Quadrotor Flight Demonstration for Heterogeneous Robot System

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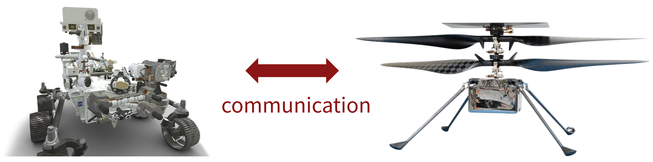
Motivation and Goal

- **Motivation : Increasing need for heterogeneous robot systems**
  A Rover and a helicopter teamed-up for NASA's mission on Mars
  - Provides different perspectives - ground, aerial
  - **Collaborative mission**
    - A rover, Perseverance : collects rock samples
    - A helicopter, Ingenuity : supports and provides Perseverance with aerial observations of rover's targets, potential rover routes, and inaccessible features



Perseverance
(Image source : NASA website)

Ingenuity

- **Goal : Flying a quadrotor stably with pose data to team up with Turtlebots**
  - A rover, Turtlebot (model : Burger)
    - A part of the NAV lab's project with NASA
    - Used to develop multi-agent navigation strategies for Jet Propulsion Laboratory(JPL)'s CADRE project
  - A custom-made quadrotor, Mr. Ping

A rover, Turtlebot

A quadrotor, Mr. Ping

Mechanism of Quadrotor Operation

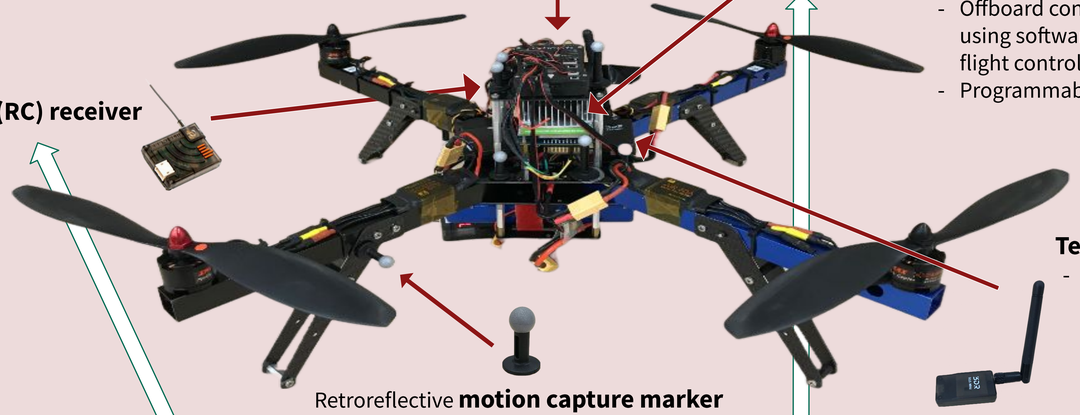
Quadrotor

Flight controller : Pixhawk 1
(Image source : PX4 website)
- Brain of Unmanned Aerial Vehicles (UAV)
- Software : PX4
- Executes lower level state estimation and control
- Enables the UAV to be controlled by a ground control station software

MAVLink through Serial port (ex. UART, USB)

Companion computer : NVIDIA Jetson TX2
(Image source : Aetina website)
- Runs Robot Operating System(ROS) and MAVROS on terminal
- Capable of high-level algorithm execution
  - Offboard control : control flight controller using software running outside of the flight controller
  - Programmable in Python, C++

Radio Control(RC) receiver



Telemetry transmitter
- Sends out sensor and status data of flight controller

Retroreflective **motion capture marker**

Why do we need pose data?
Without it, flight can be unstable
See the video ↓

MAVLink
- Micro Air Vehicle communication protocol
  - Enables communication between computer, flight controller, onboard drone components, and ground control station

MAVROS
- A ROS package (the software organization unit of ROS)
- *Enables MAVLink* between computers running ROS

Radio

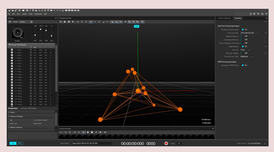
Light reflection

Radio

Stanford Flight Room

(Image source : Optitrack website)

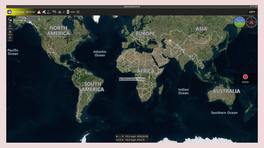
Motion capture system : Optitrack
- Optically detects reflected light from markers
  ➡ Generates ground truth **pose data**



Optical motion capture software : Motive
- Receives and streams pose data

Relay computer
- Runs ROS
- Receives pose data from Motive and publishes it through MAVROS

User



Ground control station : QGroundControl
- A software to monitor and control aircraft
- Running on a ground-based computer
- Communicates with aircraft through wireless telemetry (ex. telemetry receiver)

Telemetry receiver
- Receives data from flight controller
- Connected to the user's computer through USB

Radio control(RC) transmitter : Spektrum DX9
- Enables manual control of UAVs

Conclusion and Future Work

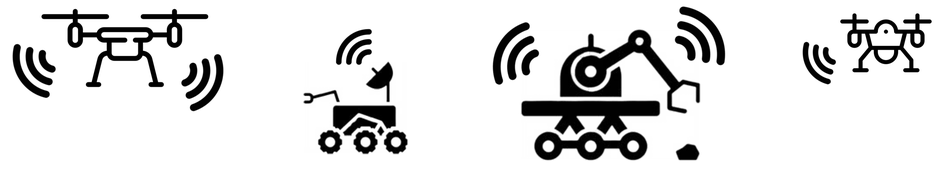
In the future, more science projects will involve various types of robots and more tasks will require collaboration and communication between them. The Mr. Ping flight project was the beginning step for a new heterogeneous robot system.

- **Future application**

This project could utilize Ultra-wideband(UWB) sensors which the NAV lab is working on by mounting **UWB sensors** on the robots.
- Enables wireless communication and distance detection between robots

➡ It could provide more accurate estimation of individual robot's position

➡ **Capable of collaborative tasks as a heterogeneous robot system**



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For further information and contact ➡