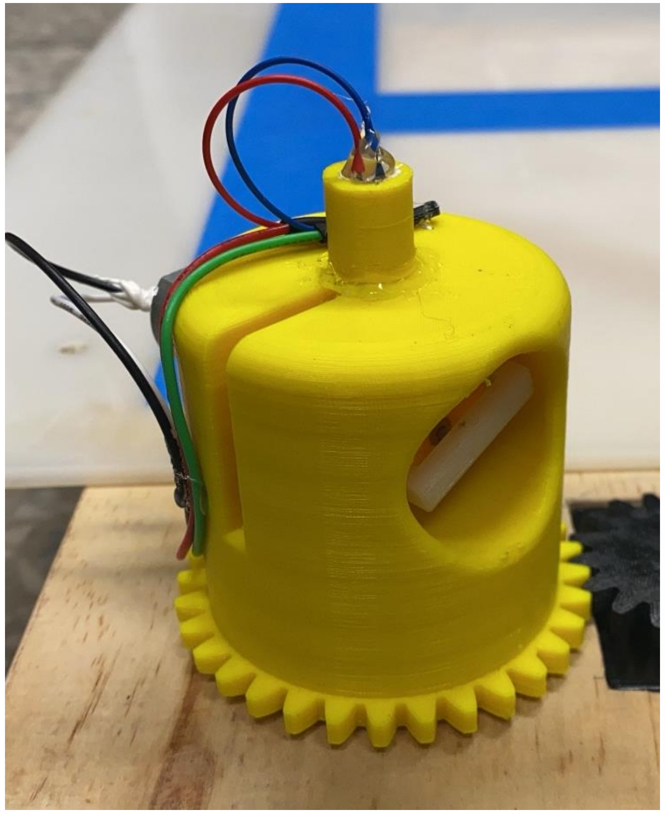

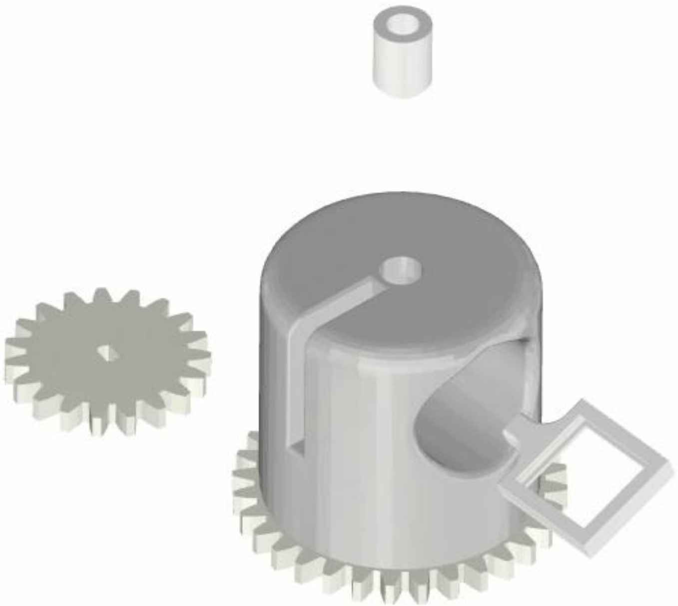

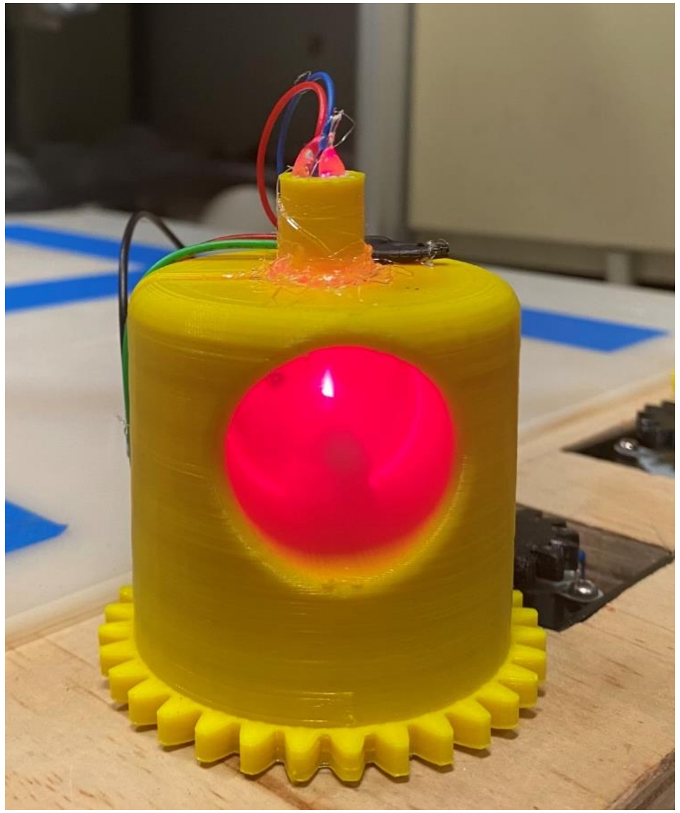

Methodology - Triangulation method

$$length\ l$$

$$\theta_1 = 2\pi - \theta_a$$

$$\theta_2 = 2\pi - \theta_b$$

$$\phi = \pi - \theta_1 - \theta_2$$

$$r = \frac{l}{\sin\phi} \cdot \sin\theta_2$$

$$x_{bias} = r\cos\theta_1 - \frac{l}{2}$$

$$= \left(\frac{l}{\sin\phi} \cdot \sin\theta_2\right)\cos\theta_1 - \frac{l}{2}$$

$$= \left(\frac{l}{\sin(\pi - \theta_1 - \theta_2)} \cdot \sin\theta_2\right)\cos\theta_1 - \frac{l}{2}$$

$$= l \cdot \left(\frac{\sin\theta_2\cos\theta_1}{\sin(\theta_1 + \theta_2)} - \frac{1}{2}\right)$$

$$y_{bias} = r\sin\theta_1 - \frac{l}{2}$$

$$= \left(\frac{l}{\sin\phi} \cdot \sin\theta_2\right)\sin\theta_1 - \frac{l}{2}$$

$$= \left(\frac{l}{\sin(\pi - \theta_1 - \theta_2)} \cdot \sin\theta_2\right)\sin\theta_1 - \frac{l}{2}$$

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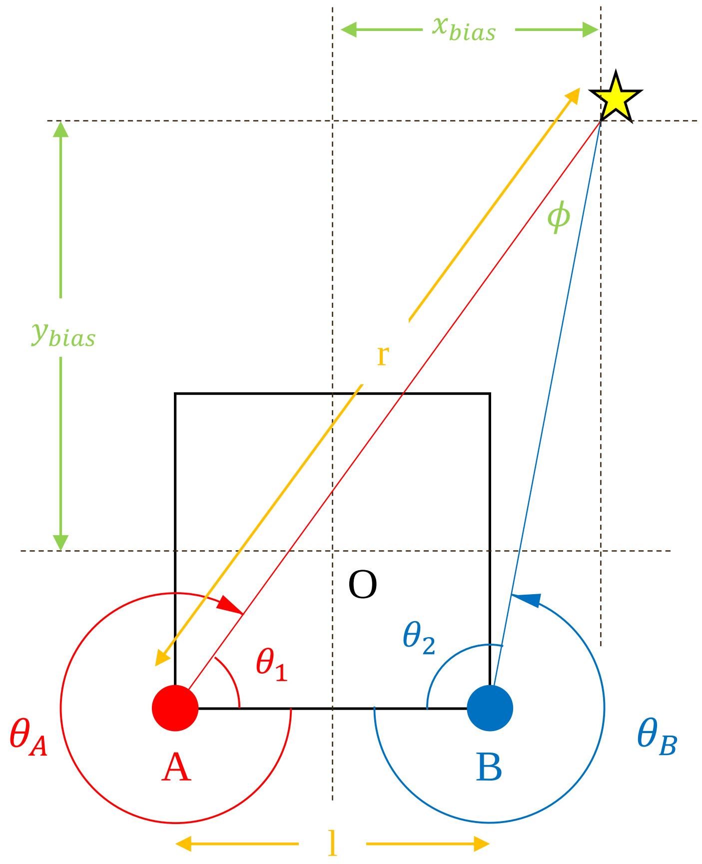
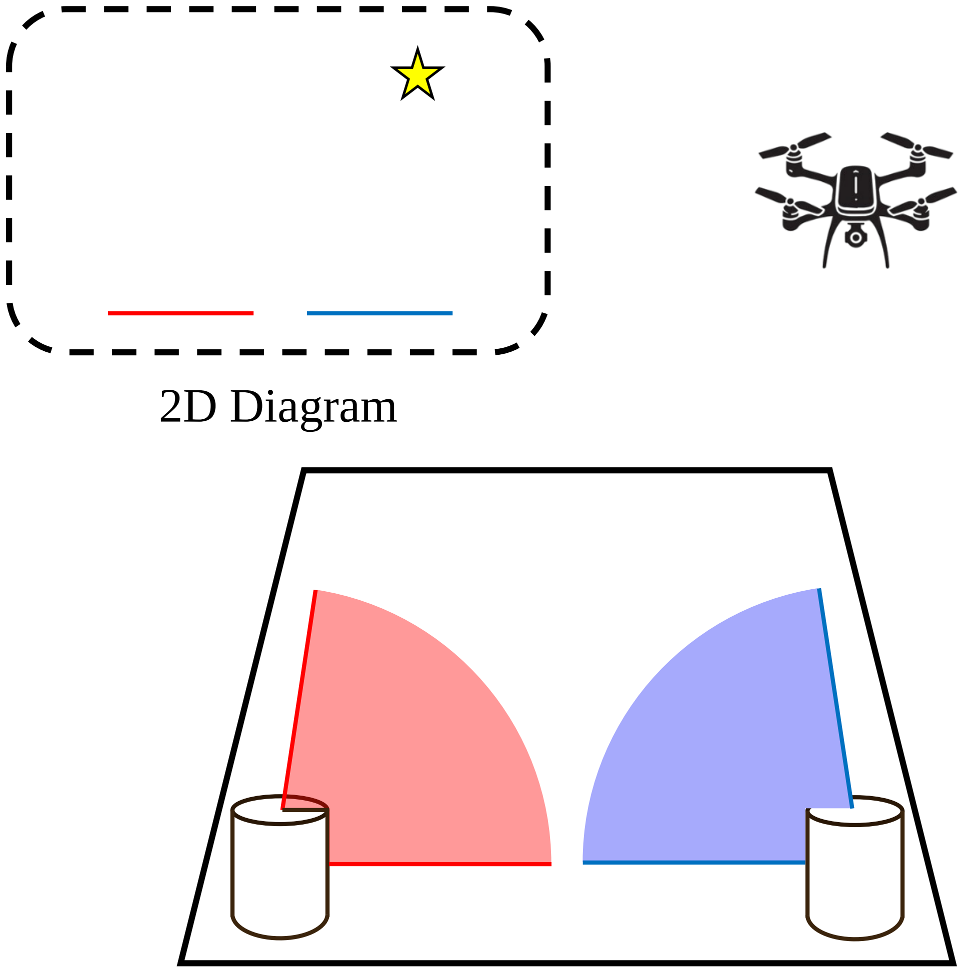


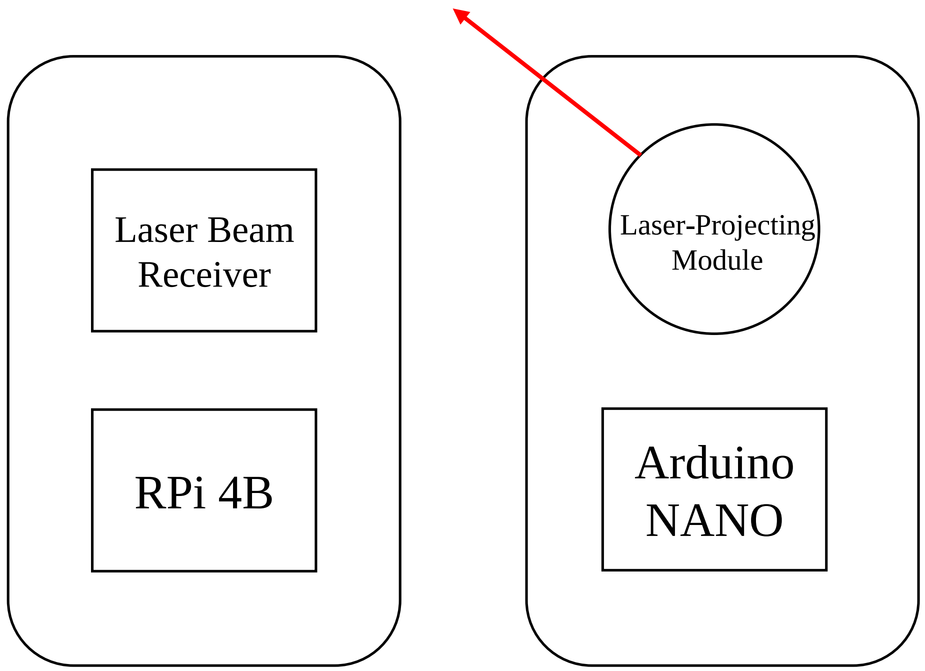
Fig. The imagination of the landing situation.

Methodology - Landing procedure



2D Diagram

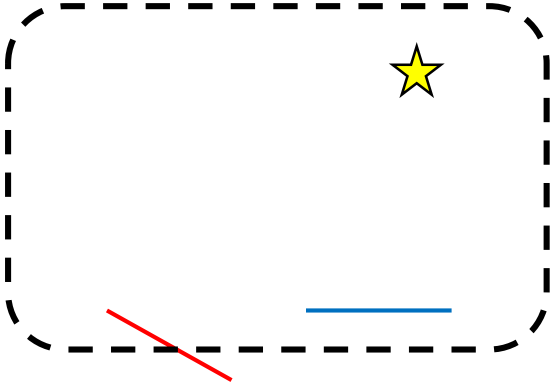
3D Diagram



Drone

Landing Base

Methodology - Landing procedure



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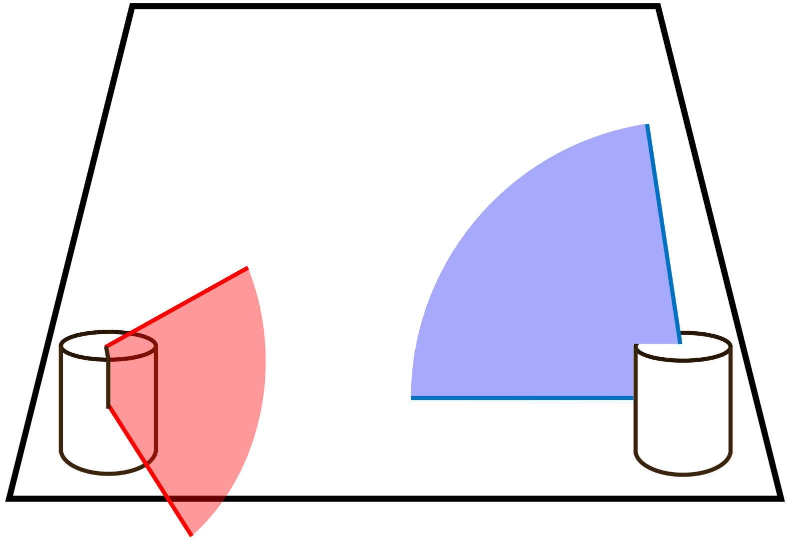
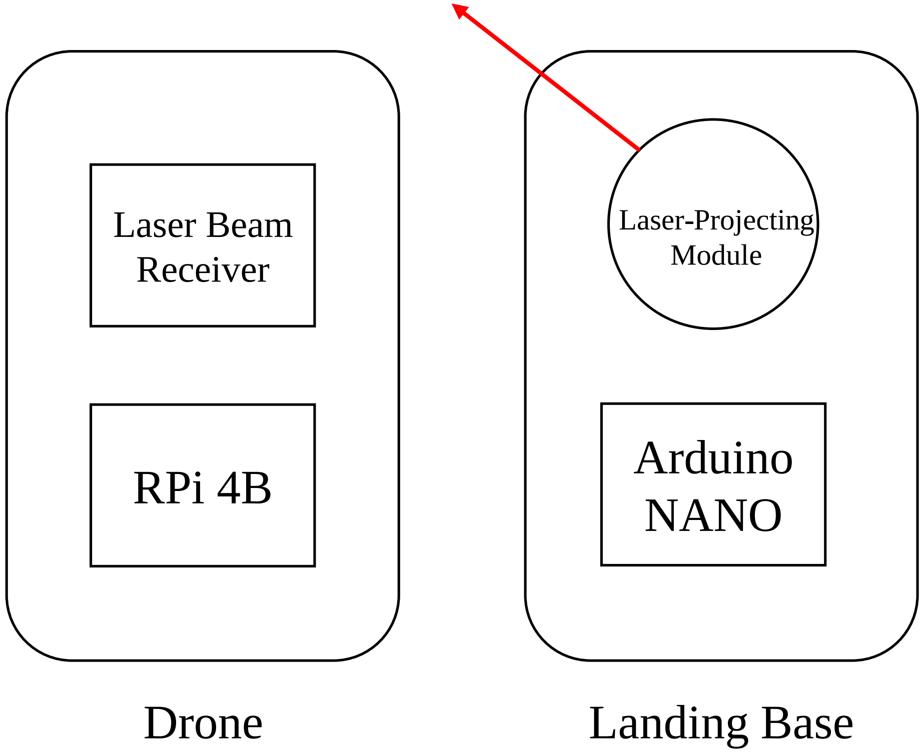
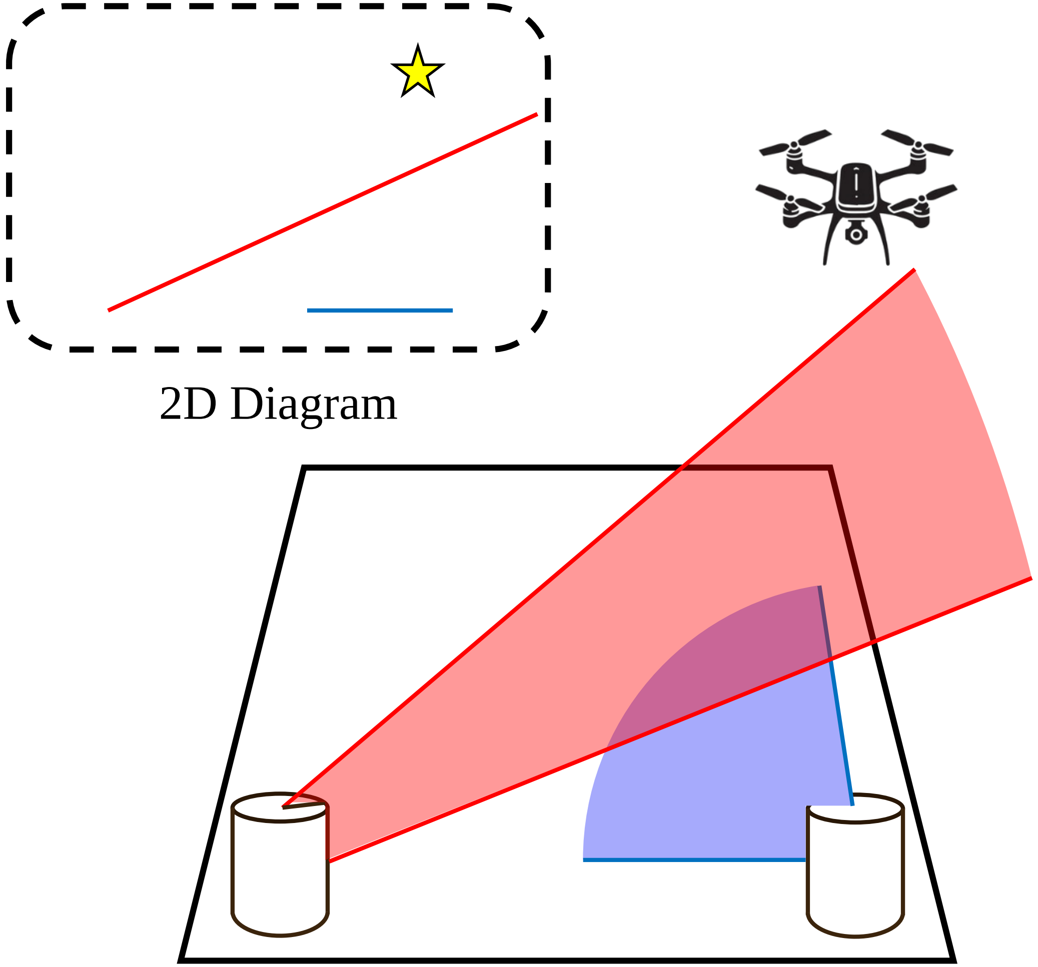


3D Diagram



Methodology - Landing procedure



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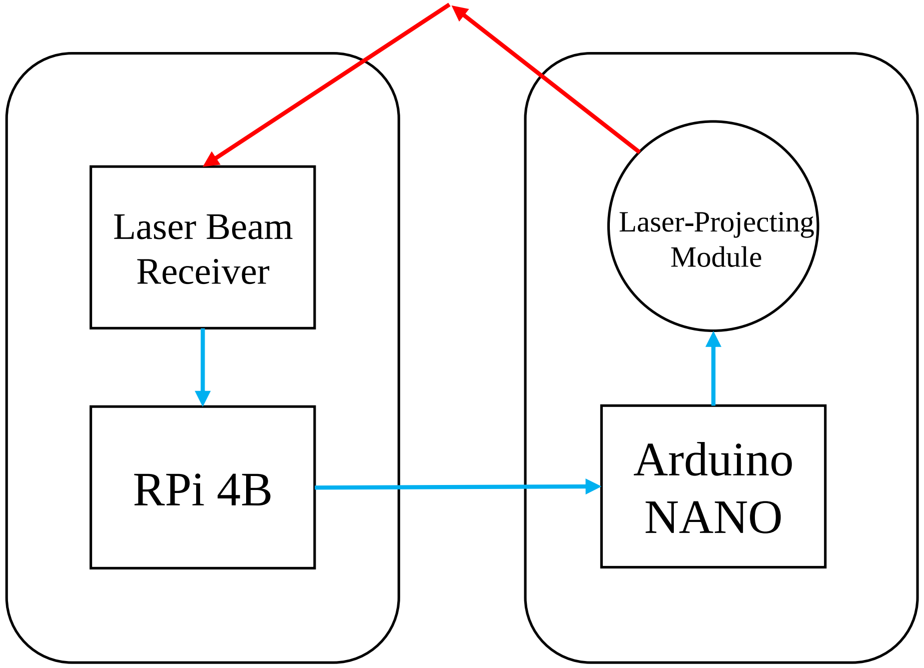
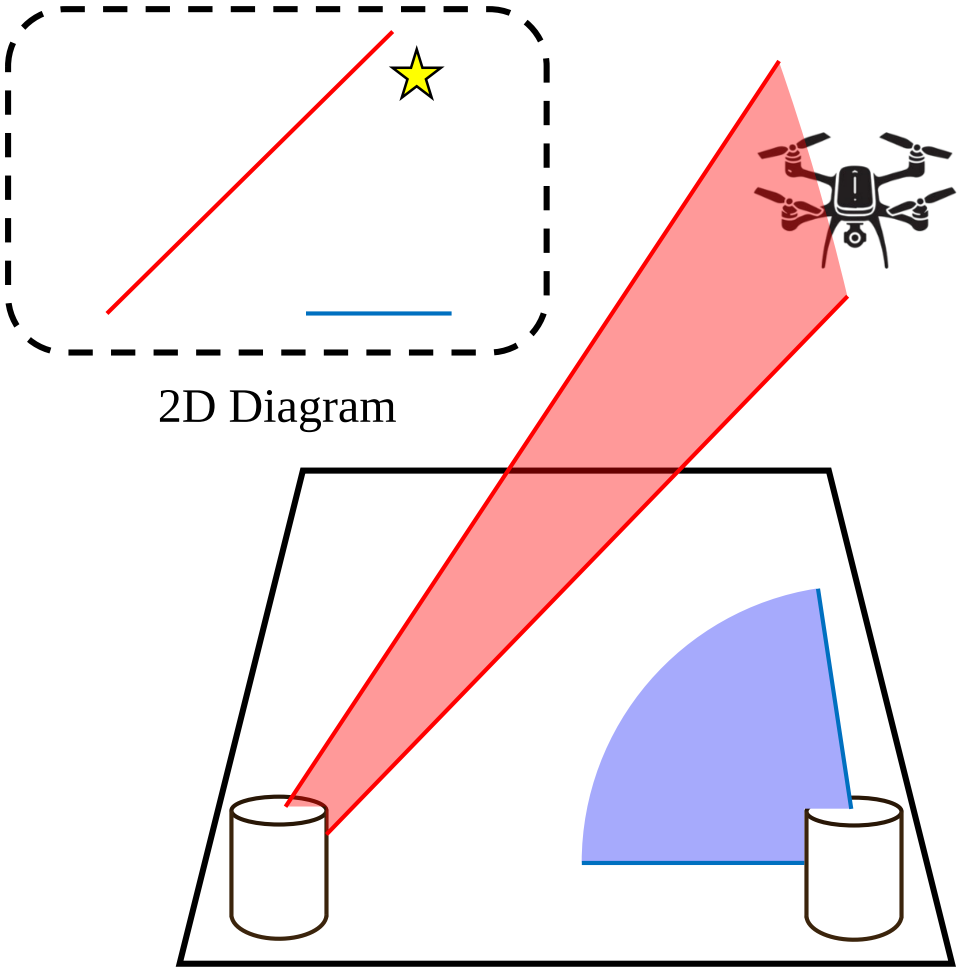


Drone

Landing Base

Methodology - Landing procedure



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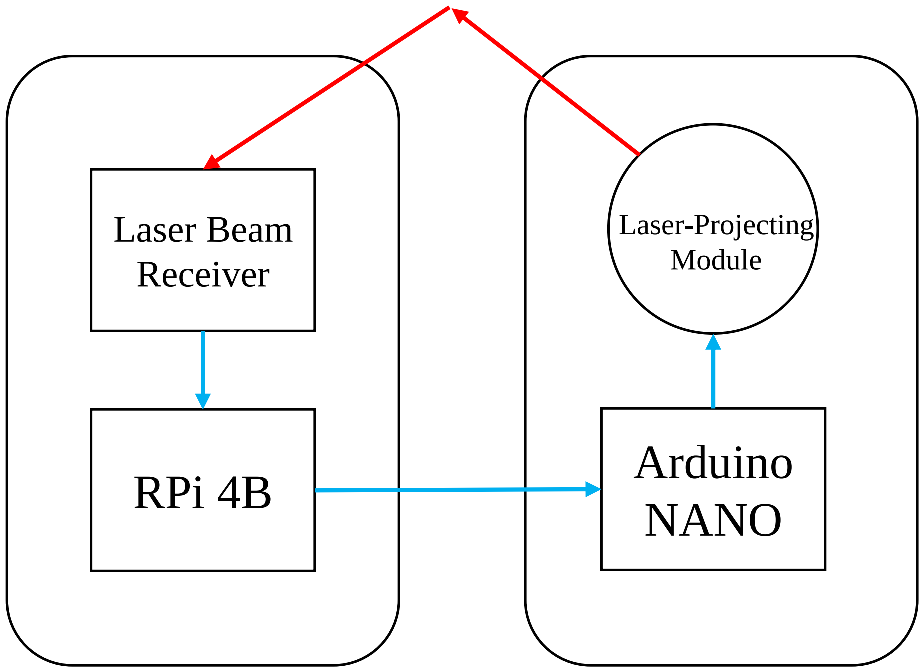
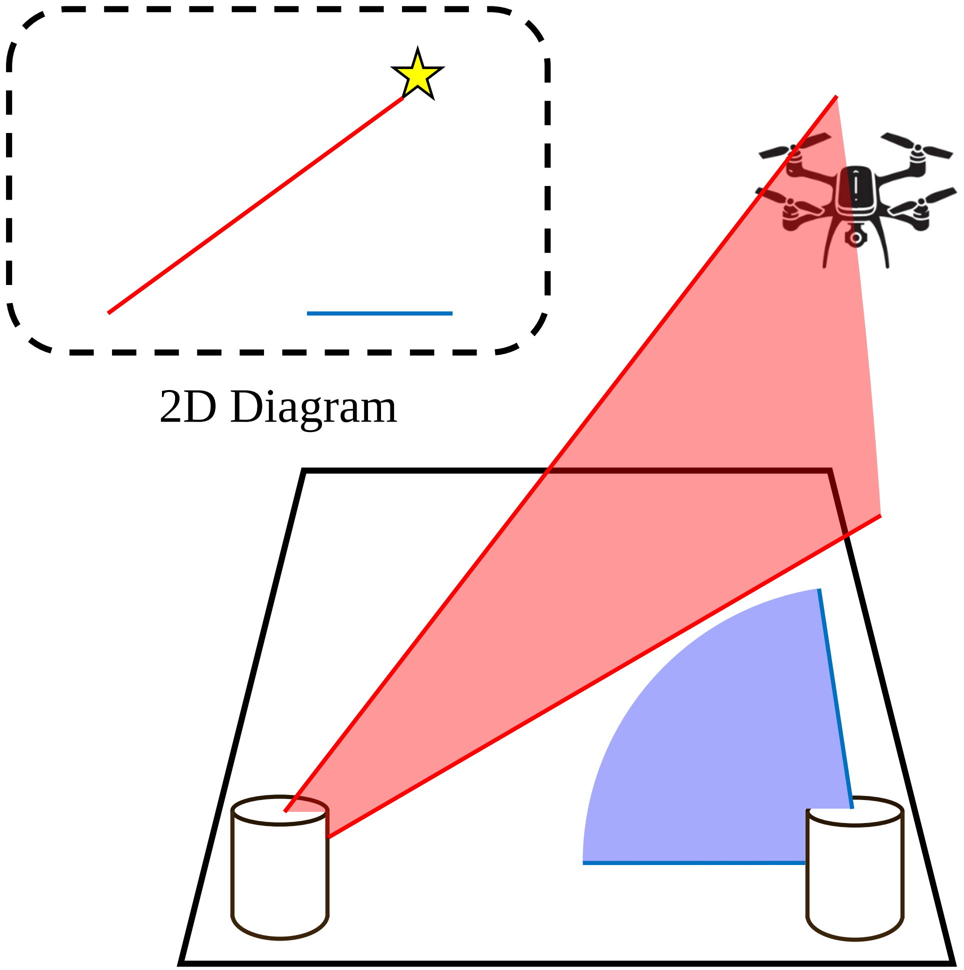


Drone

Landing Base

Methodology - Landing procedure



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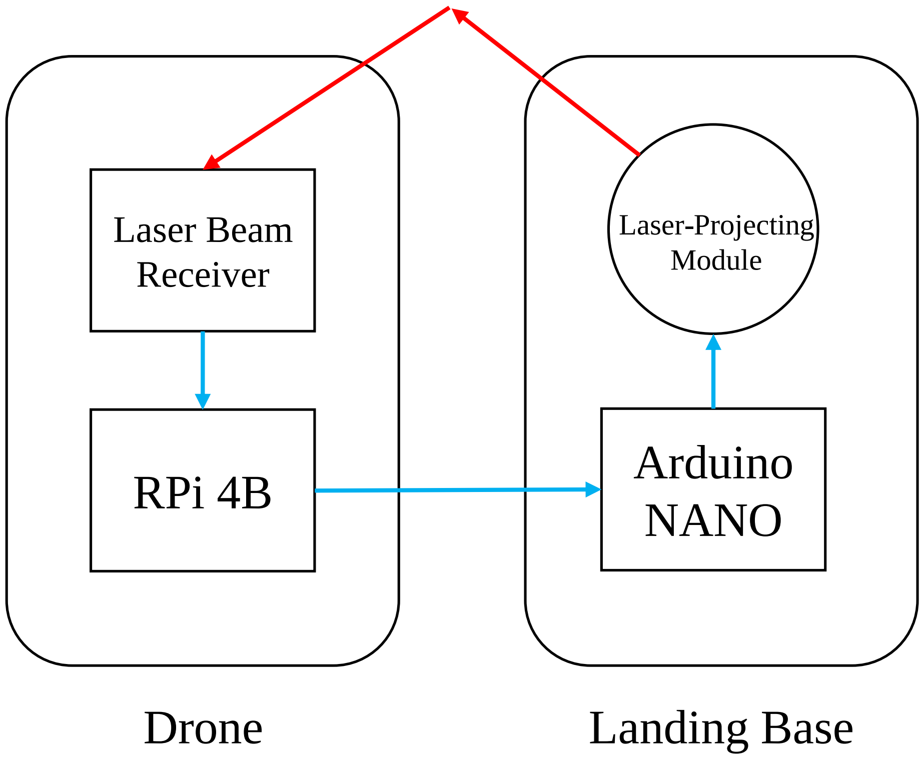

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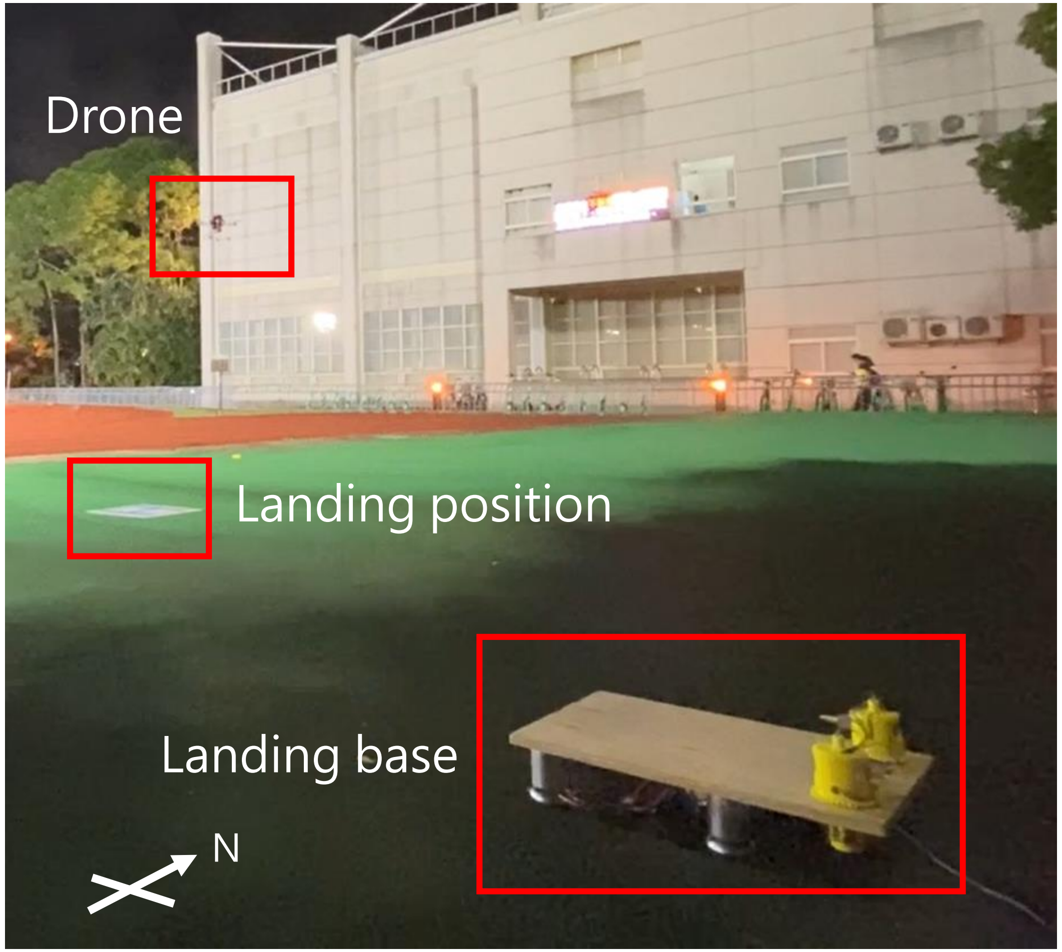
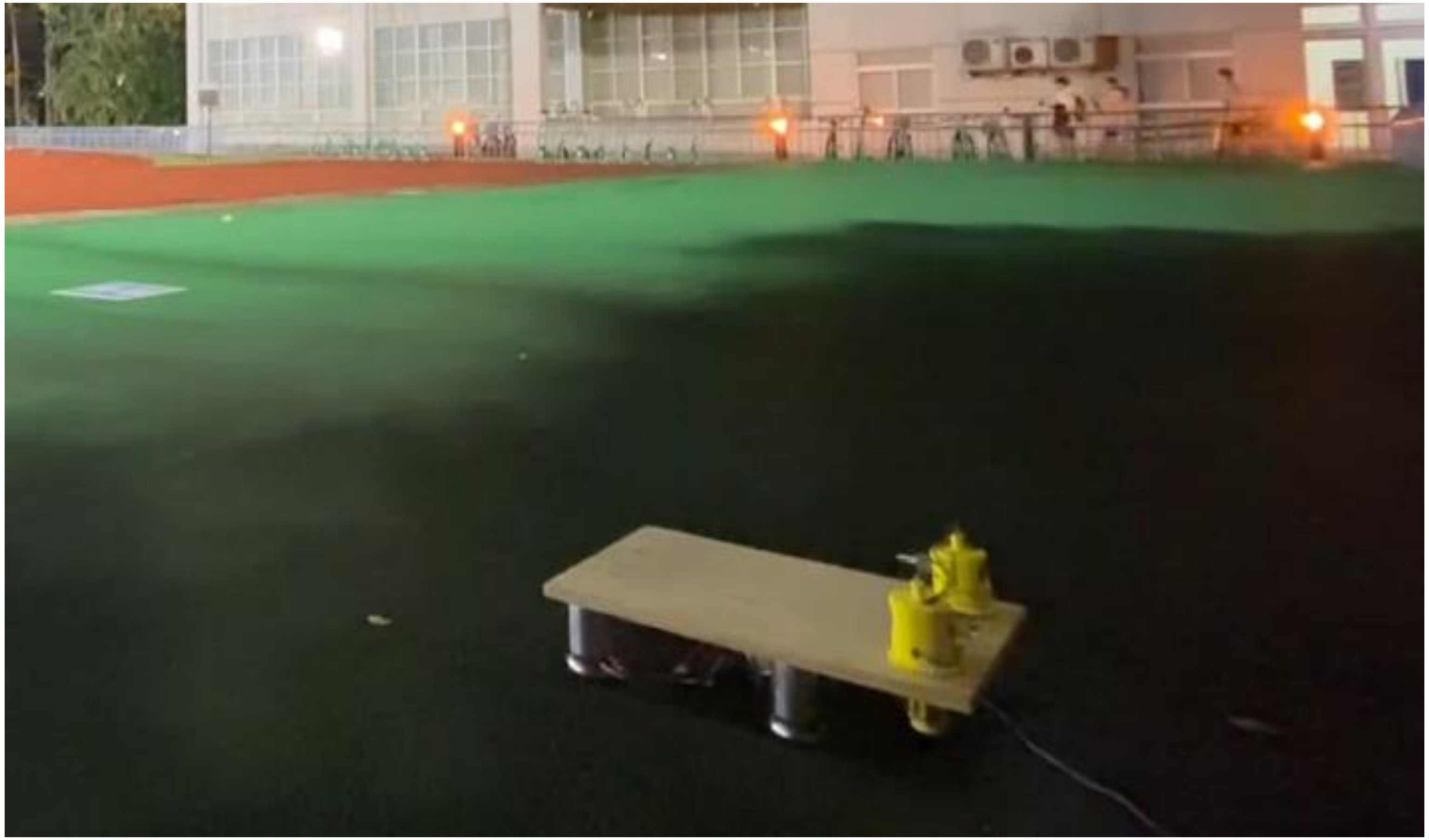
Results and Discussion

Results and Discussion - Experiment setup



Type	Data
x-axis distance	3 meters
y-axis distance	3 meters
z-axis distance	3 meters
Wind speed	6.9m/s
Wind direction(360°)	30°
Number of executions	35

Results and Discussion - Experiment



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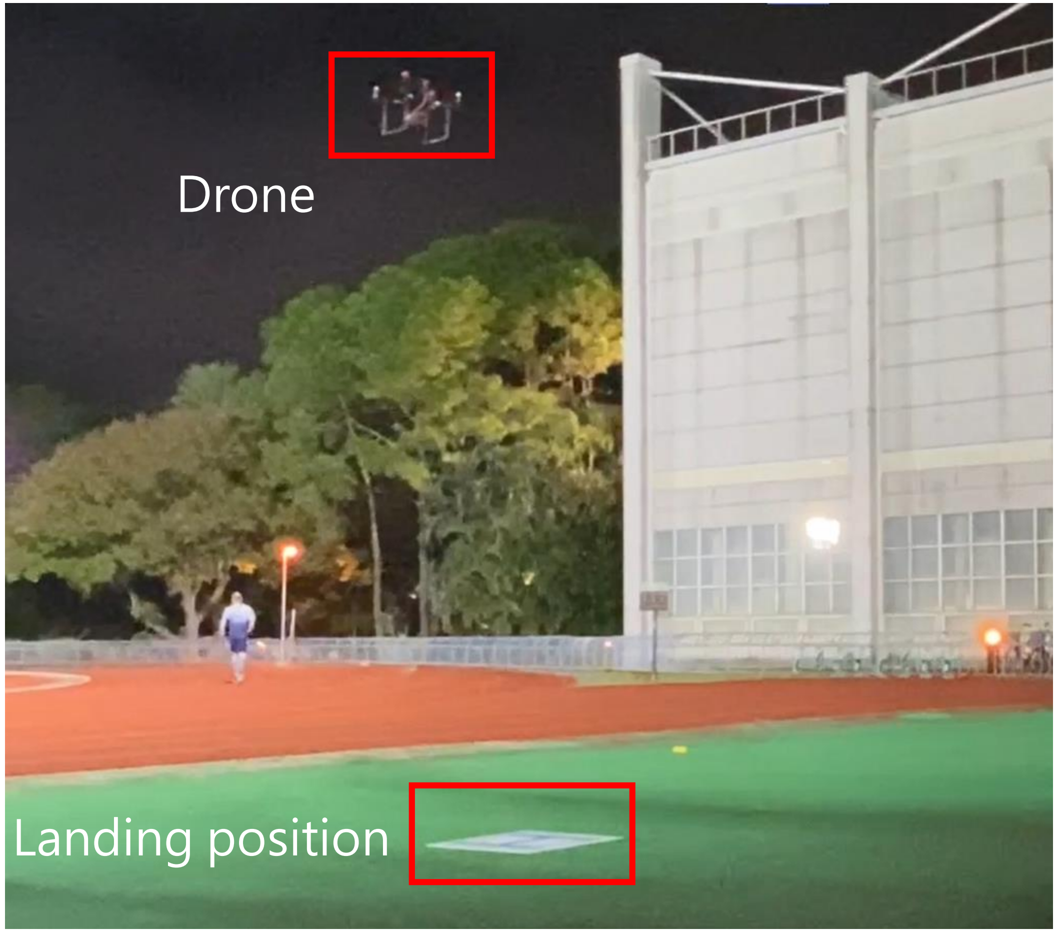

Results and Discussion - Result

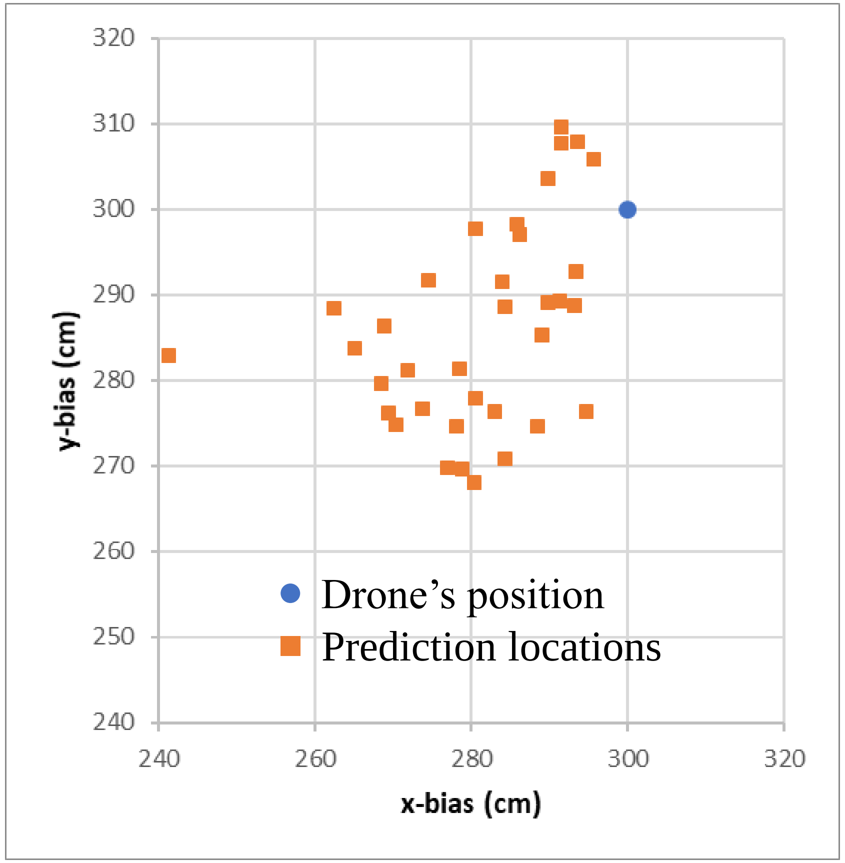

Fig. 8. Scatter plot of predicted locations of the drone

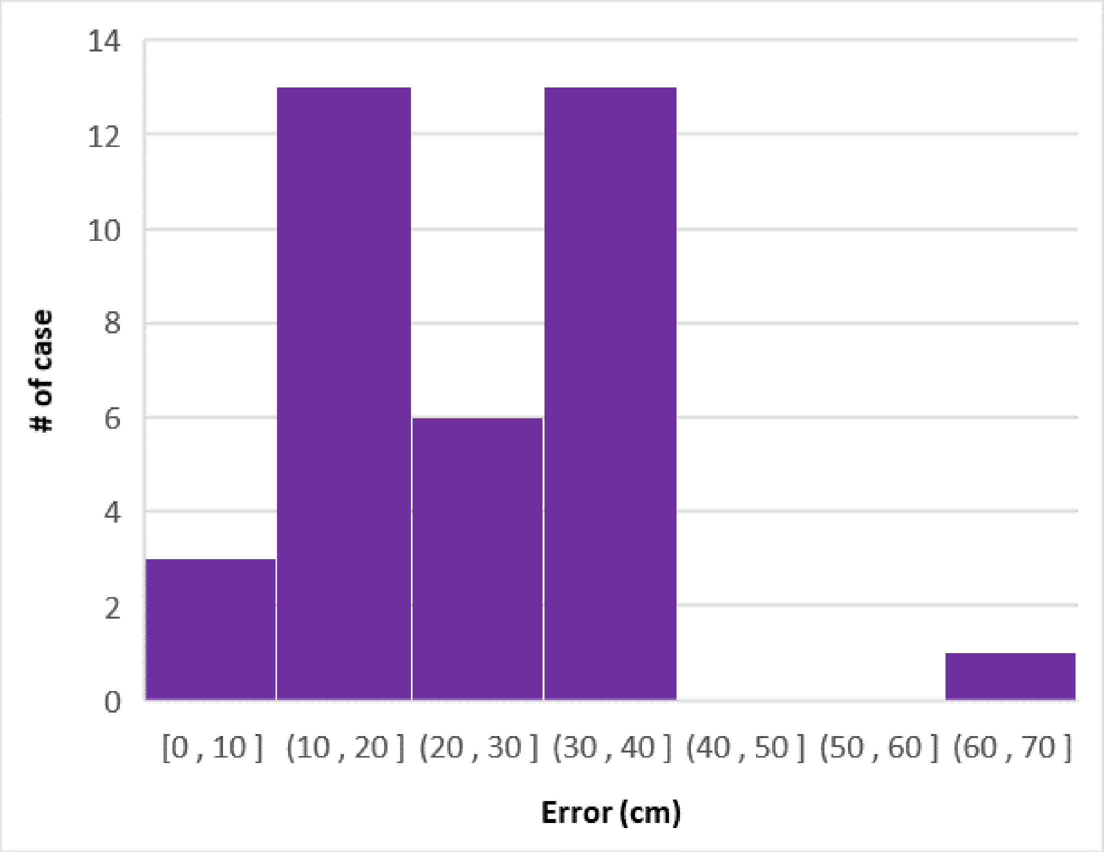

Fig. 9. Bar chart of error between the actual point and predicted locations

Results and Discussion - System comparison

Related work	System model	Weight	Power consumption
Ours	Laser receiver module + GT-38 Communication Module	15g+25g	0.1W
Ground-Based Near Infrared Camera Array System [1]	Point Grey + Near Infrared Laser Lamp Point Grey	90g+470g	4.5W+25W
Remote Marker-Based Tracking Using Visible-Light Camera Sensor [2]	Camera on DJI Phantom 4 quadcopter	120g	×
Lightdenseyolo: A Fast and Accurate Marker Tracker for Autonomous UAV Landing [3]	Camera on DJI Phantom 4 quadcopter	120g	×

[1] T. Yang, G. Li, J. Li, Y. Zhang, X. Zhang, Z. Zhang, and Z. Li, “A ground-based near infrared camera array system for uav auto-landing in gps-denied environment,” Sensors, vol. 16, no. 9, 2016.
[2] P. H. Nguyen, K. W. Kim, Y. W. Lee, and K. R. Park, “Remote markerbased tracking for uav landing using visible-light camera sensor,” Sensors, vol. 17, no. 9, 2017.
[3] P. H. Nguyen, M. Arsalan, J. H. Koo, R. A. Naqvi, N. Q. Truong, and K. R. Park, “Lightdenseyolo: A fast and accurate marker tracker for autonomous uav landing by visible light camera sensor on drone,” Sensors, vol. 18, no. 6, 2018.

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Conclusion

Conclusion

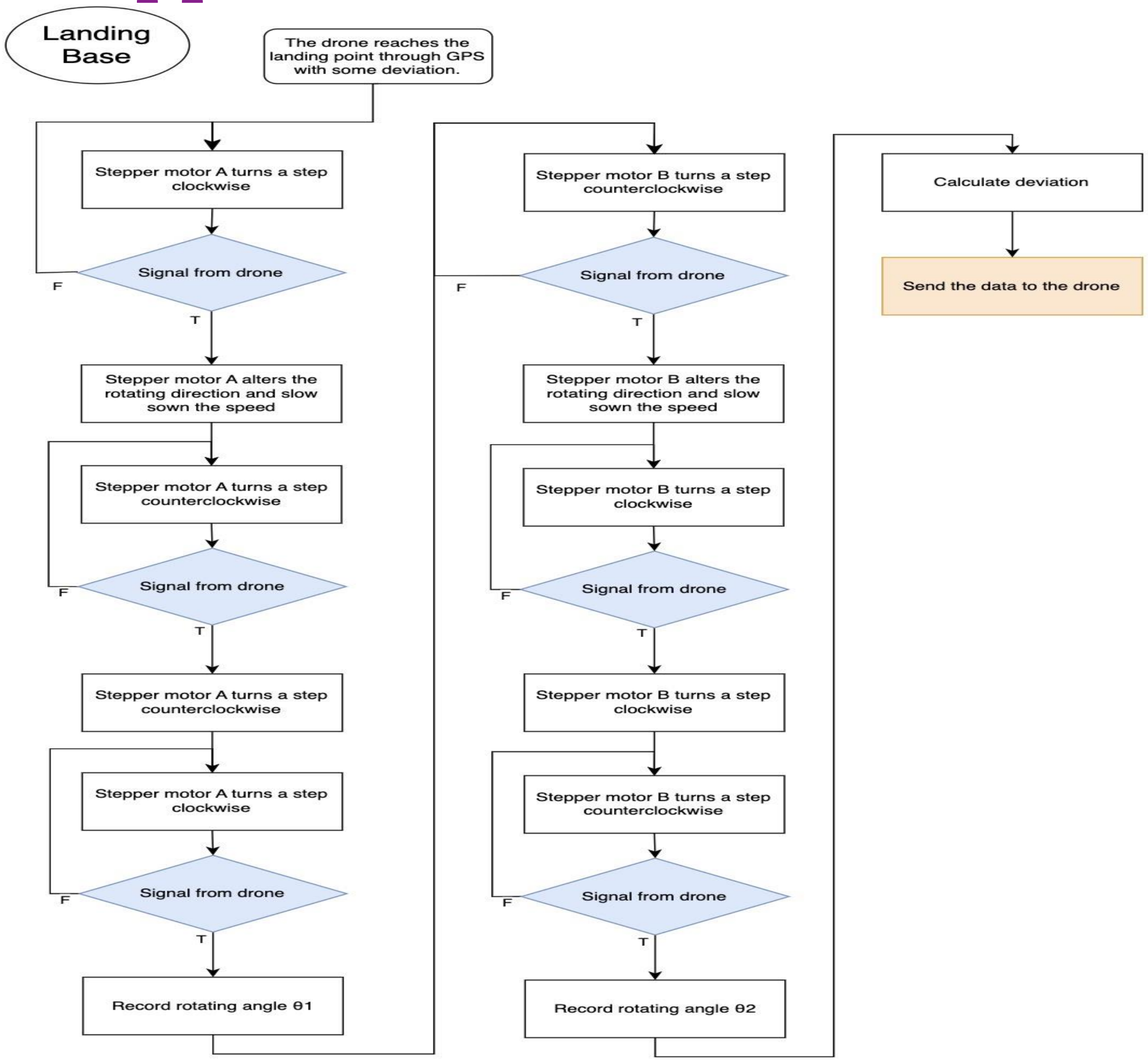
1. This research presents a **simple methodology** for drones to **land at the designated location accurately**.

2. The **experiment** results illustrate that the methodology developed in this research could **perform satisfactorily in the scenario** shown before.

3. The drones could land at the designated point with an **maximum error of about 30 - 40 centimeters** using our system.

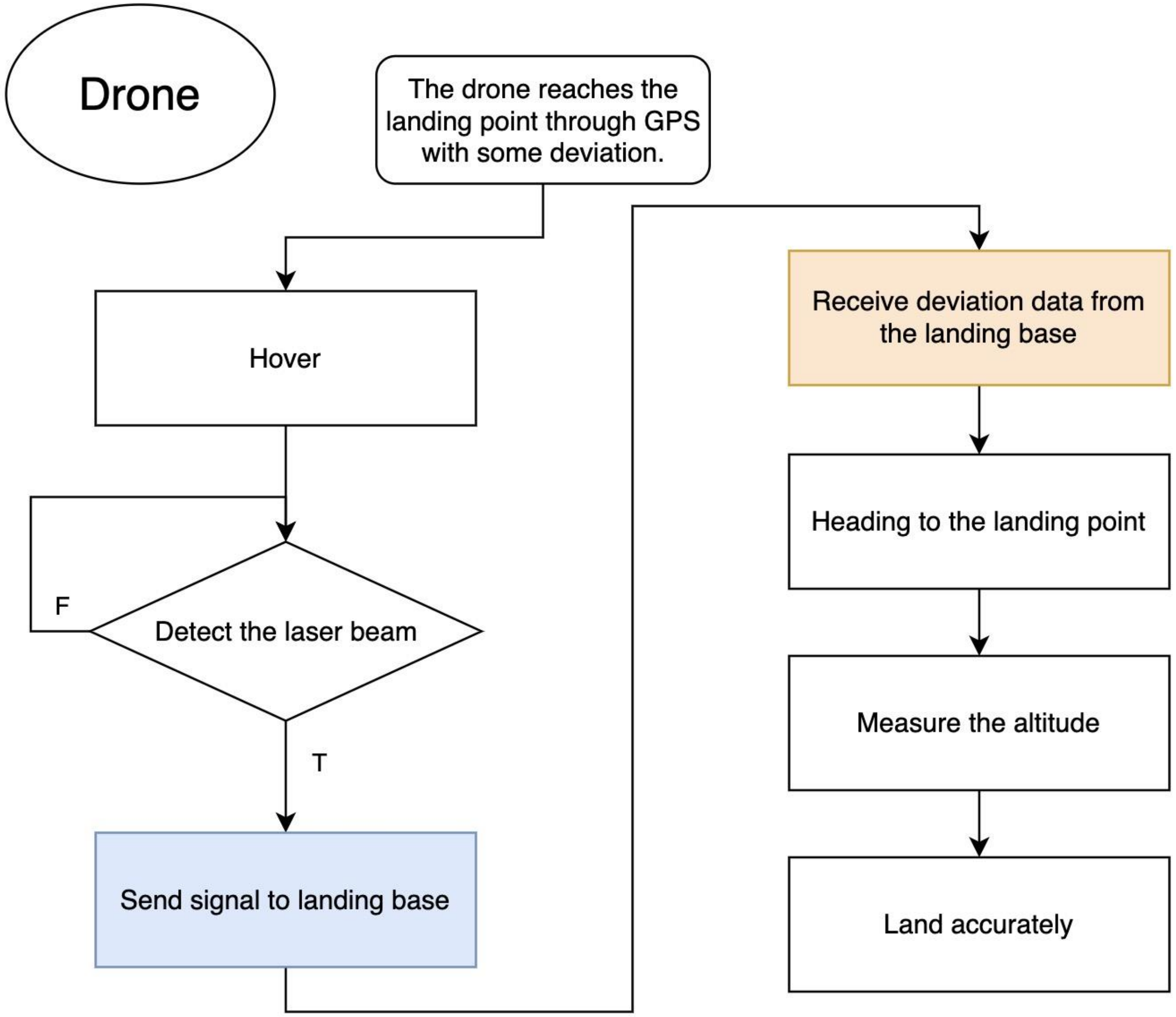
THANK YOU!

Appendix - Flow chart of landing base



- The drone hover near the landing base before landing.
- Stepper motor A (Laser-projecting module A) start rotate to locate the drone.
- Stepper motor B do exactly the same process but with the opposite direction.
- Stepper motors will rotate in the opposite direction and become slower once they receive the signal sent from the drone.
- Each stepper motor will do this process **three** times.

Appendix - Flow chart of drone



- The drone hover near the landing base before landing.
- The drone will send a signal once it receive the laser from the landing base
- The drone will fly toward the landing spot after receiving the flying instruction sent by the landing base.
- Before land, the altitude will be measured.
- The drone lands precisely.