Gesture-Controlled Quadcopter System

Anthony Yang Xu, Kendra Crawford, Vincent Yang

Introduction

- Yucan Lui, Class of 2017, designed a hand controller to communicate with off the shelf controller and quadcopter
- Initially, we design the hand controller to speak directly with the quadcopter
- We wanted to firm up a practical application for the system
    - Ed Capovani from *In Sky Aerial* works with quadcopters
        - Helps police with search and rescue missions

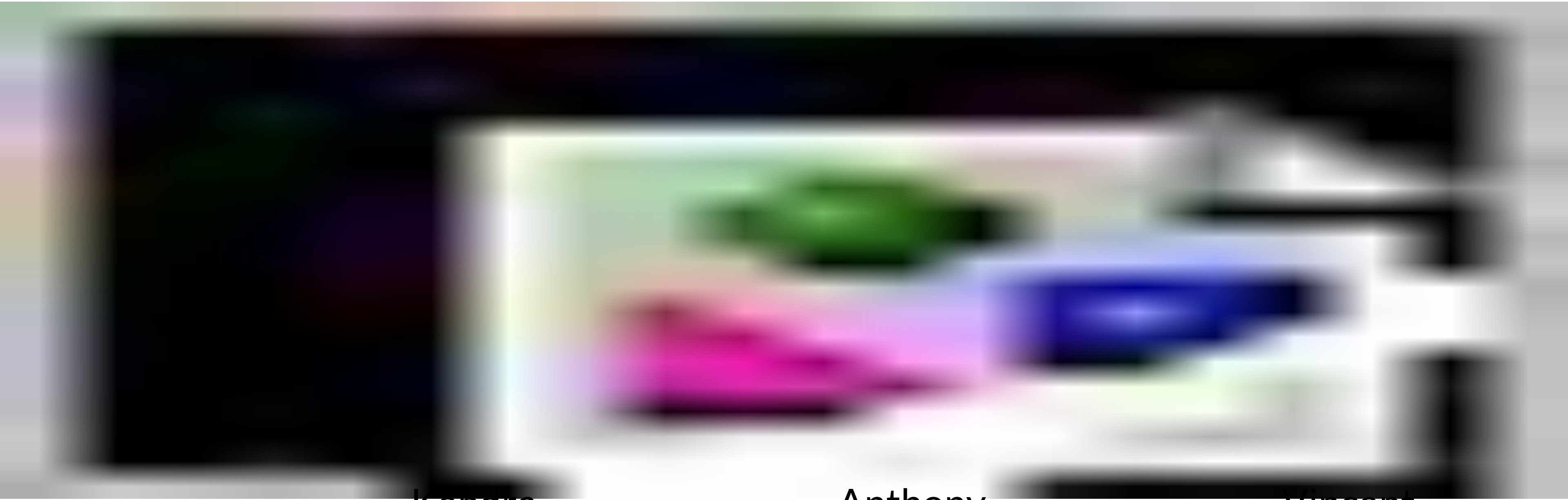
Problem Statement

- Desired System:
  - Designing and building a one-handed gesture-controlled quadcopter
  - Intuitive Controls
  - System to be used for indoor situations
- Target Scenario:
  - Police surveying the inside of a building to avoid a dangerous situations

Goals and Performance Criteria

- The system will be lightweight so that it is easy to transport
- Less than 5 minute set up time and will fly for at least 10 minutes
- The gestures will be intuitive
- Learning how to fly the system will take less than an hour
- The range from the pilot to the quadcopter must be at least 30 meters
- The system must provide video feedback to the pilot

Design Overview



Kendra Anthony Vincent

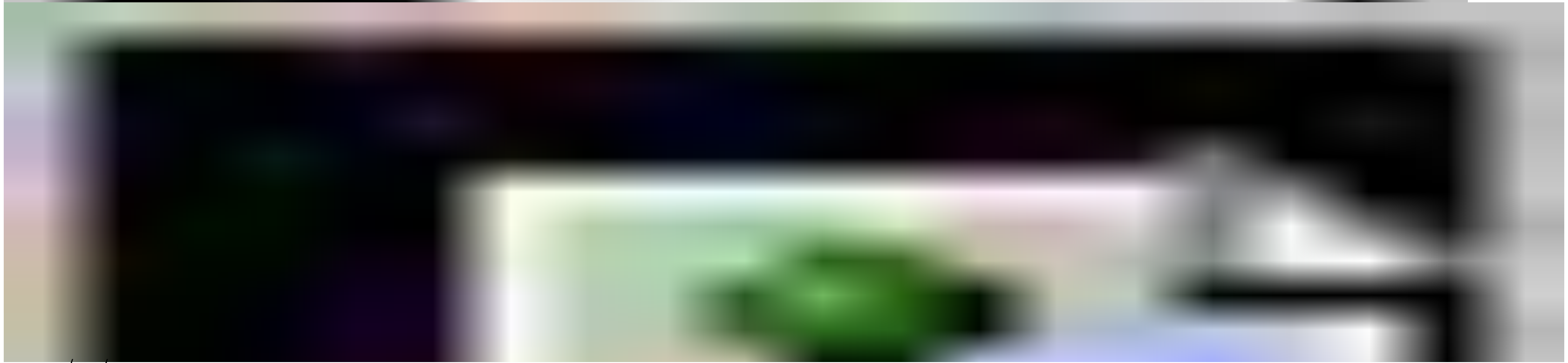
Hand Controller
Gesture-Controlled Quadcopter System

Kendra Crawford

Goals and Performance Criteria

- Hand controller will weigh less than 250 grams
- The hand controller will interpret intuitive hand gestures into positional data
- The communication speed must be within the range of .6 seconds
- It must be able to fall from a height of 1.5 meters and not damage the system

Design and Gesture Controls



aura-drone.com/us/

Special Commands

Special Commands:

- Take off:
  - Starts the quadcopter tells it lift up a few meters then hover
- Hover:
  - disable motion data collection and tells the quadcopter to hover
- Stop/Land:
  - Tells the quadcopter cut power to all engines.

Radio Communication for the Gesture Commands

Msg[10] = {Cmmd, aX, aY,aZ, (MSB)gX, (LSB)gX, (MSB)gY, (LSB)gY, (MSB)gZ, (LSB)gZ}

Special Commands :

- TakeOff: unit8_t value = 255
- Hover: unit8_t value = 85
- Stop: Unit8_t value = 170

Results & Conclusions

- Communication base and hand controller reilaby communicate up to 2 meters
- The data transfer time from the hand controller to the communication base takes approximately 2.2 seconds
- The weight of the hand controller is 18.5 grams

Future Work

- Help write the algorithm to transform the positional data to quadcopter movement
- Finalize the circuit and software for hand controller to be integrated into the system.
- Access the 9-DOF Sensor without using a library

Q&A

Communication Base
Gesture-Controlled Quadcopter System

Anthony Yang Xu

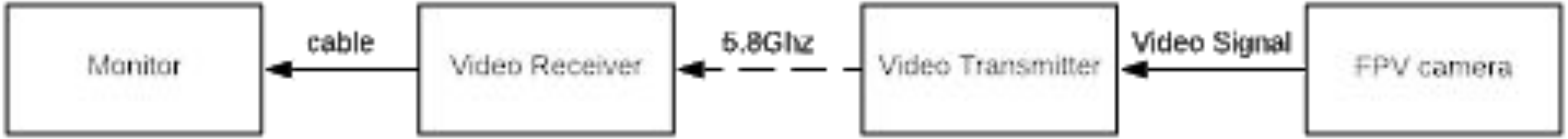
Brief ReIntroduction

- The role
  - Process incoming motion data and special command
  - Transfer the motion data to corresponding flight data
  - Receive video from quadcopter
- The purpose
  - Relief weights, power consumption and computing pressure from glove
  - Allowance of a screen
  - Easier for future upgrades (GPS and so on)

Goals and Performance Criteria

- Low processing and transmission time
  - 0.6 second delay between input and output
- Reliable communication between drone and base
  - Indoor operation range of 30m
- Rather lightweight and small size
  - Weight below 4kg
  - Volume lower than $1dm^3$
- Long operation time
  - Operate longer than 1 hour

Design


Monitor
cable
Video Receiver
5.8Ghz
Video Transmitter
Video Signal
FPV camera

Pulse-Position Modulation(PPM) signal

- Alternative to not use 8 PWM signals

Implementation

- Store 8 channels data into an array
- Use timer interrupt to generate each pulses

Internal Computation

- Note this part has not been implemented yet
- Msg[10] = {SpecialCommand, a_X, a_Y, a_Z, $gyroX_{15-8}$, $gyroX_{7-0}$, $gyroY_{15-8}$, $gyroY_{7-0}$, $gyroZ_{15-8}$, $gyroZ_{7-0}$}
- Mapping the special command to specific function
  - Landing(kill switch)
  - Take off
  - Hover
- Convert the motion data into flight command
  - 3D accelerometer
  - 3D gyroscope

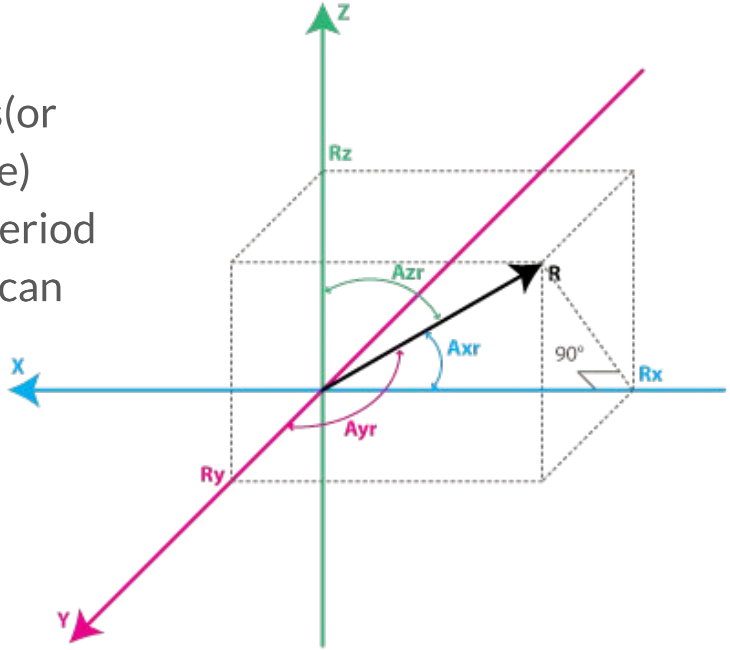
Accelerometer and Gyroscope

- Accelerometer:
  - Measure the net acceleration or force in xyz domain
  - Can find out the orientation of the object based on the relative length on each axis

Accelerometer and Gyroscope

- Gyroscope
  - Measure the angular speed along xyz axis(or yz plain, xz plain, and xy plain to be precise)
  - Calculated the change in angle in a time period
  - If given the initial angle on each plain, we can find out current angle by integration.

$$\theta = \int_0^t \omega(t)dt = \int_{t_0}^t \omega(t)dt + \theta_0$$



Result & Conclusion

- Achieved rather accurate data transmission from glove to base
- Achieved accurate data transmission from base to quadcopter
- Operation range for video transmitter exceed 30m. Can penetrate thin wall but not thick doors
- Benefit of base
    - Leverage weight, power consumption and computing pressure from glove
- Drawback
    - Extra transmission time

Future work

- Implementation and evaluation for gesture interpretation
- Testing and finding out the correct flight data for special command
- Circuit reorganization and make it portable

Q&A

Gesture Controlled Quadcopter-The Quadcopter

Vincent Yang

Recapitulation

Missions

- Controlled by hand gesture Controller
- Live stream video data

Necessity of building our own quad

- Flexibility
- Faster Responding

Goals and Performance Criteria

- Support basic quadcopter movements: Roll, Throttle, Pitch, Yaw
- Support special commands
- Delay within 0.6 seconds
- Speed limited by 10 m/s
- Setup time less than 5 minutes
- Operation time 10 minutes
- Charging Time less than 3 hours
- Size less than 25^3 cm^3
- Less than 1.5 kg

https://docs.px4.io/en/flying/basic_flying.html

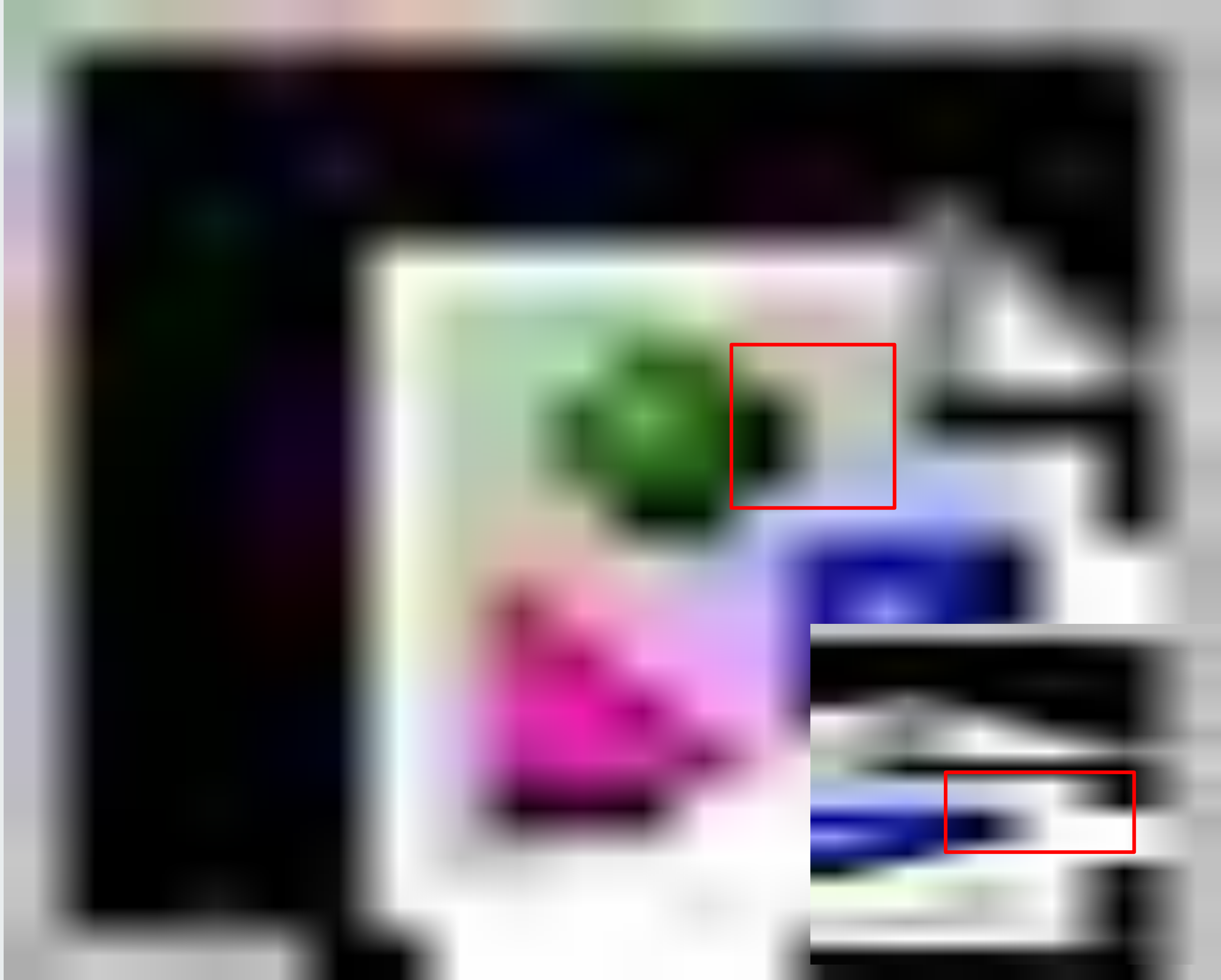
Design

Hardware

- Radio Receiver
- Flight Controller
- Electronic Speed Controls
- Motors
- FPV Camera
- FPV Transmitter

Dataflow

Implementation



Current Results

- Be able to interpret the instruction signal from the communication base with a accuracy over 99.9%
- Support the basic four movements tested by a traditional controller
- Support Special command

Current Results

- Delay is longer than 0.6 seconds
- Setup time less than 5 minutes
- Charging time less than 3 hours
- Size less than 25^3 cm^3
- Weight Less than 1.5 kg
- Operation time to be tested
- Max speed for the quadcopter to be set and tested

Conclusions

For the Quadcopter

- Compared to the overall latency, the latency between the flight controller and motors can be ignored
- The open source flight controller is the key of flexibility, and how well resources are documented and easiness of modifying matters

For the Whole System

- The three subsystem design improves flexibility
- The main source of latency comes from the low frequency communication

Future Work

For the Quadcopter Subsystem

- Special commands Optimization
- Testing Operation Time
- More depth into the open source flight controller

For the Whole System

- User test on ease of using
- Test and optimize the overall latency and accuracy of the system
- Design better gesture caption algorithms

Acknowledgments

Professor Cherrice Traver

Union College ECBE Department & Student Research Grant

Blair Hagen

Edward Capovani

Tianhao Zhang

Q&A