Preliminary Design Review

IntelliSAR
October 18, 2019

IntelliSAR

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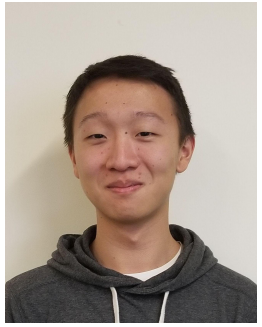
Yong Li



Derek Sun

Background and Motivation

- Safety and information of the environment are very important aspects of rescue missions
- Not fully understanding the environment and situation can lead to unnecessary risks and dangers

Examples:

Cave rescue

Explorers trapped or lost

Urban search and rescue

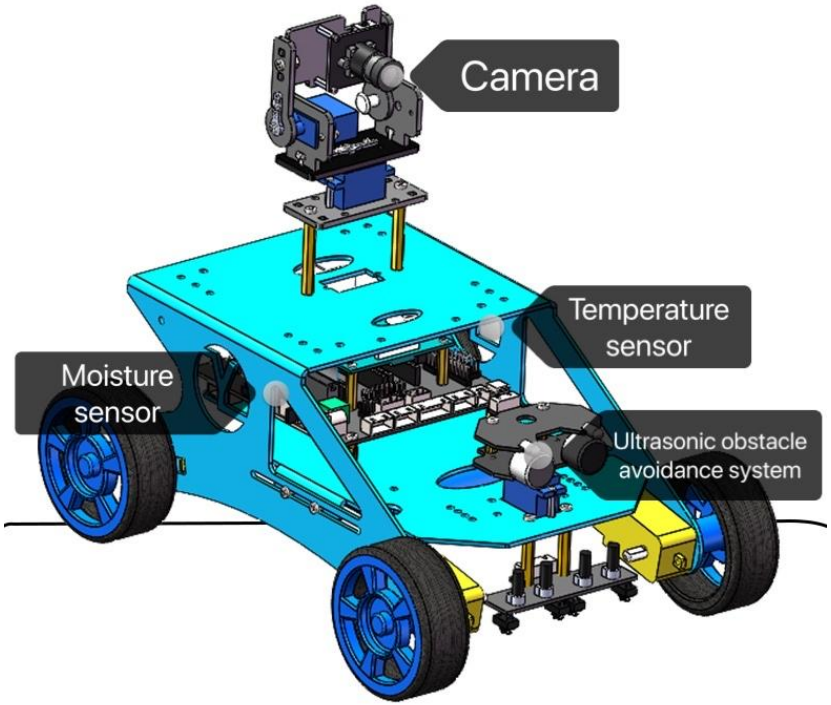
Victims trapped in Collapsed buildings

Goal

- Provide ability to remotely examine the situation and environment
- Reduce possible risks or dangers
- Improve efficiency of rescue teams in unknown environments

Method of Resolution

- A robot car that utilizes various sensors, machine learning, and computer vision to autonomously or remotely navigate around the surrounding environment and send data back to user.



Requirements Analysis

- Be able to be remotely controlled via Wi-Fi
- Be able to work in dim lighting conditions with night vision
- Be able to provide real time GPS location
- Gathered sensor data can be viewed remotely
- Can traverse uneven/sloped ground
- Be able to detect obstacles and navigate accordingly
- Be able to detect and classify objects

Requirements Analysis: Specifications

- Speed of up to 3 mile per hour
- Approximately 10 pounds
- Approximate size: 300 * 220 * 120 millimeters
- Approximately 3 hours of battery life
- Maximum grade: 30 degree
- Effective detection range of 4 meters
- Robust and durable enough to withstand minor collisions

Requirements Analysis: Inputs and Outputs

- Input
  - Camera data
  - Ultrasonic sensor
  - GPS tracker
  - Environmental sensors
  - User's control signal

- Output
  - Live video feed with object detection
  - GPS data
  - Environmental data (temperature, moisture)

Design Alternatives

iRap Robot

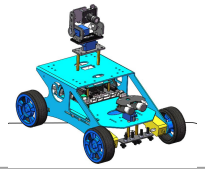
- designed for SAR teams
- exploration, victim detection, 2D map generation
- high maneuverability
- remotely controlled

https://robocup-rescue.github.io/team_description_papers/2018/Champ2018_Thailand_iRAP_TDP.pdf

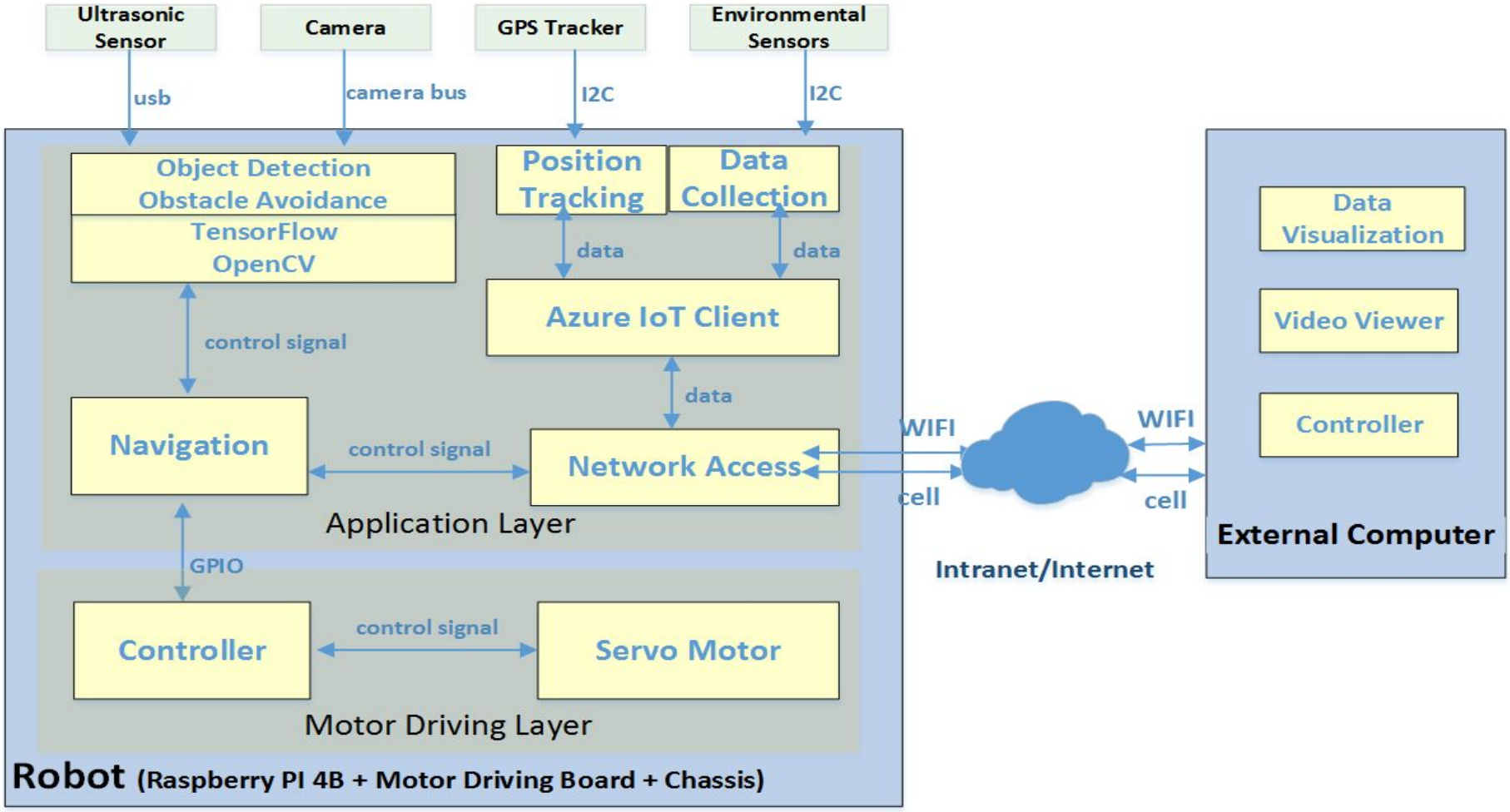
iRobot 510 PackBot

- designed for military personnel (high-threat battlefield scenarios)
- surveillance and reconnaissance, bomb disposal, vehicle inspection, etc.
- remotely controlled with few autonomous features

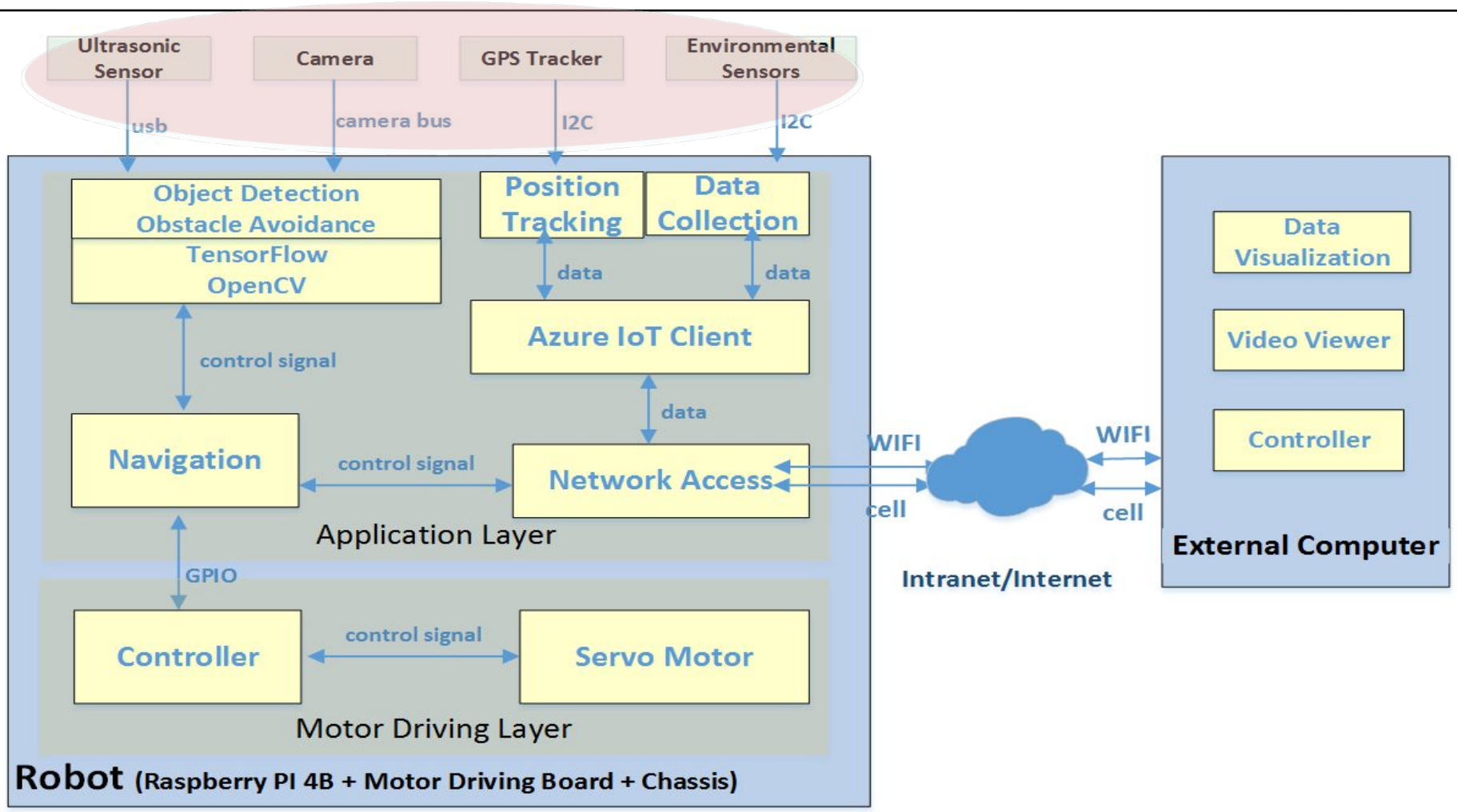
Design Alternatives

	IntelliSAR	iRap Robot	iRobot 510 PackBot
			
Size	Small	Medium-Large	Small-Medium
Communication	Wi-Fi	Wi-Fi/Radio	Radio
Navigation	Autonomous/Manual	Autonomous/Manual	Semi-autonomous/ Manual
Navigation Sensor	Camera	LIDAR	Stereo Camera, LIDAR
Visual Object Detection	Common objects	Hazmat/QR code	N/A
Target Audience	Search and Rescue	Search and Rescue	Military
Cost	Low (<$500)	High (~$30,000)	High ($100,000+)

Block Diagram



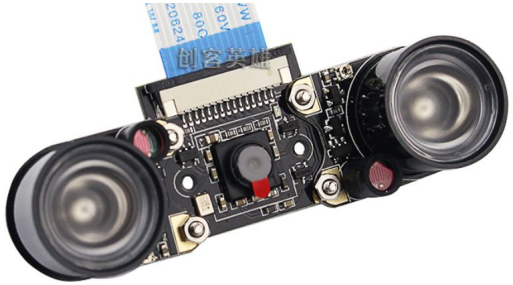
Peripherals -- Sensors, Camera, GPS



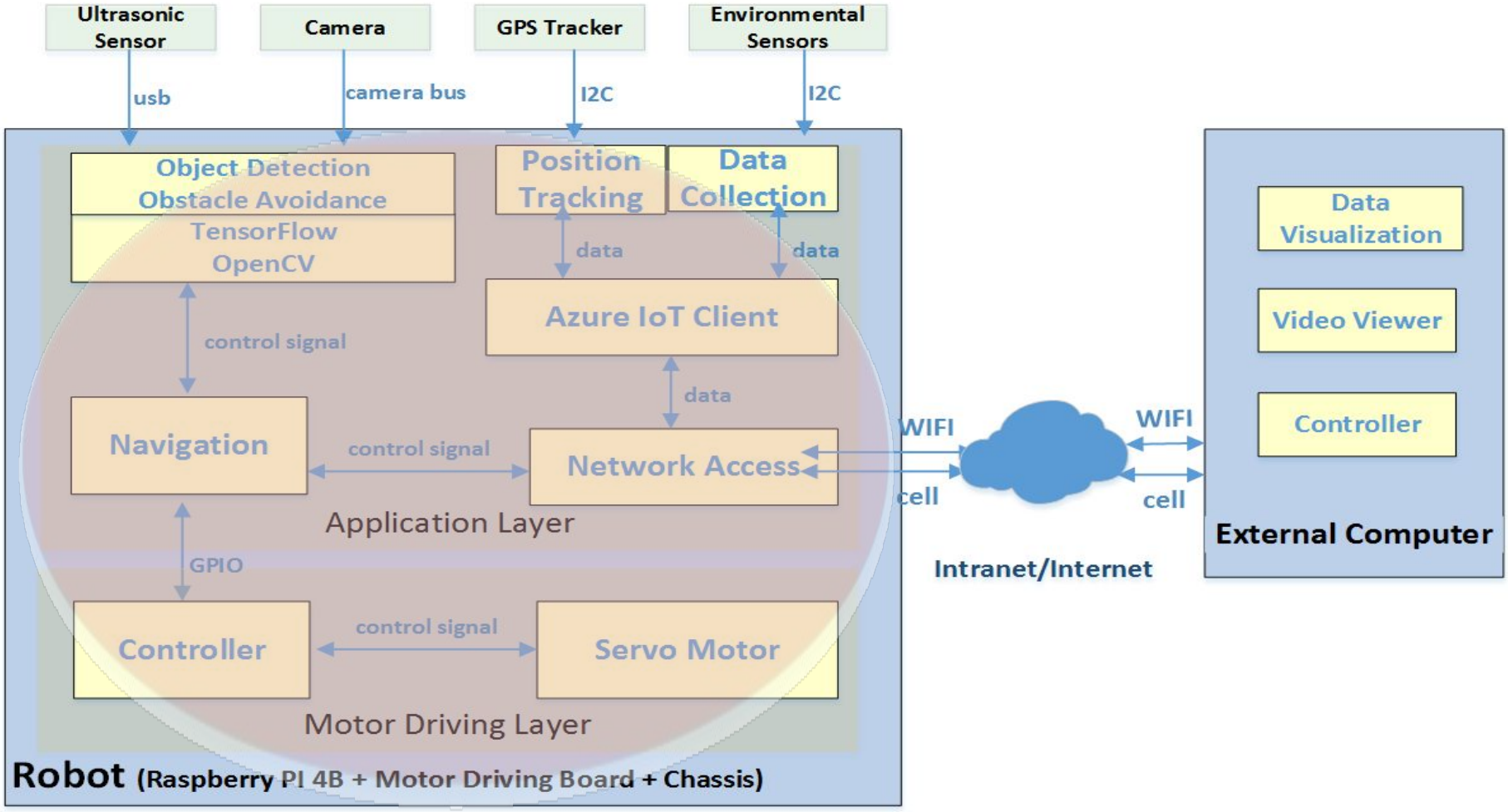
Peripherals -- Sensors, Camera, GPS

- Requirements
  - Measure temperature
  - Measure geographic location
  - Capture video at dim light conditions
  - Navigation

- Implementations
  - Temperature sensor (BME280)
  - GPS (NEO-6M)
  - Infrared camera (5 megapixel, nightvision)



Robot


Ultrasonic Sensor
Camera
GPS Tracker
Environmental Sensors
usb
camera bus
I2C
I2C
Object Detection
Obstacle Avoidance
TensorFlow
OpenCV
Position Tracking
Data Collection
data
data
Azure IoT Client
control signal
data
Navigation
control signal
Network Access
Application Layer
GPIO
Controller
control signal
Servo Motor
Motor Driving Layer
Robot (Raspberry PI 4B + Motor Driving Board + Chassis)
WIFI
cell
WIFI
cell
Intranet/Internet
Data Visualization
Video Viewer
Controller
External Computer

Robot

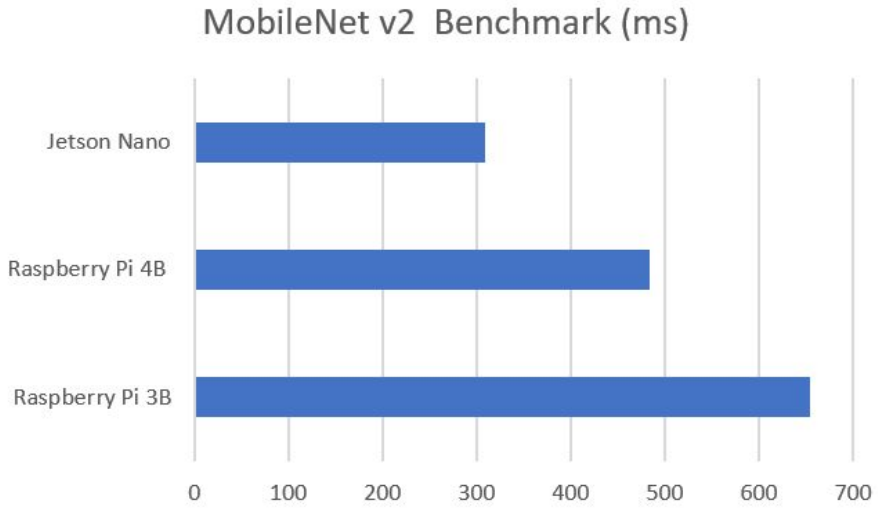
- Requirements
  - House all sensors
  - Robust & stable
  - Certain degree of maneuverability
  - Peripherals scalability
  - IoT supportability

- Implementation
  - Chassis (214*280*114 mm)
  - 12V DC motors GA25Y370)
  - Raspberry Pi 4B

Raspberry Pi 4B

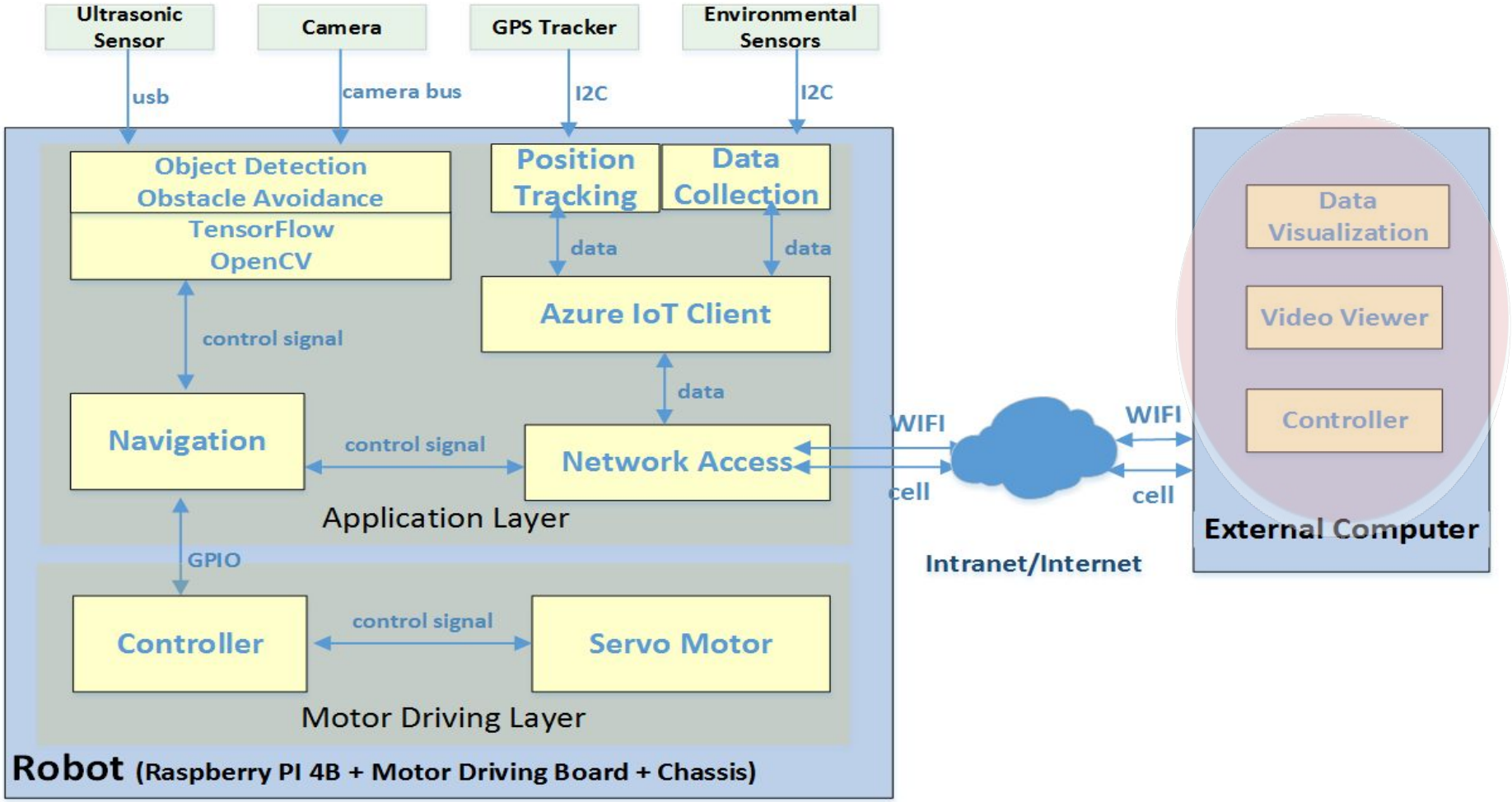
- Power: 5V DC (USB Type-C)
- Dimensions: 88 x 60 x 24mm
- Cores: 4 * 1.5 Ghz
- GPIO: 3.3V power rail 40

- Why Pi 4B
  - Performance comparable
  - Extensions
  - IoT Support
  - Economical



*Data Source

External PC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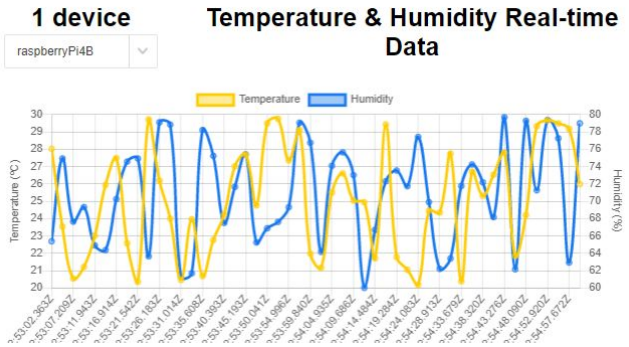
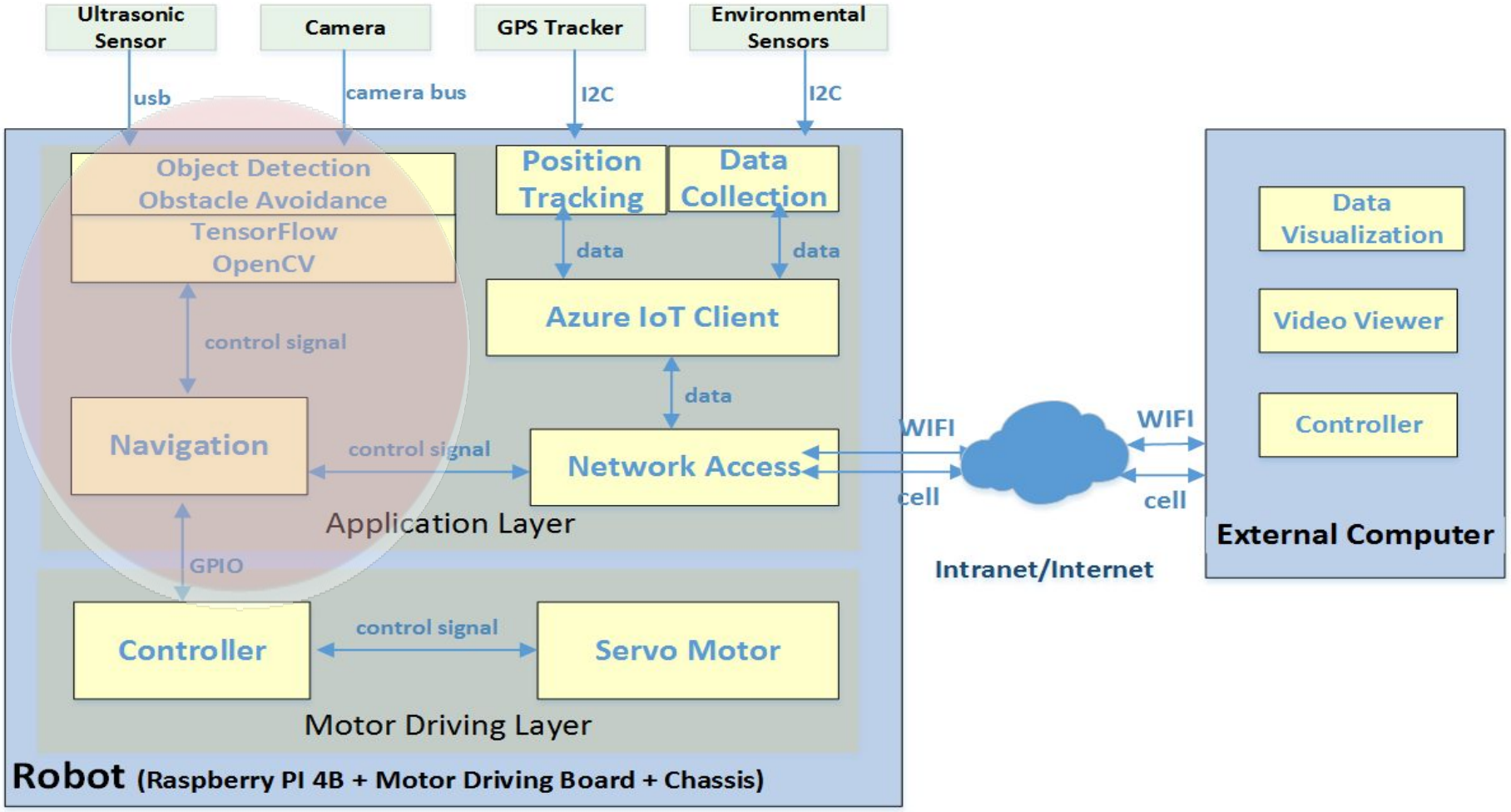
External PC

- Requirements
  - Communicate with robot through Wi-Fi
  - Display sensor data
  - Display live video feed
  - Display GPS position
  - Transmit navigation instructions to robot (manual mode)
  - Object detection
- Implementations
  - Web GUI interface
  - Edge device publish data to Azure
  - External PC retrieve data from cloud
  - Render locally
  - Navigation signal send via cloud to IoT service on robot

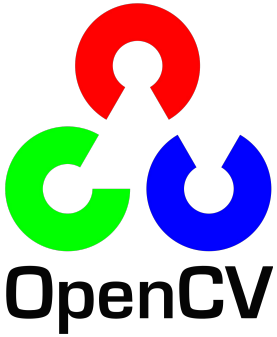


Autonomous Navigation



Autonomous Navigation

- Requirements
  - Object detection
  - Obstacle avoidance
  - Control motors accordingly
- Implementation
  - OpenCV
  - Tensorflow



Autonomous Navigation

- OpenCV
  - open source computer vision library
  - used for image processing
  - object detection
  - You Only Look Once v3 (YOLOv3) - Joseph Redmon et al.

- Tensorflow
  - open source machine learning library
  - used to build neural network
  - neural network will help make navigation decisions

Budget

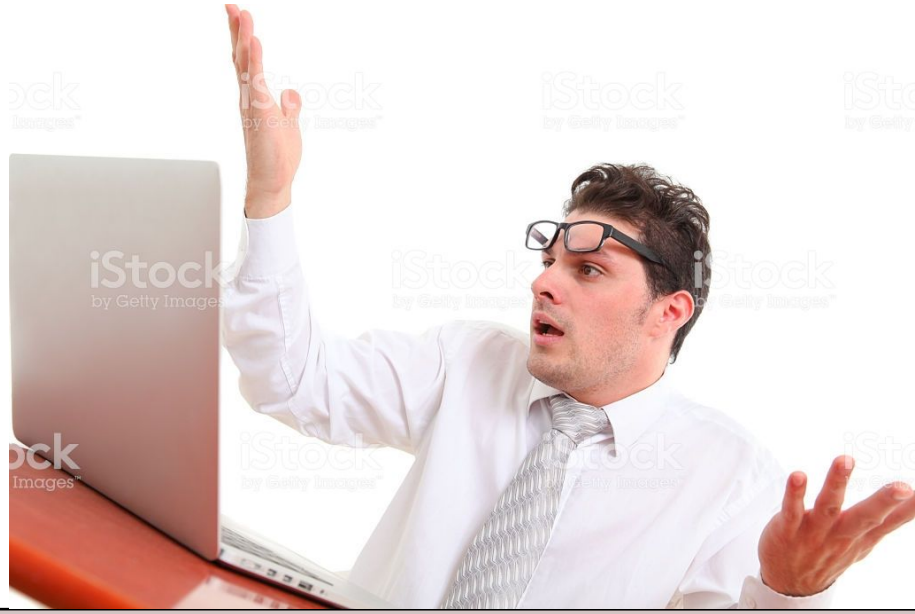
Component	Cost ($)
Raspberry Pi 4B 4G	80
Infrared Camera (500w Pixel)	20
Chassis Platform	100
Motor * 6 (GA25Y370)	60
Sensors and GPS module	50
Li Battery 2200 7.4v mAh 25c	20
Battery Charger 7.4v	20
SD card 32GB	20
Azure IoT service	Free Tier
Total	370

Responsibilities

- Yong Li
  - Hardware selection, setup Pi
  - Azure related (Sensor data, GPS, video feed)
  - Sensor data transfer
- Arthur Zhu
  - Wi-Fi connectivity
  - Maneuverability
  - Autonomous navigation
  - Robot motor control
- Derek Sun
  - Object detection
  - Autonomous navigation
  - Application development

Roadblocks/Challenges

- Autonomous navigation
- Accurate object detection
- Component compatibility and system connectivity
- Robot maneuverability



Proposed MDR Deliverables

- Functional robot able to be remote controlled
- Azure setup for our system
- Train YOLOv3 model to be able to detect/classify certain objects

Responsibilities

- Yong Li
  - Robot functionality
  - Sensor connectivity, Azure connectivity
- Arthur Zhu
  - Networking, Motor control
- Derek Sun
  - Object detection

Proposed FPR and Demo Day Deliverables

FPR

- Live demonstration of IntelliSAR capabilities

Demo Day

- IntelliSAR on display
- Object detection demonstration
- Video that shows IntelliSAR in action
  - Perspective of robot (w/ object detection)
  - Data from sensors

Questions?