Reconnaissance robot (SCD pitch)

ECE 445 Senior Design

Team 55

Team members:
Xuqing Sun(xsun63)
Shenyi Wang(swang250)
Pu Jin(pujin2)

TA: David Hanley

February 6th, 2019

1 Introduction

1.1 Objective

When people want to explore areas that have potential danger, how can they effectively collect information including images and sound about the areas without exposing to dangers by themselves?
Our goal is to design and build a reconnaissance robot that can send back useful information about the areas or spaces that have potential hazards. The robot should be able to move freely in such spaces and transfer back high-quality image and sound data. In addition, the robot should have a mounted light that allows it to take pictures in dark environments. The robot should be relatively small so that it can move through single point of entry without stucking. Users should be able to use a mobile app or computer software to control the movement of the robot, adjust the position of camera and turn the light on and off.
Collaborating with University Police Department and Siebel Center for Design, our team can make a more customized design based on the police officer's needs.

1.2 Background

When police officers need to check out suspects in an unknown location (e.g. suspects' shelter), it can be dangerous sometimes. These shelters are usually dark and cramped for deceiving purposes. Police officers can be ambushed by suspects if they enter without having full awareness of the space. If there is a robot that can help officers do some pre-recon, risks can be significantly reduced.

1.3 High-level requirements list

- User is able to control movements of the robot on flat ground through a digital interface installed on computer or mobile phone.
- The robot can transfer back images and sound data under dark conditions below 1 lux (with the help of light).
- The power system can sustain the robot for at least one hour of full operation.

2 Design

2.1 Block diagram & Physical design

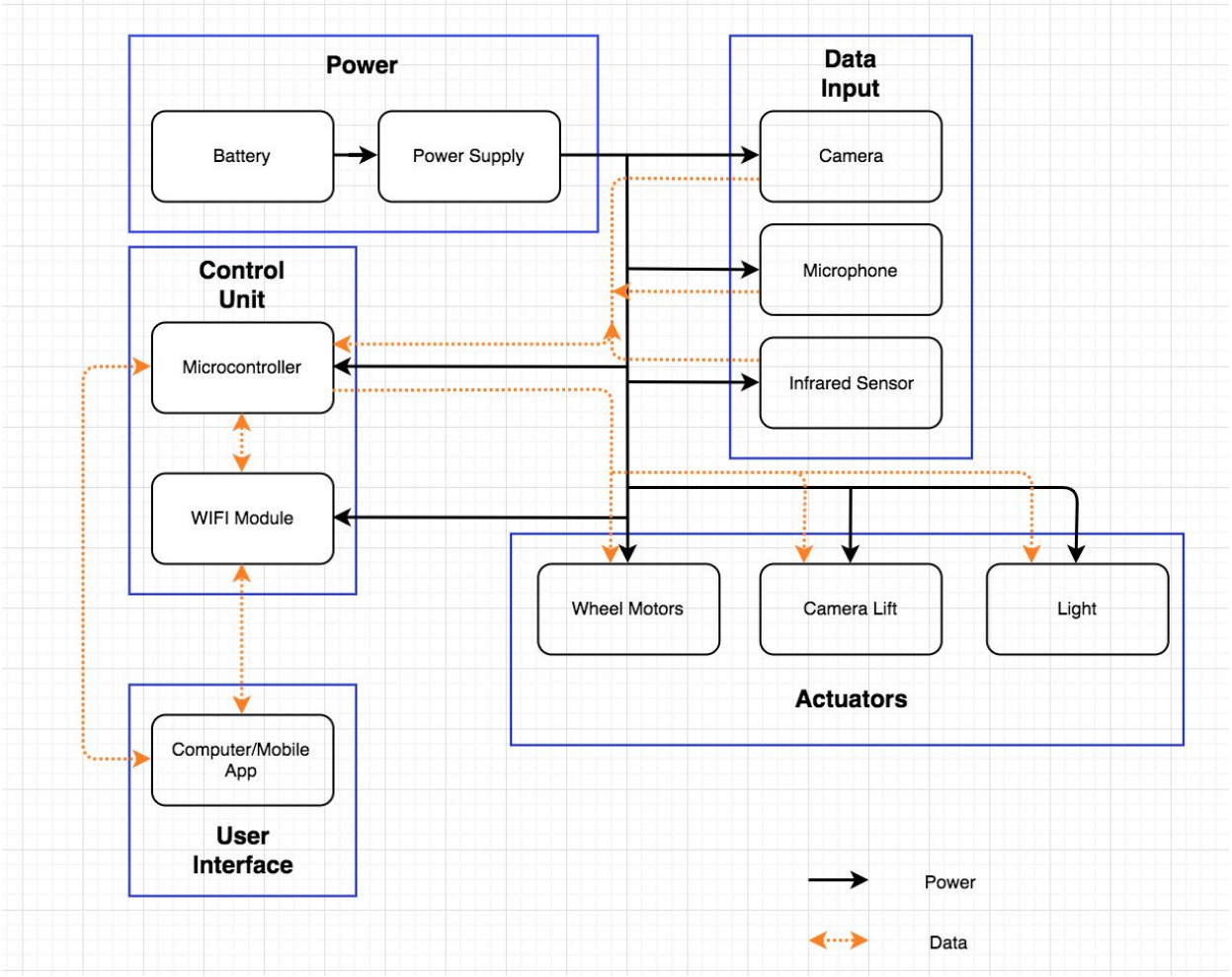

Figure 1. Block Diagram

Our robot mainly consists of 5 large modules. The control unit contains a microcontroller and a Wifi module. It coordinates all other parts on the robot and also communicates with the user end. The user interface is a computer or mobile app. Users will receive images and could send out different commands to the robot. The data input module includes a camera to capture images, a microphone to capture sound and infrared sensors that could detect the position of human beings. The actuators of the robot contains wheel motors, a camera lift and a light, but not limited to these parts. With each block working, the commands from the user would be sent to microcontroller via wifi and microcontroller would send signals to move the wheels, lift the

camera lift up/down and turn on/off the lights; the images from camera, audio data from microphone and data from sensors would be sent to microcontroller and sent back to user interface.

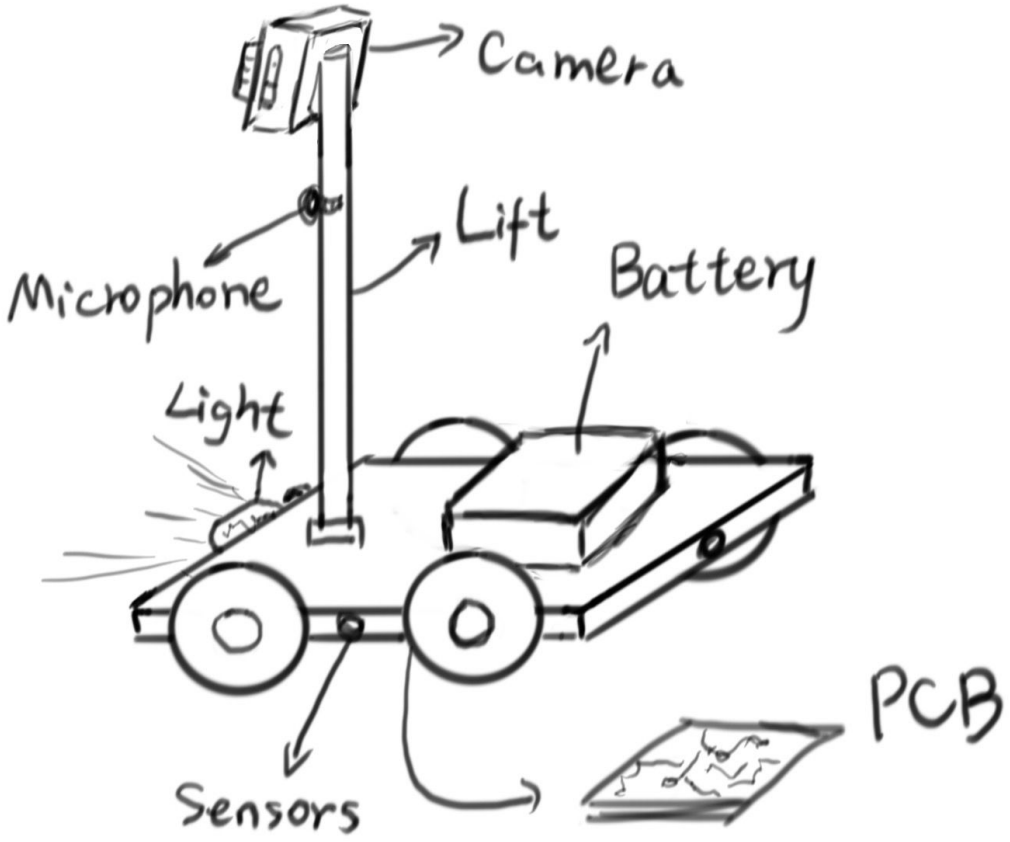

Figure 2. Physical Design

In our physical design, the robot consists of four wheels which are driven by four motors. Our PCB is in between four motors below the skeleton. A battery is on top. The robot has a camera lift up front, with camera attached to top. A microphone is also attached to the lift in order to capture sound data. There is a light that would lighten the path ahead. Four infrared sensors are attached on skeleton at all four directions.

2.2 Power

Power Supply is designed to provide power for all electronic components including motors, camera lift, light, microcontroller, wifi module, camera, and microphone. It consists of a battery and a voltage regulator that supplies suitable voltage to each component; such regulator would power other blocks through the power interface which provide ports for wires. This block supports all other blocks to do their work so the robot could not operate at all without it.

2.2.1 Battery

A rechargeable battery must be used to power the entire system. The battery should also has a power indicator which can tell users whether the battery is charged or not.

Requirement: The battery should store at least 1500mAh.

2.2.2 Power Converter

Since different electronic component requires different voltage input, a power converter is used to supply power in different voltage depending on the needs of components.

Requirement 1: The converter should be able to operate under 6V-12V power input.
Requirement 2: The converter should have adjustable output range from 5V to 15V.

2.3 Control Unit

All data input and outputs are acquired, processed and sent in control unit. The microcontroller takes charge of the internal operation of the robot while wifi module helps it to communicate with user. Without control unit, control of the robot or communication of data would be impossible. Both microcontroller and wifi module are powered by power supply and the microcontroller is connected to each other component via data bus.

2.3.1 Microcontroller

The microcontroller operates as the core coordinator of the whole robot. It will receive users' instructions through Wifi module, and also send data captured by camera, microphone and sensors to user end. It should process and compress the data before sending it to the interface, making sure the amount of data sent is compatible with the network bandwidth. After receiving commands controlling the motion of wheel motors, camera lift and light, the microcontroller would coordinate the components to reach such demands.

Requirement 1: The microcontroller must be able to simultaneously communicate data over more than 7 channels with at least
Requirement 2: The microcontroller must have at least 4kb of memory.
Requirement 3: The microcontroller must operate at more than

2.3.2 Wifi Module

Wifi Module is a significant part of the control unit to make sure user end and the robot controller could communicate each other wirelessly. We are planning to use ESP8266 Serial WIFI Module, with a rate up to 11Mbps. We are also looking for Wifi modules with larger bandwidth because a large bandwidth could improve the quality of images transferred.

Requirement 1: The Wifi must be able to communicate at minimum rate of 11Mbps.
Requirement 2:The router that sends out Wifi signal should cover a distance of at least 30 meters.

2.4 Data Input

Data input consists all information users want to know and the whole point of this product is to transfer this data back to users. Images captured by the camera, audio captured by the microphone and human position (motion) captured by the sensors would be sent to microcontrollers independently through data bus.

2.4.1 Camera

A camera is going to capture a large angle of view in front of it. It should be able to capture image under dark environments with help of the light.

*Requirement 1: The camera resolution should be no less than 352*240.*
Requirement 2: The camera should be able to take at least 30 pictures per second.

2.4.2 Microphone

A microphone is needed to capture sounds in surrounding environment. User should be able to receive sound data from microcontroller.

Requirement 1: The microphone should be able to detect sounds with microphone sensitivity more than -60dB.

2.4.3 Sensors

Passive infrared sensors are used to detect the approximate position of human (when they move) within the area. With several sensors, we could know the relative direction by comparing the data from different sensors.

Requirement 1: The infrared sensors should be able to detect heat or motion at the directions they are facing within at least 5 meters.

2.5 Actuators

Actuators allow user to control the robot to help them better collect information. The voltage inputs of motors and the light is sent to the components by the microcontroller.

2.5.1 Wheel motors

Wheel motors should have different speeds depending on different voltage inputs. The responsibility of coordinating wheel motors lies on control unit.

Requirement 1: The motor should have free-run speed larger than 12k rpm.
Requirement 2: The motor should be able to operate with a voltage larger than 3V.
Requirement 3: The dimension of the motor should be smaller than 5 cm.

2.5.2 Camera lift

The camera lift will hold the camera. It can adjust vertical position of the camera by ascending or descending in order to have view of different height. The lift should also be able to rotate around its axis, so the camera could see different angle without turning the robot.

Requirement 1: The lift should be able to rotate at least 180 degrees at 18 rpm.
Requirement 2: The lift should be able to ascend more than 0.3 meters above baseline.

2.5.3 Light

The light will turn on and off based on commands from control unit. The light will provide better view for the camera when the space is relatively dark.

Requirement 1: The light should able to be switched on/off via control signal from wires.
Requirement 2: The light should output at least 10k MCD.

2.6 User interface

The user interface is an app on mobile or controller which allows user to communicate with the robot. Users can control the robot to move in different directions and see the images captured by the camera. Sound data is also available on the user interface.

Requirement 1:It should decode data sent from robot, show images continuously, play the audio data collected and mark potential human movement detected by the sensors.
Requirement 2: It should allow user to give commands to choose directions such as forward, left and right; to switch on/off the light; control the lift ascend/descend and rotate. Those data should be sent to the robot subsequently.

2.7 Risk analysis

Our greatest concern is that the wifi module in the control unit may not provide enough bandwidth and stability for the communication channel between the robot and users. If wifi connection is lost, neither transfer of image and sound data nor control instructions of robot’s

motion can be accomplished. We realize that we have to transfer images quick enough to enable the user to control the robot while sustaining the quality of the images; Wifi bandwidth is likely to be the bottleneck of the whole data flow process. If the wifi bandwidth is too small, we may have to reduce the resolution of the image or send less images per second; either choice will lead to worse user experience.
Thus, we want to pick a high quality wifi module that provides robust connection and generous bandwidth. 11Mbps is the minimum bandwidth we can tolerate.

3 Ethics and Safety

3.1 Ethical

The main ethical concern of our product is that is has a camera that transfers real-time data and that may lead to infringement of privacy. This may conflict with the IEEE ethics code which states we ought to “to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist” [1]. Although the robot is designed to detect suspects, it may also detect and transfer pictures of irrelevant personal. For us engineers, we are unable to distinguish between targets and passerby and have no control over what’s the product’s usage once it is sold out. We can only make sure the product is placed in the right hands and expect the police will follow their own ethical code of not infringing privacy.

3.2 Safety

Potential safety concerns in this project include both electronic and mechanical aspects. Rechargeable battery is an important component of our robot. Since many batteries have potential risk of overheating and ignition, we should ensure compatible charger and voltage inverter are used, and properly charge the battery every time.
Also, electricity leakage and circuit shortage might happen during the building and operation phase. According to Occupational Safety and Healthy Standards from United States Department of Labor, “To ensure safety, the circuits and equipment to be worked on shall be disconnected from all electric energy sources. Control circuit devices, such as push buttons, selector switches, and interlocks, may not be used as the sole means for de-energizing circuits or equipment”.[2] While building and operating the circuit, we would strictly follow the safety guidelines.
On the mechanical side, the spinning motors may lead to injuries, and the robot may crash into people and hurt them. We will construct and test our robot in a free room so that no bystanders will be hurt by accident. Also, though acknowledging those concerns, we think those problems are rare and mostly caused by wrong usage of the device. We would make the motor unaccessible from the outside and try to avoid sharp angles on the physical design to avoid serious injury to people.

Reference

[1] “Department of Labor logo UNITED STATESDEPARTMENT OF LABOR,” *Occupational Safety and Health Administration*. [Online]. Available: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.333. [Accessed: 08-Feb-2019].
[2] “Department of Labor logo UNITED STATESDEPARTMENT OF LABOR,” *Occupational Safety and Health Administration*. [Online]. Available: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.333. [Accessed: 08-Feb-2019].