Quadrotor for Indoor Surveillance and Reconnaissance

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Overview

- Unmanned Aerial Vehicles (UAVs)
- Motivations
- Research Objectives
- Simultaneous Localization and Mapping
- Hardware
- Software
- Obstacle Avoidance
- Autonomous Flight
- Conclusion
- Future Work

Unmanned Aerial Vehicles

- Unmanned Aerial Vehicle – Remotely piloted by human or autonomous (using autopilot)
- Replace manned operations to reduce human risk, cost, and expand capabilities
- Used for: surveillance, target strike, search and rescue missions, precision agriculture, etc.

Motivations

- Autonomous navigation in GPS denied indoor environments
- Aerial reconnaissance for assessment of indoor environments
  - Investigate unknown environments
  - Evaluate hazardous or inaccessible environments
  - Minimize human risk
- Promote usability of indoor UAVs

Research Objectives

- Implementation of Simultaneous Localization and Mapping (SLAM) for navigation in indoor environments
- Develop a quadrotor capable of supporting the system.
    - Minimal size and weight
    - Payload capacity and integration
  - 3D imaging
    - Real-time mapping using a 3D Imaging Camera
    - Design a portable power plant
  - Wireless capabilities
    - Data acquisition from 3D Imaging Camera

SLAM

- “Simultaneous localization and mapping”
- Use of 3D Imaging Camera sensors for 3D mapping

  - Infrared (IR) projector

  - RGB camera

  - IR monochrome camera
- Use of FARO Scenect™ software for 3D image integration

SLAM (cont.)

- Technique used by autonomous vehicles to build/update map of an environment, while keeping track of current location
- Use of many different sensors: 1D to 3D
  - 3D Imaging Camera sensors utilize 3D image reconstruction based on depth perception information
  - 3D vision describes not only shape, texture, and color but depth and distance

3D Imaging Cameras

- Microsoft Kinect and Asus Xtion Live Pro sensors used for 3D image reconstruction:
  - Infrared (IR) projector
  - RGB camera
  - IR monochrome camera

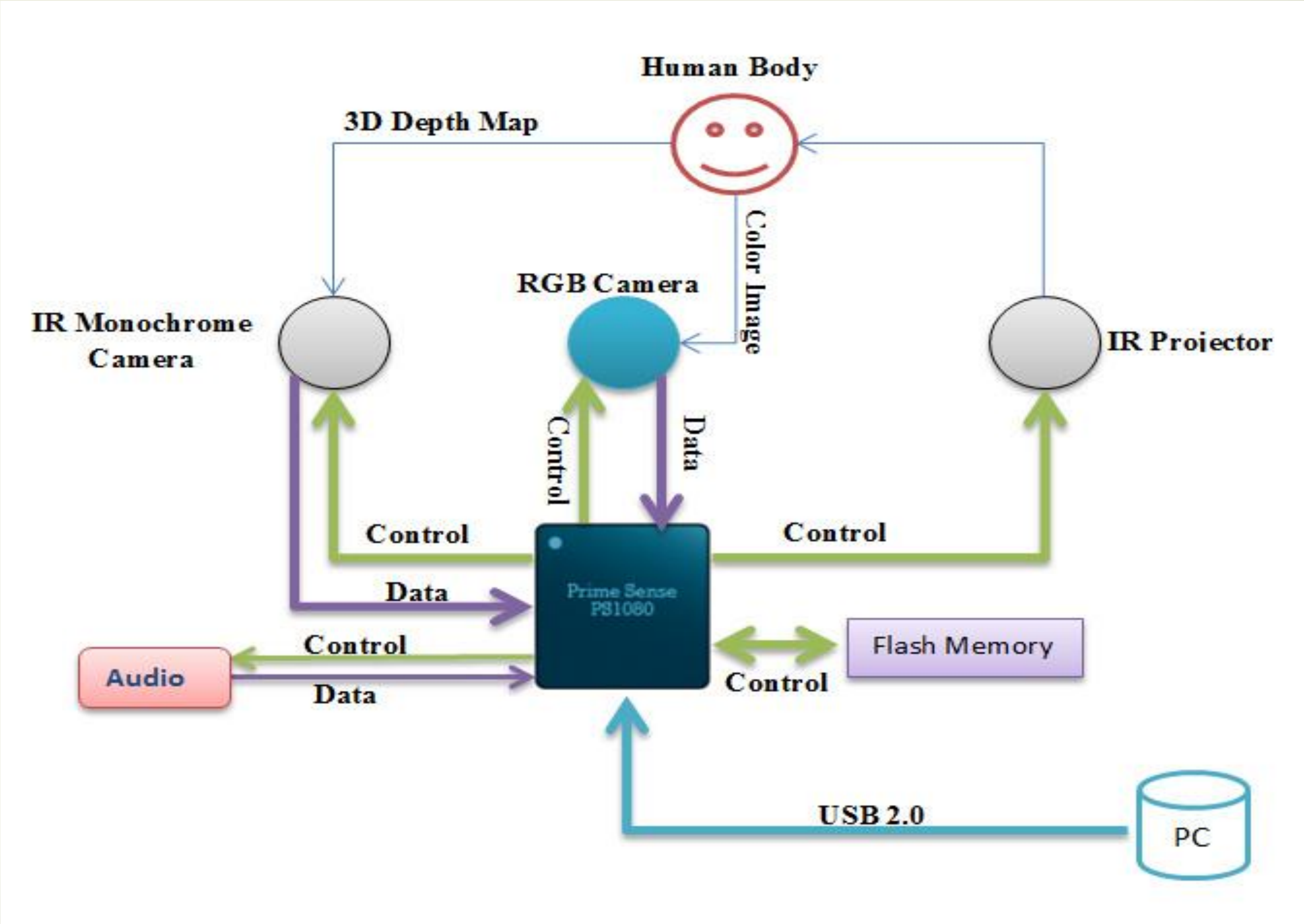
Camera Comparison

	Asus Xtion Live Pro	Microsoft Kinect
Price	≈$150	≈$150
Power Consumption	<2.5 W	12 W
Distance of use	0.8 m < x < 3.5 m	0.8 m < x < 4 m
Field of View	58° H; 45° V; 70° D	57.5° H; 43.5° V
Depth Image Size	VGA (640 x 480) 30 fps; QVGA (320 x 240) 60 fps	VGA (640 x 480) 30 fps
Resolution	SXVGA (1280*1024)	SXVGA (1280*960)
Software	Open NI SDK bundled	Kinect for Windows SDK
Dimensions	18 x 3.5 x 5 cm	28 x 8 x 8 cm

3D Mapping Process

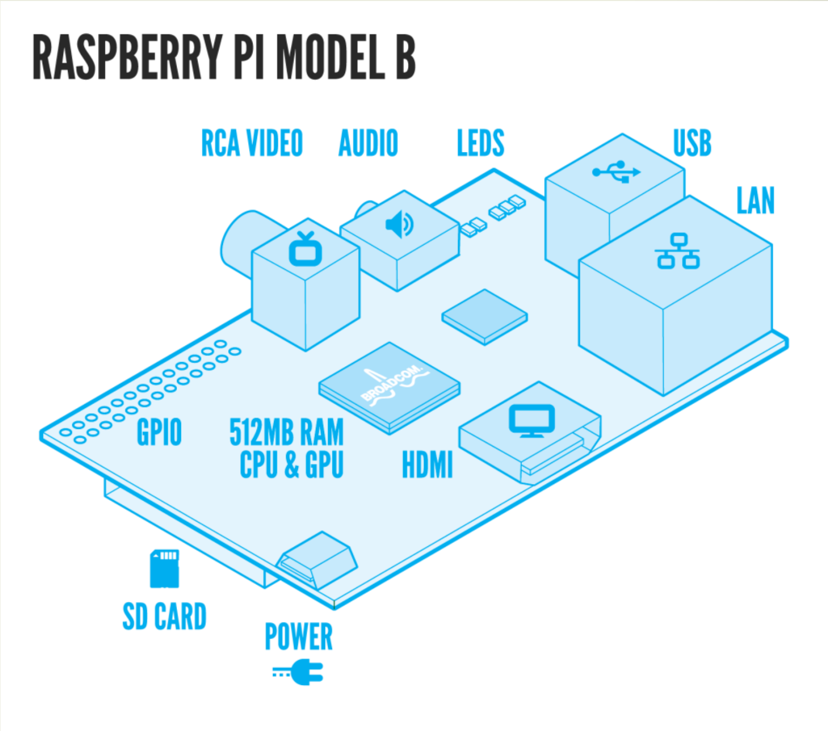
- Signals are emitted from the IR projector
- Reflected infrared signals are retrieved on the IR monochrome camera
- 3D depth map is generated
- Chromatic and 3D depth images can be obtained simultaneously with texture from the RGB camera
- Camera provides automatic calibration based on physical environment
  - Accommodates for the presence of obstacles

Architecture for 3D Mapping

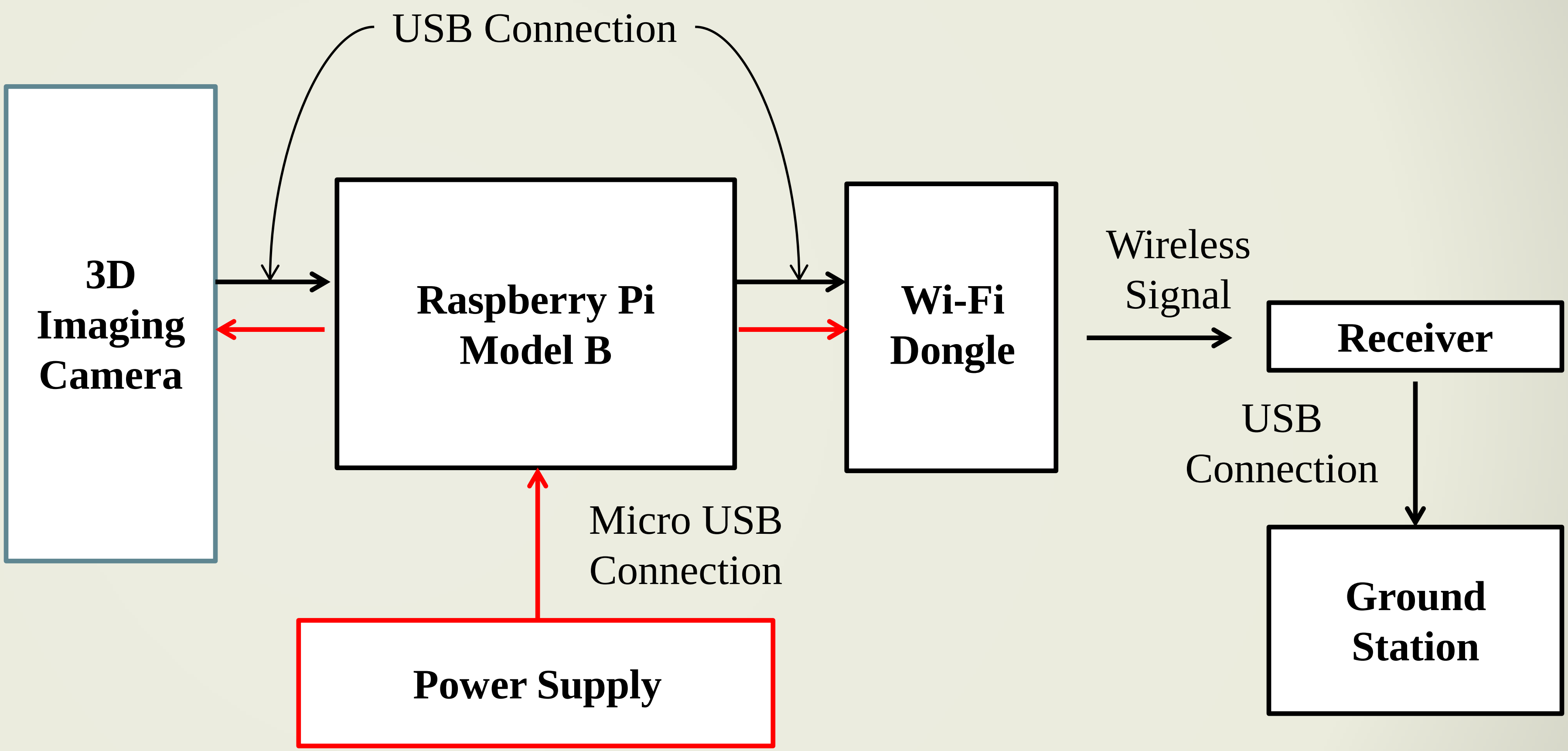


Raspberry Pi

- Possible solution for wireless data transmission
- Description:
  - Single board computer
- Considered due to its small size, light weight and Wi-Fi capability
- Method: 802.11abgnAC interface can be used to transmit images compressed or device native/raw



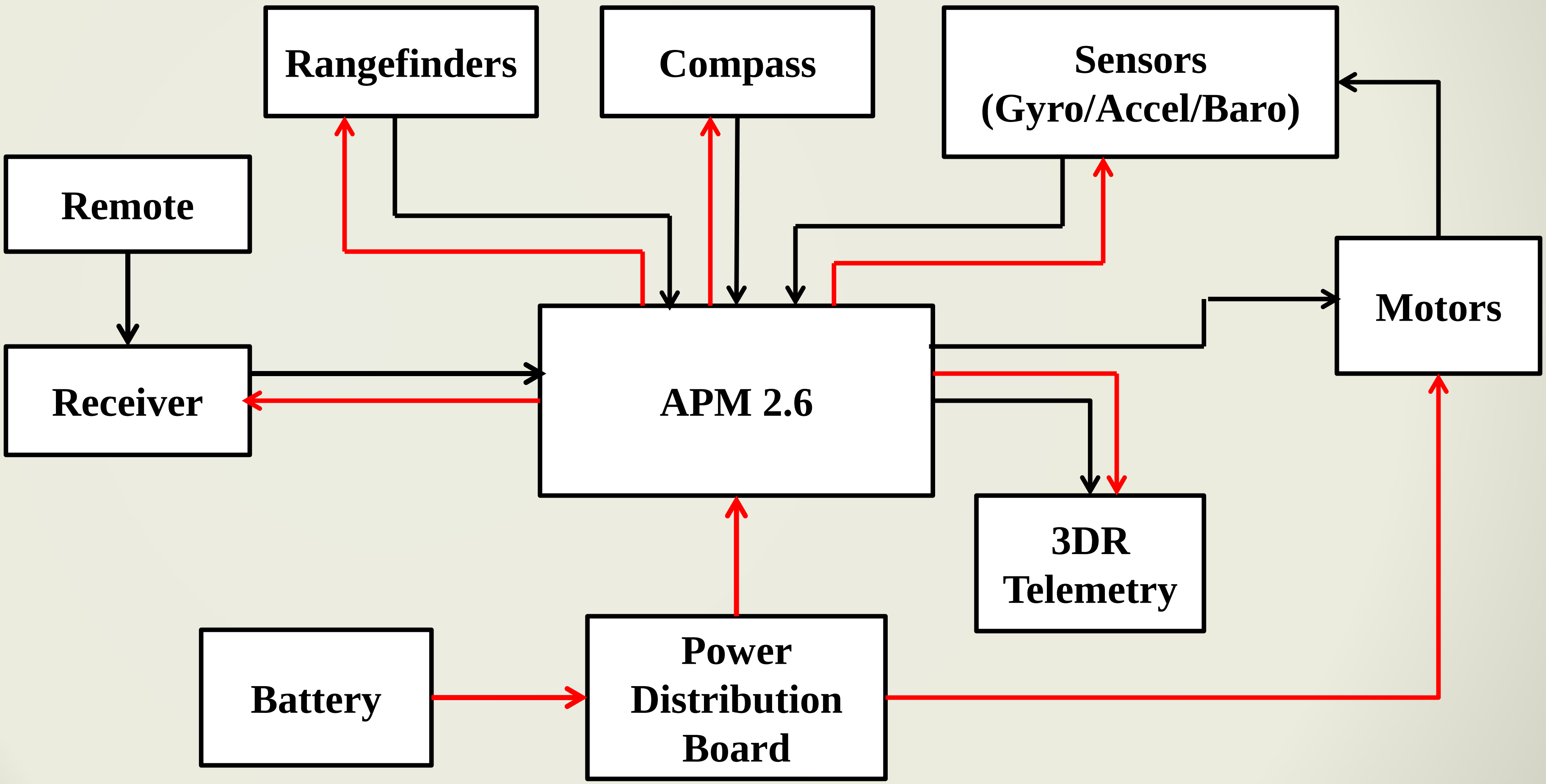
Camera Hardware Architecture



Black – Signal
Red – Power

Quadrotor Vehicle

Autopilot and Sensors



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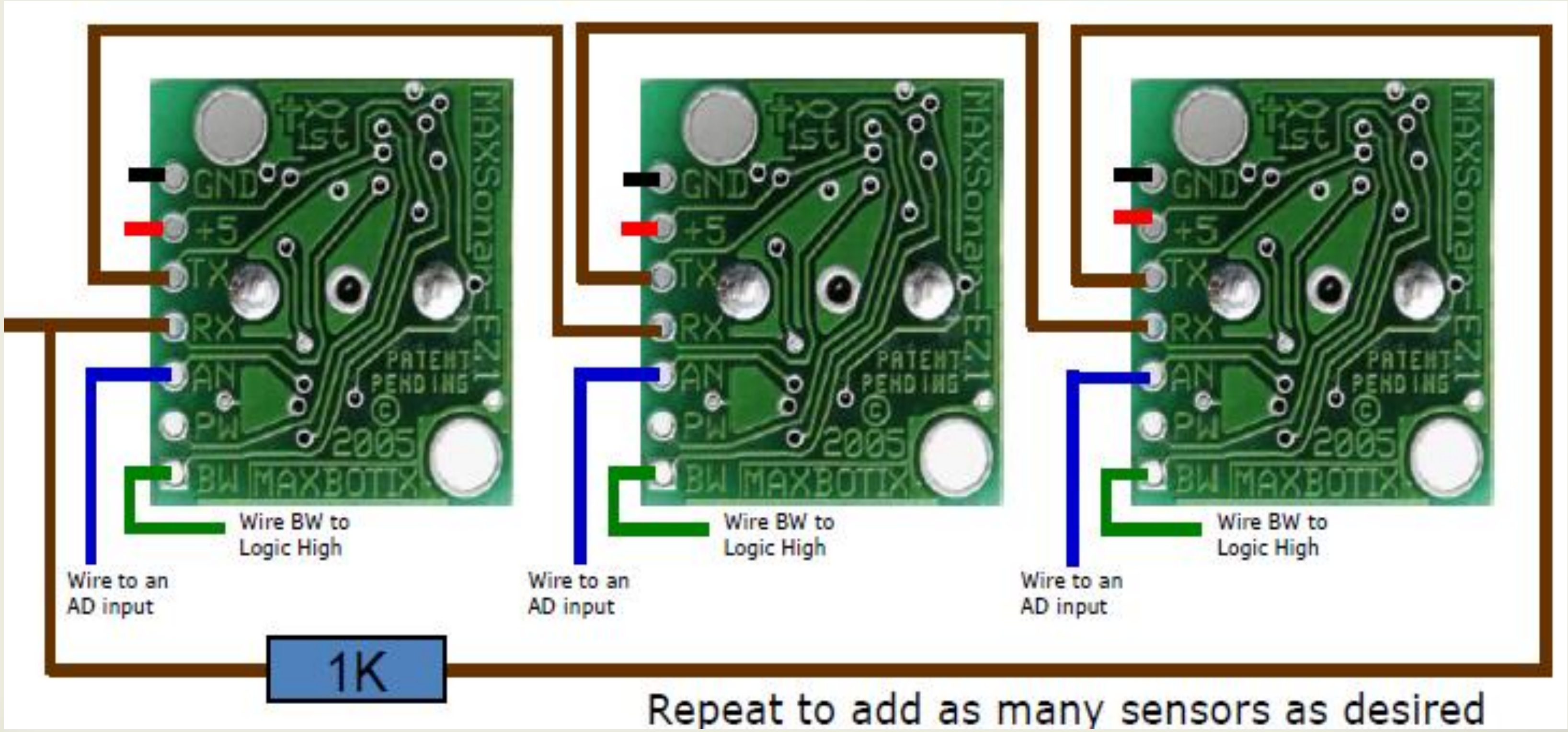
Ultrasonic Range Finder

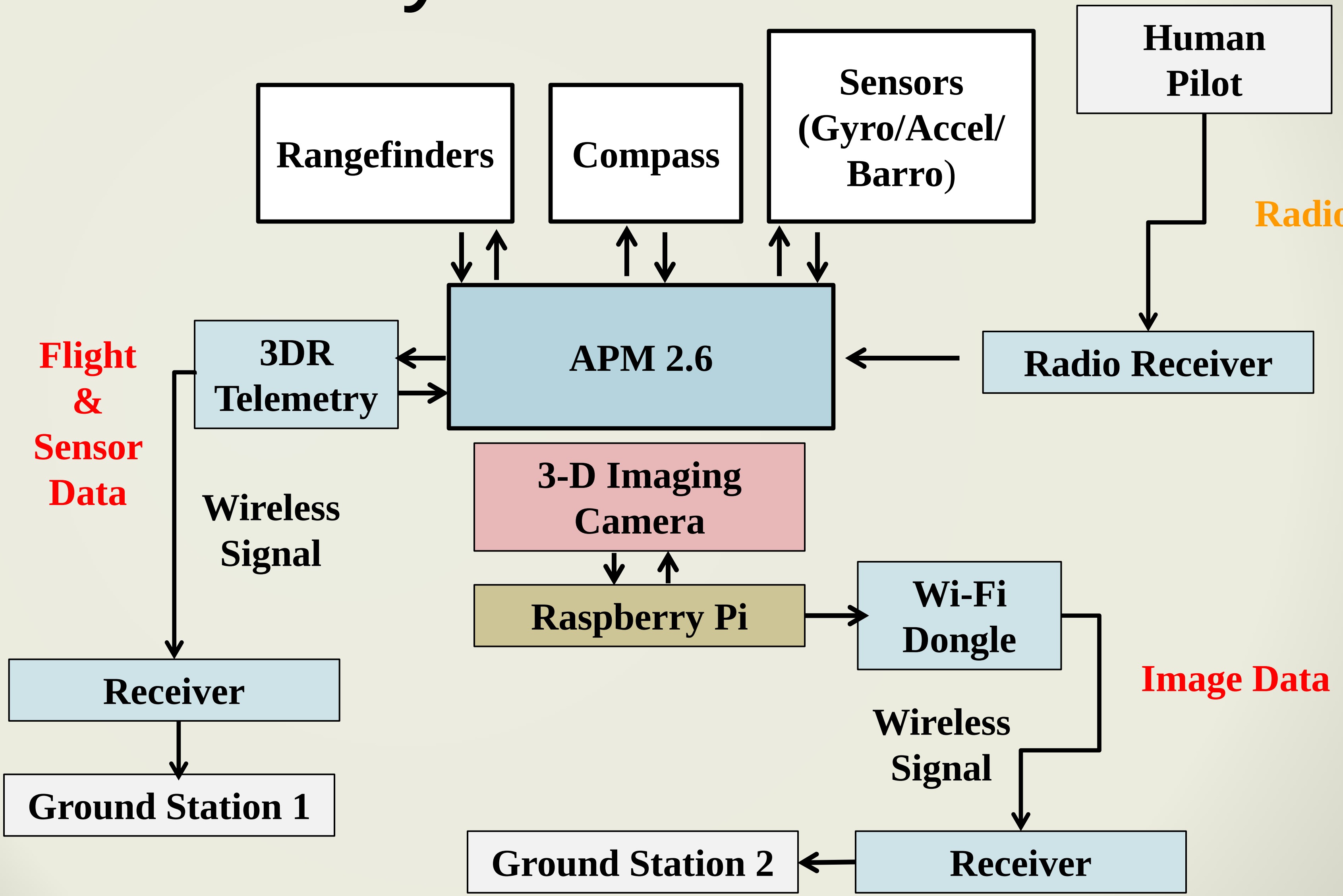
- LV-MaxSonar EZ0™
- Range: 6 in – 254 in (6.45 m)
- 2.5V to 5.5V with 2mA current draw
- Readings can occur every 50ms (20 Hz rate)
- Serial, Analog, and Pulse width

Range Finder Assembly

- Daisy chaining multiple sonars due to current software restrictions
- Allows to constantly loop in sequence and provide latest range reading



Overall System Architecture



Flight Control Software

- Runs on ArduCopter V3.1.2 Quad Configuration
- Works in conjunction with APM Mission Planner

    -Simple configuration and calibration

    -Displays vehicle status

    -Displays and monitors various sensor data

Software (cont.)

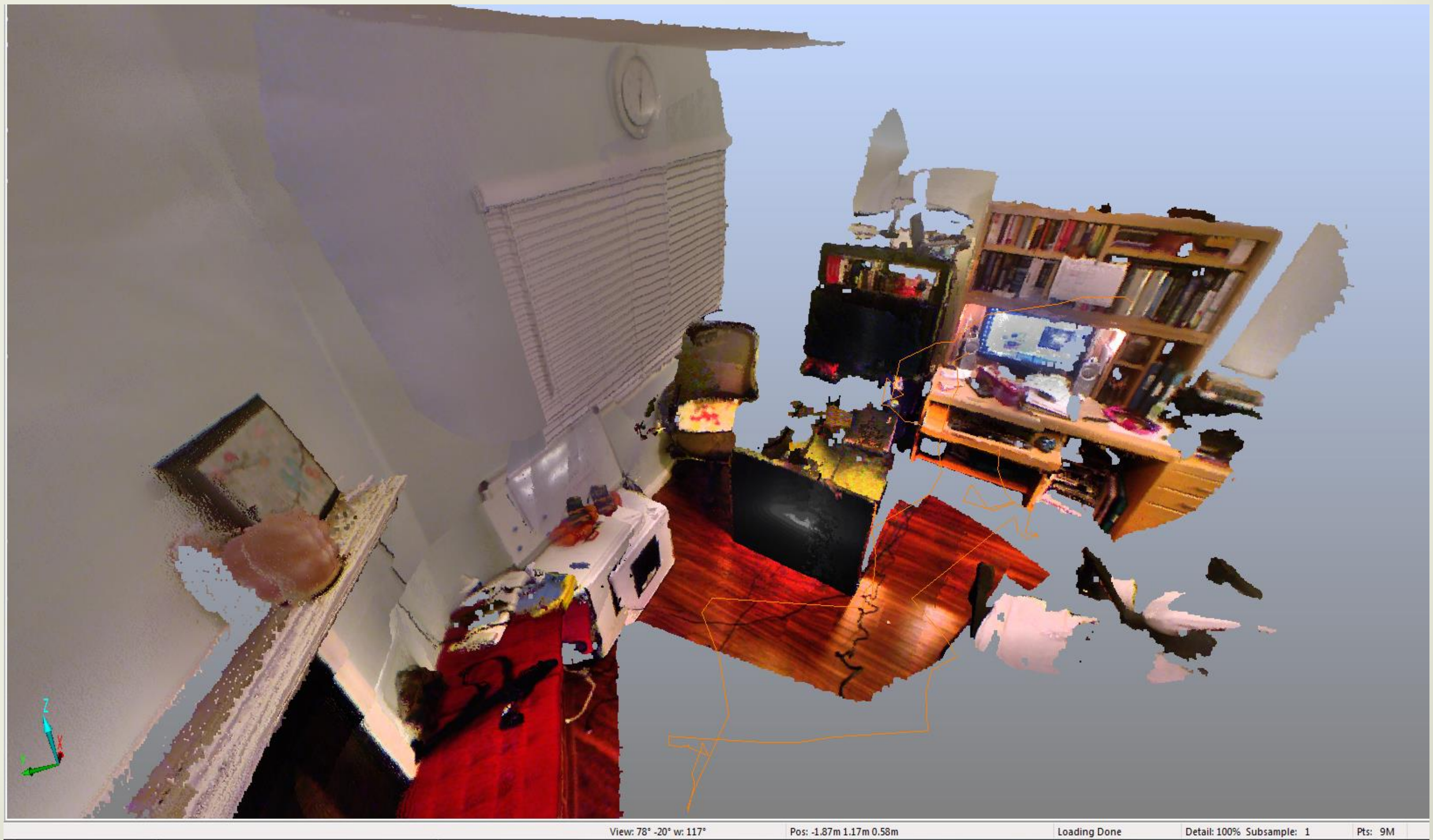
- Vehicle Status

SCENECT

- The SCENE software family is a comprehensive 3D point cloud processing and managing software for users
- SCENECT by Faro allows the use of 3D Imaging Camera sensor to capture objects and environments in 3D in real-time
- Allows the users to view, process and analyze recordings
  - Can export to different formats for use in third party applications, like CAD programs

3D Reconstructed Room

- Using SCENECT, 3D image reconstruction of a room was mapped

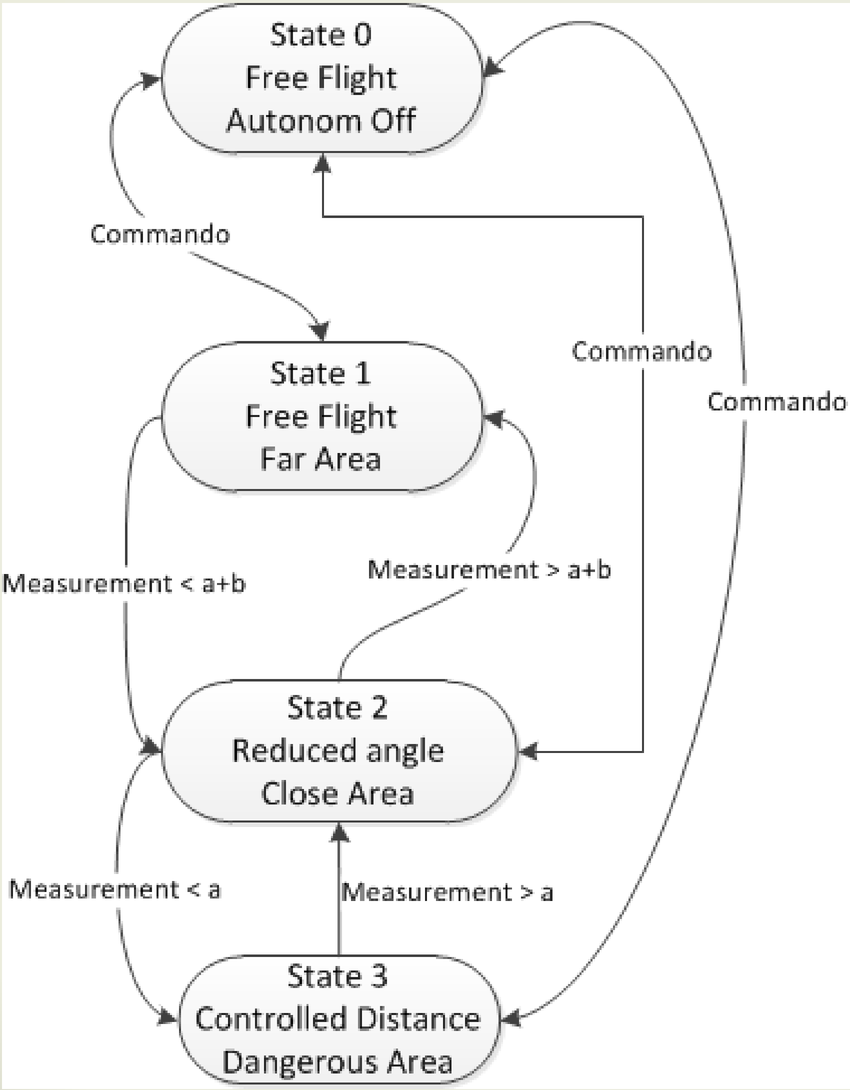


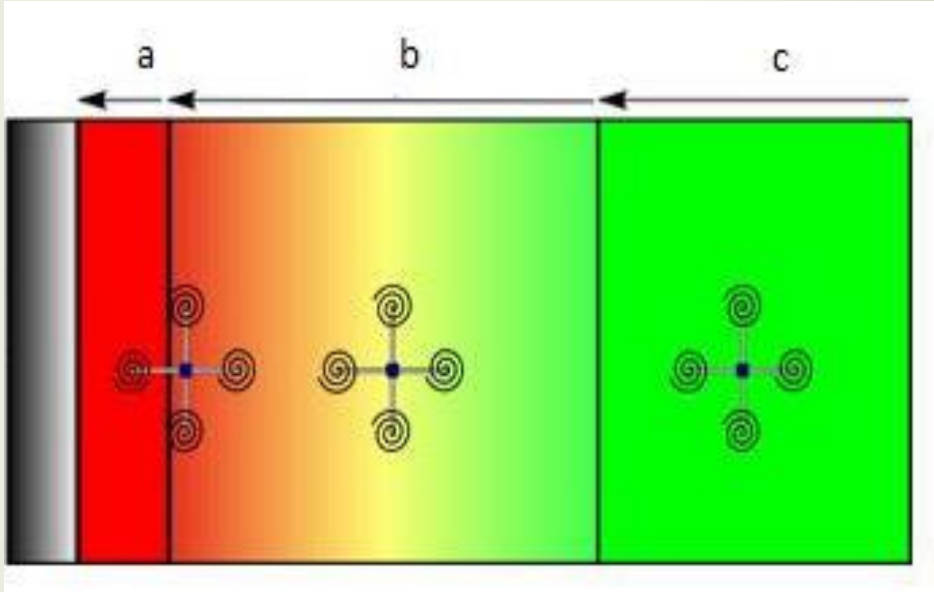
Obstacle Avoidance

- Use of rangefinder sensors to detect obstructions within the vehicle's path.
  - Reflected signals from the rangefinder discovers the position and distance

- Six rangefinders will be implemented within the system
  - Aligned within half angles of each other to retrieve a clear resolution of an obstacle

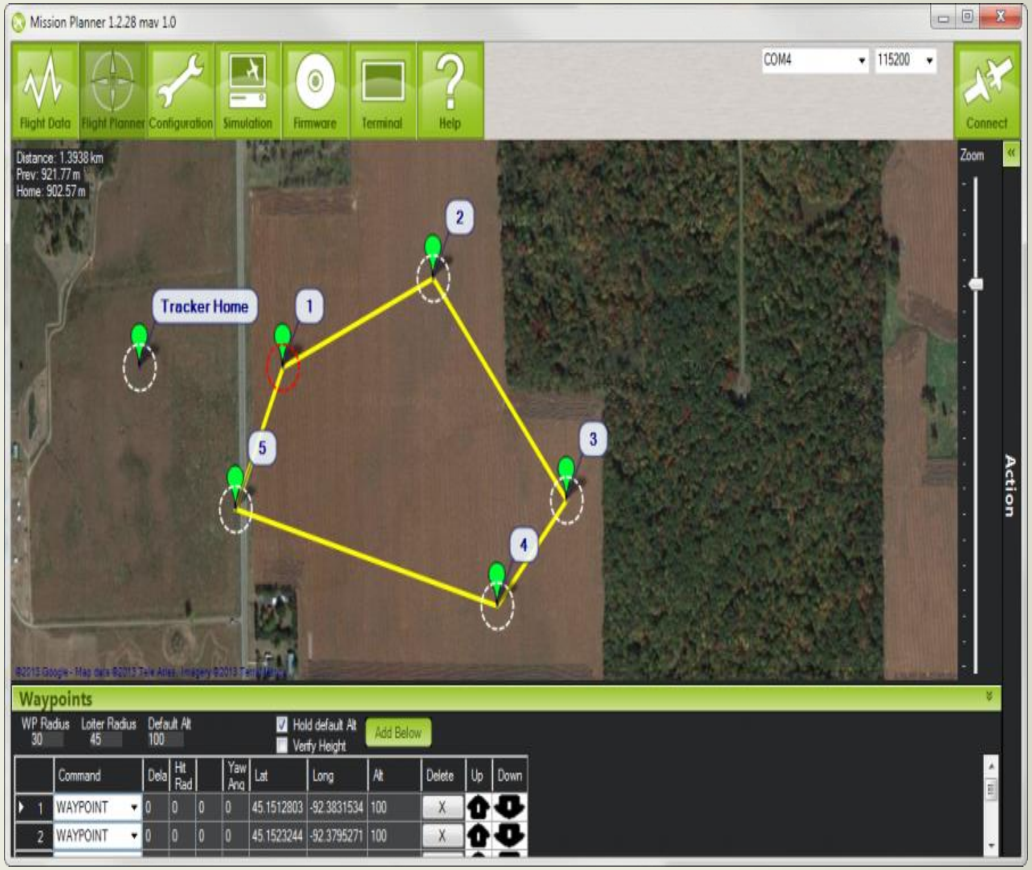
Obstacle Avoidance (cont.)





Autonomous Flight

- Can be used in any environment
- Uses barometer, magnetometer, gyroscope, accelerometer, and range finder to follow the assigned path



Conclusion

- Obstacle avoidance allows for the safe navigation of autonomous UAV systems in various environments
- Implementation of SLAM into UAV systems provides ground work for future applications.
  - Mapping of unknown environments
  - Creating virtual models of large regions or objects

Future Work

- Refinement of Obstacle Avoidance system
- Weight reduction of overall system
- Improvement of overall flight endurance

Acknowledgements

- Aerospace Engineering
  - Dr. Subodh Bhandari
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Questions?