Design Specification
For
Project Lead the Way

Prepared by:

Group Name: Team 7

Derrick Thompson *thompson.644@wright.edu*
Jordan White *white.554@wright.edu*
Samuel Basham basham.8@wright.edu
Caihong Novak novak.27@wright.edu
Niko Mize mize.9@wright.edu

For:

Project Sponsor **Wright State University**

Erik Buck *erik.buck@wright.edu*
Soon Chung *soon.chung@wright.edu*
Mike Saville *michael.saville@wright.edu*

1. Executive Summary

This document outlines the proposed system design for the new Lead The Way autonomous assistant robot as designed to assist elderly and disabled individuals carry small objects that are a hassle to keep on their person. This document is based on the design specification standards and guidelines given in EE-4910/CEG-4980. This document will outline the scope of the project covering the issues this product is designed to help with; the advantages and disadvantages of existing solutions; the design requirements, objectives, constraints, and standards; user documentation for both hardware and software; our testing and evaluation methods; and the qualifications of this team to successfully design and implement the project.

1.1 Document Purpose

The hardware system architecture consists of a mobile phone, raspberry pico microcontroller and GPIO expansion board, a HuskyLens vision sensor, four 12V 25mm gear motors, four mecanum wheels, two L298n motor controllers, one servo motor, a IR break beam sensor, a 14.8V 4 cell li-ion battery pack and charger, a dual-mode bluetooth module for raspberry pico, a speaker, multiple 3.3V and 5V voltage regulators, two ultrasonic sensors, and the aluminum frame that will be the body of the product. The software we will be using consists of the mobile phone and app software, the bluetooth and Wi-Fi software, and the software necessary for the IR and ultrasonic sensors as well as the speaker and microcontroller. The vision sensor comes with its own software already installed. Interface and communication will consist of the mobile phone, microcontroller, and the bot itself.

1.2 Design Scope

The objective of our little autonomous robot is to follow the user and carry smaller items such as wallets, car keys, mobile phones, medicines etc. The benefits of this robot are the ability for elderly and disabled individuals who may have trouble carrying everything they need on their person to have some help without the need of an aid/nurse or family member to always be around and to eliminate some compromise they may have to make when it comes to choosing what they can and can’t carry with them. The end goal is to make life easier for elderly and disabled people.

For this project, we will be responsible for ordering and assembling all parts and using the material for the frame to build our own body for the robot. We will also be responsible for the software that will be used to interface and communicate with the various components. We will not be responsible for designing the camera software as it includes its own.

1.3 Intended Audience and Document Overview

The different kinds of readers we expect will be referring to this document consist of project sponsors, project clients and users. The document is intended to answer questions consumers and sponsors might have as well as give the consumer as much knowledge on the project as possible.

1.4 Definitions, Acronyms, and Abbreviations

ISO: International Organization for Standardization

IEEE:Institute of Electrical and Electronics Engineers

ANSI: American National Standards Institute

1.5 References and Acknowledgements

[1] Provance, Patricia G. "Mobility and Walking Issues." *MSAA*, 20 Oct. 2022. [Online]. Available: https://mymsaa.org/ms-information/symptoms/mobility/. [Accessed: April 27, 2023].

[2] Knutsson, Kurt. "How Drones Are Revolutionizing Delivery by Taking to the Skies." *Fox News*, FOX News Network, 17 Mar. 2023. [Online]. Available: https://www.foxnews.com/tech/how-drones-revolutionizing-delivery-taking-skies. [Accessed: April 27, 2023].

[3] Marr, Bernard. "The Future of Delivery Robots." *Forbes*, Forbes Magazine, 9 Nov. 2022. [Online]. Available: https://www.forbes.com/sites/bernardmarr/2021/11/05/the-future-of-delivery-robots/?sh=2040e3737337. [Accessed: April 27, 2023].

2.1 Problem Statement

Many people have the issue of not being able to carry around all necessary items on their person. This may be to a heavy load or from health issues that cause mobility deficiencies. To solve this issue, our team has designed a robot that will be able to carry around a person's belongings. The robot will be equipped with sensors and safety features to ensure that it does not collide with other objects or pose a risk to the user or others in its vicinity. Developing such a robot would provide a convenient and accessible solution for people who need assistance carrying their belongings.

Existing Solutions

1. Physical therapist’s are health professionals who help individuals improve their movement, but it takes time and it does not guarantee to help individuals recoverfully.
2. Physical activity will help individuals strengthen their bones and muscles, but some individuals can be in too much pain for physical activity.
3. Providing emotional care can help individuals who are newly experiencing mobility issues, but it takes time and some individuals could be emotionally damaged.

Proposed Solutions

What’s the best way to help to carry items for individuals with mobility issues without being physically there? The answer is using drones to help carry items for individuals. Food drones are an excellent example of carrying items for individuals with difficulty with mobility. Food drones have been growing in popularity since the pandemic [2]. Alastair Westgarth, a company CEO named Starship, said they are trying to make their delivery robots more autonomous [3], which means the robots will move by themselves and help carry products to individuals who order online.

2.1 Historical Introduction

Mobility issues affect individuals by making those individuals develop physical problems in their bodies. Patricia G. Provance, a Semi-retired physical therapist, said that individuals would have symptoms of “weak legs, problems with balance, fatigue/decreased endurance.” [1]. With these symptoms, it can be difficult for individuals to carry items because of improper balance and weak legs, which can cause harm to the individual. However, technology will continue to advance, allowing individuals to carry items but not have those items physically. Air drones are being developed in our society to help carry packages; those traits will be included in our robot.

Group 07 *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

Design Objectives

The overall goal of this project is to create a robot that can autonomously follow a person/object by tracking their position through the use of cameras/sensors and avoid obstacles in its path to maintain a set speed and distance from what/who is being followed. It shall also be able to store objects that are within the size requirements.

Objective 1: The system shall be a robot capable of autonomously following a set person/object.

This system shall have a camera/sensor that tracks an individual/object's position and is set to follow them at a certain distance.

Objective 2: The system shall be capable of storing objects within itself.

This system shall have internal storage allowing the user to store objects that meet or are below the size requirements.

Objective 3: The system shall use auditory queues to inform the user they cannot be tracked or if the robot is too close to an obstacle.

This system shall have attached speakers that play different noises based on whether it can't see the user or if an obstacle is too close.

Objective 4 (optional): The designed robot shall be capable of avoiding obstacles in its path to continue following the user.

If the robot is to encounter something blocking its path it shall be able to navigate around and continue following the user without getting stuck and stopping.

Objective 5: The robot has wireless capabilities.

The robot shall be able to communicate with a mobile app so the user can change the robot's state of operation.

Group *07* *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

Design Assumptions

Assumption 1: The robot shall operate on flat terrain.

Assumption 2: The robot shall be able to follow one individual/object.

Assumption 3: All cameras shall be cleared of debris.

Assumption 4: The robot shall not be permanently stopped by objects/people in its path.

Assumption 5: The robot shall be able to see its target throughout the entire test.

Assumption 6: All sensors shall be free of debris.

Assumption 7: There shall be no wet surfaces on the flat terrain.

Assumption 8: The robot shall not be damaged while holding/transporting objects while within the weight limit.

Assumption 9: The robot shall not be expected to climb any surface.

Assumption 10: The robot shall communicate with wireless capabilities.

Group *07* *Project Title: Lead the Way*

Major: **Team members:**

ITC *Jordan White*

CS CaiHong Novak

CS Derrick Thompson

CS Nicholas Mize

EE Samuel Basham

Design Requirements

Requirement 1: The robot shall be able to follow the user for at least 1 minute.

Requirement 2: The robot shall be able to carry up to 1 lb of items in its storage.

Requirement 3: The robot shall have wifi capabilities.

Requirement4: The robot shall emit auditory sounds.

Requirement 5: The robot shall be able to detect when the user is changing directions, and adjust accordingly.

Requirement 6: The robot shall have a battery life of approximately 24 hours.

Requirement 7: The robot shall be able to detect drops in height to avoid falls that could be damaging.

Requirement 8: The robot shall have a camera video capture of the user.

Req No.	Obj No.	Requirement
10	*1*	The robot shall be able to follow the user for at least 1 minute.
20	*2*	The robot shall be able to carry up to 1 lb of items in its storage.
30	3	The robot shall have wifi capabilities.
40	4	The robot shall emit auditory sounds.
50	5	The robot shall be able to detect when the user is changing directions, and adjust accordingly.
60	6	The robot shall have a battery life of approximately 24 hours.

70	7	The robot shall be able to detect drops in height to avoid falls that could be damaging.
80	8	The robot shall have a camera video capture of the user.

Definitions:

Storage - The action of keeping an object within available space.

Capacity - The maximum amount an object can contain.

Emit - To produce, in this case, a sound.

Group *07* *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

Design Constraints

Const No.	*Constraint*
10	The robot shall be no more than 45 cm in height.
20	The robot shall be no more than 45 cm in depth.
30	The robot shall be no more than 60 cm in width.
40	The robot shall not exceed a speed of 50 cm/s.
50	The system's battery shall not exceed 10Ah.
60	The total price of the system shall not exceed $300.
70	The robot shall not weigh more than 20 kg.
80	The robot shall be no louder than 70 decibels.
90	The robot shall not reach a temperature too high/low for touch.
100	The system shall have no more than 5 states of operation.

Definitions:

"State of Operation" - Refers to the current mode the system is performing actions in.

"Decibels" - a unit used to measure the intensity of sound.

Group 07 *Project Title: Lead the Way*

Major: **Team members:**

ITC *Jordan White*

CS CaiHong Novak

CS Derrick Thompson

CS Nicholas Mize

EE Samuel Basham

Design Standards

Stand. No.	*Standard*
10	ISO/IEC 12207:2008 - Systems and software engineering -- Software life cycle processes", ISO, 2008.
20	*ISO 13482 - Robots and robotic devices — Safety requirements for personal care robots.*
30	*AANSI/RIA R15.08-1-2020 American National Standard for Industrial Mobile Robots - Safety Requirements.*
40	*ISO 13849-1 - Safety of machinery — Safety-related parts of control systems.*
50	*Robots shall comply with one or more communication standards such as IEEE 802.11.*
60	*Robots shall comply with electrical connection standards such as IEEE 2025.1.*
70	*Robots shall comply with guidance and system navigation standards such as IEEE 1559-2022.*
80	*Robots shall comply with human interaction standards such as ISO 10218-2.*

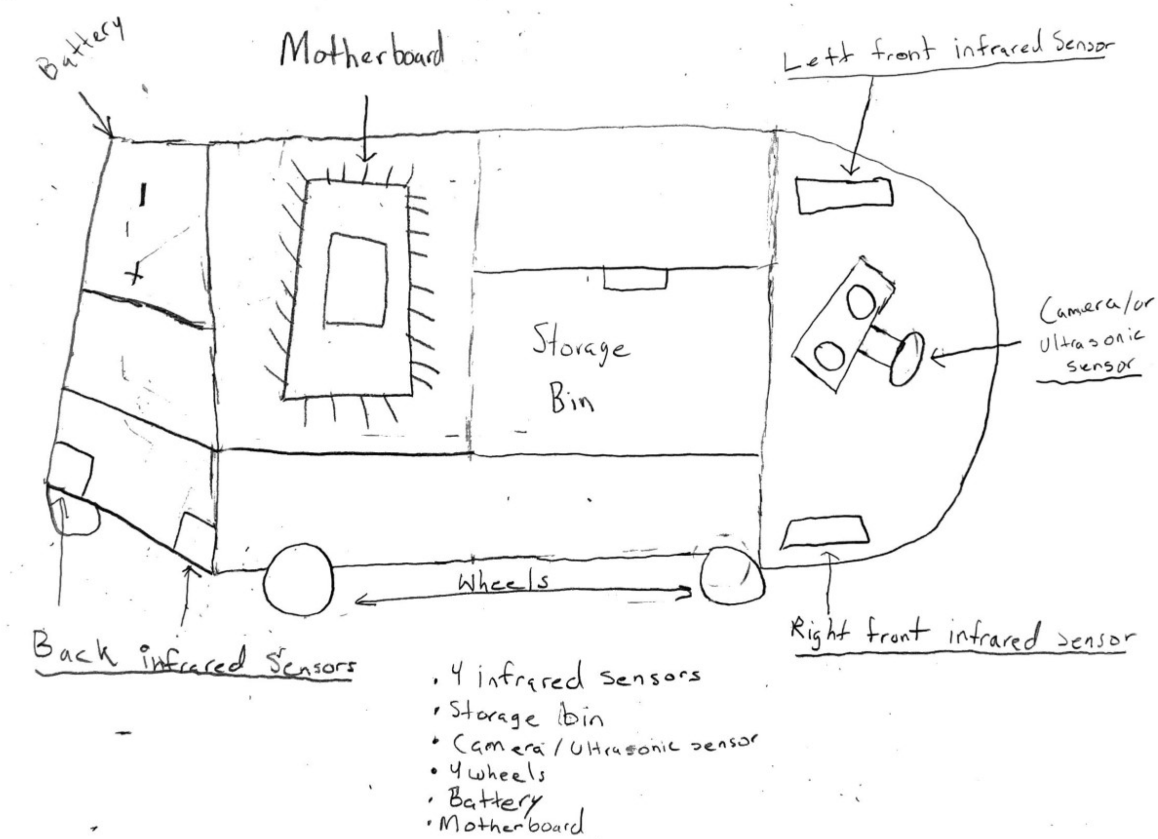
Group *07* *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

Design Functionality

1. User is detected
    a. The robot must be able to detect the presence of a user to follow.
2. Robot follows user
    a. The robot must be able to follow the user, adjusting its direction and speed as necessary.
    b. The robot should maintain a safe distance from the user, avoiding collisions.
3. Obstacle detection and avoidance
    a. The robot must be able to detect obstacles in its path and avoid them, adjusting its path or speed as necessary.
    b. The robot should be able to distinguish between obstacles and the user it is following.
    c. The robot should be able to alert the user when it is unable to avoid an obstacle.
4. User can communicate with robot
    a. The user's phone communicates with a bluetooth signal which then connects to the system via an application.
    b. The mobile app will be able to change the robots current state: such as stop, go, follow, etc.
    c. The robot's camera will be sending out wifi signals as well, allowing a broadcast between the camera and the app.
5. System can detect users face

a. The robot will be programmed with a database of objects it is able to detect, including the user.



Group 07 *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

Design Impact

1. Cultural

- The primary function of project Lead the Way could provide a positive impact. Since it is being designed to follow a user around if it were to be tracked, then other users could see its movements and use it to find their kids when out of sight if that is who it was following.
- One potentially negative cultural impact with this robot would be privacy. The bot's primary purpose is to follow a user around and navigate towards them, which has the potential to unintentionally record people around the user.

2. Economic

- A positive impact of this design would be creating jobs in the field of production, while also not replacing any labor as it isn't being designed to make any specific jobs easier or more efficient/productive.
- A negative economic impact would be potential high costs. Our design is required to be made with <=$300, which could lead to more robots in the future thereby increasing the cost.

3. Environmental

- One positive impact could be storing waste that is capable of fitting inside the interior of the robot. The robot could reduce the amount of waste that can be found in public areas or in private lives.

- One potential negative impact of this robot is the generation of electronic waste. As with any electronic device, these robots could eventually end up in landfills or recycling centers, contributing to the growing issue of tech waste. This could be mitigated through responsible disposal and recycling programs.

4. Global

- One positive impact is increasing natural resources by allowing workers to store their resources in the robot. This has the potential to increase efficiency, especially if the job requires multiple trips to a destination to complete.
- While project lead the way has the potential to improve productivity and efficiency in various fields, it could also contribute to global carbon emissions through its energy consumption in use and in production. One potential mitigation strategy is to use renewable energy sources to power the robots.

5. Public health

- A positive impact could be the delay of serious chronic issues in the elderly such as arthritis, spinal stenosis (back pain), etc.
- Negative Impact would be possible links of cancer due to chronic exposure to the type of radiation given off by the system (RF for example). Mental Health could also be a negative impact of project lead the way, as having a robot do tasks for you could reduce the amount of social interaction the user experiences which could cause depression, anxiety, etc.

6. Public safety

- One potential positive impact on public safety would be how the system could make life easier for elderly or disabled users. It can carry things and follow the user around on its own so that they wouldn't have to carry some things from one place to another potentially preventing some accidents such as falls or injuries.
- One potential negative impact could be battery fires as explained in the example article. Another negative impact could be an environmental hazard in a public setting, such as a person near the user tripping on the robot and succumbing to injury.

7. Public welfare

- One positive impact for project Lead the Way could be its potential to improve productivity and accessibility.
- One negative impact is that it could also lead to job displacement and reduced social interaction. Mitigation strategies could include supporting affected workers and encouraging social interaction through other means.

8. Social

- One positive impact is that it can improve mobility and independence for some users, which would allow them to go to more events, gatherings, etc.

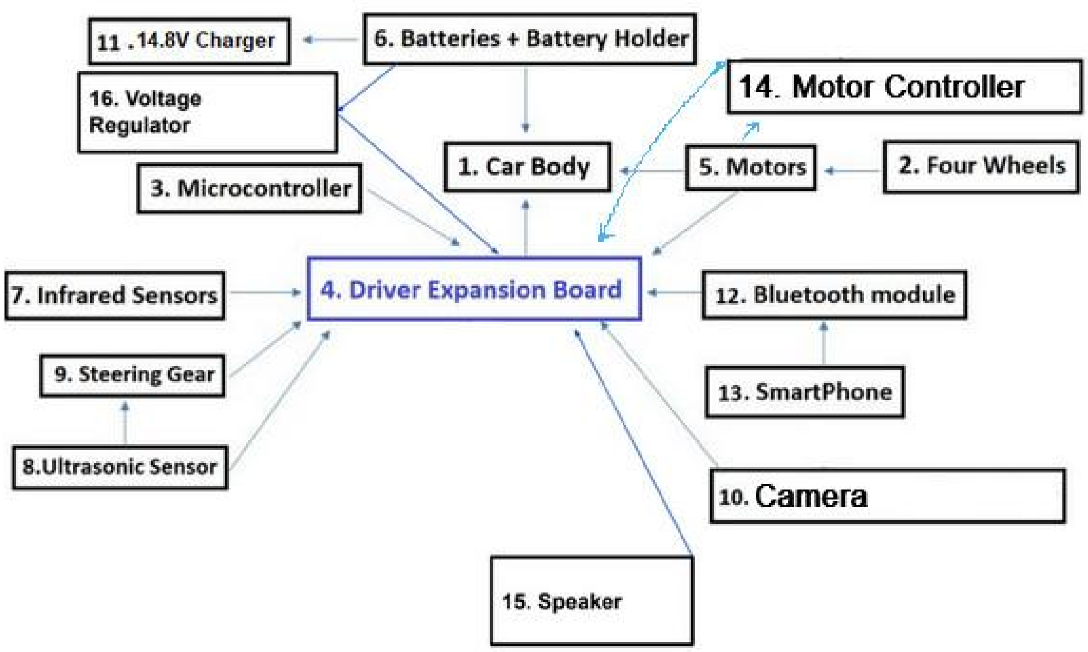
- One negative impact is that it could exacerbate social isolation and lead to a loss of human interaction. Mitigation strategies could include developing the robot in ways that encourage social interaction and addressing concerns about the impact on social relationships.

Group 07 *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

System Architecture

Hardware Architecture

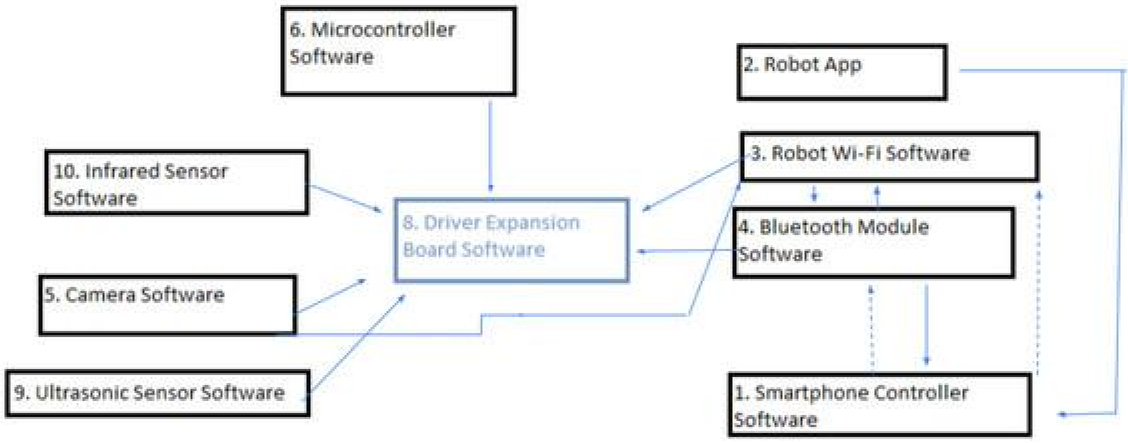


Hardware functional block definitions

1. Car Body: The platform holding and supporting all the components together.
2. Four Wheels: The wheels that will be controlled by the motors to move the robot.
3. Microcontroller: The circuit responsible for controlling the functions of the other components.

4. Driver Expansion Board: Used to add functionality to the microcontroller platform and designed to stack onto existing pin headers or pre-configured attachment ports.
5. Motors: The components required to supply motive power for the four wheels in order to move the robot around.
6. Batteries + Battery Holder: The source of power for the robot to perform the functions it is designed to perform. For this system an 18650 battery pack will be used. The battery holder is a simple box-like piece to hold the batteries in place.
7. Infrared Sensors: Radiation-sensitive optoelectronic components that will be used by the system to aid in tracking and following the user.
8. Ultrasonic Sensor: Electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Will be used to aid in following the users.
9. Steering Gear: This will allow the camera to look left and right for visual tracking.
10. Camera: The platform that will support the camera, robot will support facial tracking features.
11. 14.8V Charger: Charger for the batteries to provide multiple uses of the robot once the batteries die. Charger must have the same voltage as the battery.
12. Bluetooth module: Used for short-range 2.4G wireless communication between components. When the Bluetooth signal is connected to the smartphone, the app can control the robot's movement stages such as panic, stop, and turn on or off.
13. SmartPhone: Mobile phone that will be used to receive and view the video image transmission from the camera and allow the user to see the robot’s movements from its point of view.
14. Motor Controller: Receives input signals from the robot's control system, and based on those signals, it adjusts the power supplied to the motors to achieve the desired motion.
15. Speaker: Used to emit a sound in case the user needs to find the robot, this is where the “panic” button will be implemented.
16. Voltage Regulator: Used to regulate the voltage the components are receiving, preventing overheating and failure of any components that need much less voltage than the battery supplies.

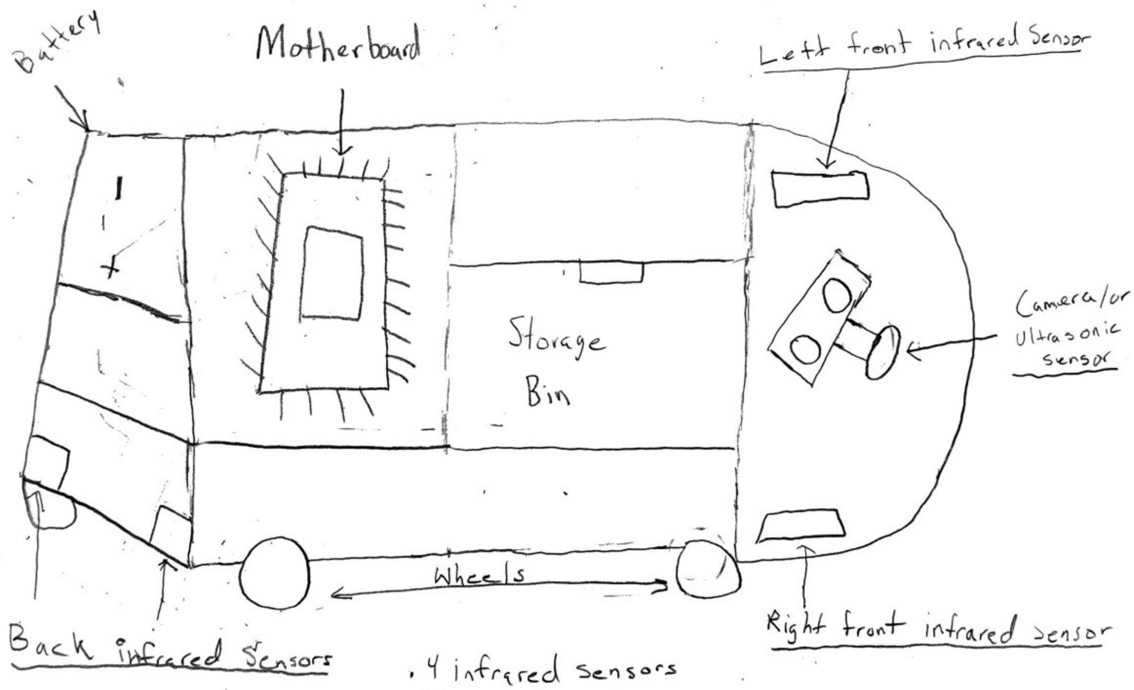
Software Architecture



Software functional block definitions

1. Smartphone Controller Software: Smartphone controller is connected to the robot via bluetooth.
2. Robot App: The robot app will be used to give the robot instructions to stop, go, and follow.
3. Robot Wi-fi Software: The robot's Wi-fi will be connected to the user's smartphone to communicate instructions via robot app.
4. Bluetooth Software: The user's smartphone will be connected to the robot's software by using the app.
5. Camera Software: This allows the robot's camera to send a video feed back to the user's app.
6. Microcontroller Software: This is embedded to the robot giving the software control functions.
7. N.A.
8. Driver Expansion Board Software: This allows the robot to interface with wifi, camera, bluetooth ultrasonic sensor, and infrared sensors.
9. Ultrasonic Sensor Software: This allows the robot to follow the user by using ultrasound waves.
10. Infrared Sensor Software: This allows the robot to avoid objects that it detects using pulses that it outputs from its system.

Sketches



- 4 infrared sensors
- Storage bin
- Camera / Ultrasonic sensor
- 4 wheels
- Battery
- Motherboard

Group *07* *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

System Design Trades

Hardware Design Trades:

1. Which material to use for the frame.
2. The type of wheel and size.
3. The model of microcontroller must be paired correctly with expansion board
4. The model of expansion board must be paired correctly with microcontroller
5. How much to spend on the motors. The voltage.
6. Rechargeable batteries or not. The energy charge that the battery will hold.
7. Type of infrared sensor to use. Max measurement distance. How much to spend. Best voltage. The wavelength.
8. Type of ultrasonic sensor to use. How much to spend. Max measurement distance needed. Number of signal pins.
9. Sliding pairs or turning pairs will need to be chosen for steering gear.
10. The camera will need to be chosen as well as the type of mount.
11. Which battery charger. Charging speed.
12. How and where to install bluetooth.
13. The operating system for the smartphone.
14. The decibel range for the speaker.
15. The operating voltage range of the regulator.

Software Design Trades:

1. Getting the phone to connect.
2. The implementation of the robot app commands.
3. Getting the Wifi software to send signals.
4. Getting the camera to broadcast to the phone.
5. Getting the bluetooth software to send signals
6. Having the microcontroller functions sending signals.

7. Having the expansion board software communicate with all other tools connected.
8. Having the robot be able to detect the user via ultrasonic software.
9. Having the robot be able to detect obstacles via infrared software.
10. Implementing language in C/C++.
11. Operating System: Linux.

.

Group 07 *Project Title: Lead the Way*

Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

HW/SW Design Trade

	Microcontroller & Expansion Board		
Criteria	**Raspberry Pi 3 model B**	**Arduino Uno**	**Raspberry pi pico RP2040**
Cost	$125	$32	$15-20
Core	A Series Quad Core A10 5700	Cortex M7 and M4	Dual ARM Cortex
Speed	1.2 GHz	16MHz	133MHz
Voltage - Supply	5.1V	7-12V	3.3V
Memory	1 GB	256 KB	2MB
Program Languages	Python/C++	C++	Python/C++

Due to its low price and low voltage requirement, the Raspberry pi pico is the optimal choice. Raspberry pi pico is also more energy efficient and generates less heat, as well as not requiring an expansion board (independent).

	Motor Driver Module		
Criteria	**L298n motor driver**	**Dual H-Bridge Motor Driver L293D**	**HiLetgo BTS7960 43A High Power Motor Driver**
Voltage	5V	4.5-36 V	6V-27V
Drive current:	2A(MAX)	600mA	Maximum current: 43A
Drive voltage	7v-35v	4.5-36 V	3.3-5V
Weight	33g	0.81 ounces	3.21 Ounces
Price	$14	$8	$15
Compatibility	STEM32/Raspberry Pi Pico	Raspberry Pi	Ar-duino/Raspberry Pi

For compatibility considerations, the L298n motor driver is most suitable for the Raspberry Pi Pico.

	Frame Material (sheets)			
Criteria	**Acrylic**	**Aluminum**	**Wood**	**Carbon Fiber**
Cost	$8-20	$15-20	$6-10	$18-20
Durability	Good when maintained	Very good	Average	Very good except with sharp objects
Flammability	Inflammable	Very Low	High	Low
Waterproof	Yes	Yes	No	Yes

For the frame material we will use aluminum due to its high durability, low flammability, and being waterproof. It is more expensive than acrylic or wood but also slightly cheaper than carbon fiber so it seems to be the best choice between the two. This material will house all of the components and the storage bin will be made out of this.

	Wheels				
Criteria	**Hard Plastic**	**All-Terrain**	**Foam**	**Mecanum**	**Aluminum**
Cost	$1-4	$16-33	$2.50-5.10	$6.70-130	$5-12
Durability	High	High	Low	High	High
Traction	Poor	High	Average	High	Average
Width	7-8mm	39-60mm	19.1mm	30-65mm	4-5mm
Turning Ease	Higher	Lower	Lower	Highest	Average

Mecanum wheels will be used to carry and transport the robot. Mecanum wheels, while more expensive than most other options, have low-cost options and good stats as can be seen above. Their width is higher than most other options but not so high that turning ease is too low. The wheels will be attached to the motors on the bottom of the robot, two on each side.

	Infrared Sensor				
Criteria	**RB-Dfr-787**	**Sharp GP2Y0A21YK**	**IR Break-Beam Sensor**	**RB-Wav-29**	**WWZMDiB IR Sensor Module**
Cost	$13	$15	$5	$4	$8
Req. 90 (Range)	0-200cm	10-80cm	50cm	Unknown	0-200cm
Const. 70 (Weight)	Unknown	Unknown	3g	5g	8g
Const. 90 (Operating Temp)	25-75°C	-10-60°C	-25-60°C	Unknown	Unknown

The WWZMDiB IR sensor module will be used in our design as it has a great range, low cost, and it doesn't require any more space when considering the number of inputs available.

	Ultrasonic Sensor				
Criteria	**MB1000 LV-MaxSonar -EZ0**	**400SR16M Ultrasonic Transmitter & Receivers**	**HRLV-MaxSonar-EZ4**	**MB7052 XL-MaxSonar -WRMAT**	**HCSR04 Ultrasonic Sensor**
Cost	$35	$5.44	$39	$115	$4
Range	15-645cm	15-900cm	30-495cm	25-765cm	2-400cm
Power Supply	2.5-5.5V	3.3-5.5V	2.5-5.5V	3.0-5.5V	5V
Read Rate	20 Hz	40 Hz	10 Hz	6.7 Hz	40 Hz
Operating Temp	0-60°C	-30 to 70°C	-15-65°C	-40-70°C	0-40°C

2 HCSR04 ultrasonic sensors will be used for obstacle avoidance. They are cheap, have an okay range and input voltage will align with the 5V voltage regulators being used for other components. The read rate is also higher than other sensors being considered.

	Camera				
Criteria	**Arducam Mini 2MP**	**Huskylens Vision Sensor**	**ArduCam OV5647**	**USB CMOS**	**Arducam 5MP**
Cost	$29	$57.43	$30	$20	$14
Resolution	1600×1200	320x240p	1080p	480p	1080p/720p/480p
Rate(fps)	8MHz	30	30	Unknown	30/60
Operating Voltage	5V	3.3-5V	1.5-3V	5V	Unknown
Includes Machine Vision?	No	Y	N	N	N

Face Recognition?	N	Y	N	N	N
Object Tracking?	N	Y	N	N	N

We will use the Huskylens VisionSensor. Its operating voltage aligns with our regulators. The fps rate isn't bad. This product has machine vision with 7 built-in functions: face recognition, object tracking, object recognition, line tracking, color recognition, tag recognition and object classification.

	Motors				
Criteria	**DC 6V 300RPM 3mm Gear Motor #RobotShop**	**16mm DC Planetary Gearmotor - 12V, 17.5 RPM #RobotShop**	**12V 25mm Gear Motor, 17rpm #RobotShop**	**U-Type Inversion Mini Gear Motor - 12V 43 RPM #RobotShop**	**424 - 1/53 - MOTOR - Kit #Mouser**
Cost:	$8.85	$12.55	$6.58	$9.87	$19.99
Voltage Rating:	3V - 12VDC	12VDC	9V - 15V	12V	6V
Duration:	Long lifetime	Long lifetime	Long lifetime	Long lifetime	Unknown
Motor Size:	12mm * 10mm * 26mm	26.8L * 1.5W * 12H mm	⌀25 x 57 (L) mm	Unknown	Unknown
Draw Current	Unknown	0.8 A	1.2 A	0.45 A	0.01 A
Req. 40 (Amps)	Unknown	0.8 A	1.2 A	0.45 A	0.01 A
Const. 50 (Amps)	Unknown	0.8 A	1.2 A	0.45 A	0.01 A

We will be using the 12V 25mm Gear Motor. This motor is rated for 9V-15V, has a long lifetime duration, and the size of the motor meets the requirements and constraints. The draw current meets the requirements and constraints not exceeding 10 Ah.

	Steering Gear				
Criteria	**KPower 6kg Analog Plastic Gear RC Servo #RobotShop**	**KPower Digital Metal Gear RC Servo #RobotShop**	**426-SER0047 #Mouser**	**M5-Stack SG90 Servo #RobotShop**	**426-SER0053 #Mouser**
Cost:	$7.99	$9.99	$6.90	$5.50	$5.00
Voltage Rating:	4.8V - 6.0V	5.0V - 8.4V	4.8V - 6.0V	4.8V - 6.0V	4.8 VDC - 6VDC
Torque:	6.5 kg-cm / 4.8V | 6.kg-cm / 6.0V	3.4 kg-cm / 5.0V | 4.0kg-cm / 8.4V	Unknown	1.6 kg-cm / 4.8V | 1.8kg-cm / 6.0V	0.45 kgf-cm to 0.55 kgf-cm
Speed:	0.15 sec / 60° / 4.8V | 0.13 sec / 60° / 60V	0.13 sec / 60°/ 5.0V | 0.11 sec / 60° / 8.4V	Unknown	0.1 sec / 60° / 4.8V | 0.09 sec / 60° / 6.0 V	Unknown
Current	6.5 A	3.4 A	Unknown	1.6 A	1.6 A
Req. 40 (Amps)	6.5 A	3.4 A	Unknown	1.6 A	1.6 A
Const. 50 (Amps)	6.5 A	3.4 A	Unknown	1.6 A	1.6 A

We will be using M5-Stack SG90 Servo; voltage and the amps meet the requirement and the constraints. The cost is lower than most. And the current isn't too high.

	Bluetooth Module				
Criteria	**Hiwonder Bluetooth Module #RobotShop**	**HC-05 Bluetooth Module #RobotShop**	**634-BGM240 PA32VNA3R #Mouser**	**DFRobot Serial Bluetooth Module #RobotShop**	**Dual-Mode Bluetooth Module for pico #RobotShop**
Cost:	$16.99	$18.55	$11.83	$19.99	$4.49

Baud Rate:	9600 bps	max. 2.1 Mbps	Unknown	Unknown	115200 bps
Input Voltage:	Unknown	3.3-5V	Unknown	3.5V - 8V	3.3V - 5V
Operating Temperature:	Unknown	max. 60 °C	Unknown	-20 ~ +55 °C	-40 ~ +80 °C

The Dual-Mode Bluetooth Module for Raspberry Pi Pico is the Bluetooth module we will use for our robot. Its baud rate is 115200 bps, allowing our robot to transfer communication between the user and the robot. Its operating temperature is low enough to remove worry of overheating, and the voltage can be 3.3-5V.

	Battery				
Criteria	**18650 14.8 V Lithium-Ion Battery Pack Dantona Ind. #Digikey**	**MXJO 18650 3000mAh 20A Battery**	**12V 1600mAh Rechargeable NiMh Battery**	**12V 2800mAh Rechargeable NiMh Battery**	**USB rechargeable 9V lithium battery pair, 650mAh**
Cost:	$15	$7 each	$34.91	$53	$18.40 per pair
Nominal Voltage:	14.8V	3.7-4.2V	12V	12V	9V
Discharge Current:	8A (max)	20A Max Continuous, Rated 35A Max Pulse	1.6A	2.8A	0.65A
Nominal Capacity:	3400 mAh	3000 mAh	1600 mAh	2800 mAh	650 mAh
Protected (Y/N)	Y	N	Y	Y	Y
Rechargeable (Y/N)	Y	Y	Y	Y	Y

Based on the potential needs of the system, the Dantona Industries 14.8V 18650 battery pack will be the voltage source for the robot. The high capacity will allow the robot to run longer and ensure that every component can draw the current it needs. The high voltage will allow us to stick to 1 battery paired with a voltage regulator to ensure each component gets the exact voltage it requires. The pack is also protected and rechargeable which is very important for safety and simplicity.

Useful links: https://community.robotshop.com/tutorials/show/basics-how-do-i-choose-a-battery

	Speaker			
Criteria	**Thin Speaker - 0.5W** **#RobotShop**	**Velleman Digital Speaker Module** **#RobotShop**	**Wide Frequency Range Speaker - 3in. (Polypropylene Cone)** **#SparkFun**	**Qwiic Speaker Amp** **#SparkFun**
Cost	$1.10	$8.80	$11.95	$10.95
Decibels	70dB	80dB	83dB	80db
Input Voltage	1.5V	5V	8-8.9V	0.3-6V

The **Thin Speaker - 0.5W** was chosen to be used on our robot due to its price and not exceeding the decibel limit in the design constraints (70dB).

	Voltage Regulator			
Criteria	**Step-Up/Down Voltage RegulatorS7V8** **#RobotShop**	**5V 1.5A Linear Voltage Regulator** **#Adafruit**	**3.3V 800mA Linear Voltage Regulator** **#Adafruit**	**5V, 600mA Step-Down Voltage Regulator D24V6F5** **#RobotShop**
Cost	$11.95	$14.95	$16.95	$9.49
Operating Voltage	2.7V - 11.8V	5-30V	4-50V	6-42V
Dropout Voltage	2.5V	1.3V	1V	1V
Maximum Output Current:	1A	1A	0.6A	0.6A

The 5V Linear and 3.3V Linear Voltage Regulators will both be used on our robot because the operating voltages are rated for our battery selection and will reduce voltage for other components requiring 3.3-5V. Its maximum output current is 1A meeting the current requirements and constraints.

Software Section:

	Getting Phone to Connect to Robot	
Criteria	**The robot connects to a phone app via bluetooth**	**The robot does not connect to a phone**
Req.10	10	5
Req. 70	10	0
Req. 120	10	5

The robot will be implemented to connect to a phone via bluetooth, as this was the only viable option for connection.

	Robot App Commands		
Criteria	**Robot Can Stop, Go, Turn off, Turn on, and Panic**	**Robot has no commands**	**Robot Can Stop, Go, Turn off, and Turn on**
Req. 10	10	0	10
Req. 70	10	0	0
Req. 90	10	0	10

The robot will have an app to stop, go, turn on and off, and panic to ensure a minimum of 5 app commands is met.

	Bluetooth Software				
Criteria	**No connections have been made to the robot.**	**A computer is connected to the robot.**	**A phone is connected to the robot.**	**A phone and a computer are connected to the robot.**	**A printer is connected to the robot.**
Req. 10	0	10	10	10	3
Req. 60	0	10	10	10	5
Stand. 80	0	10	10	10	7

We are going to be using our phones to use the bluetooth software. The user can communicate with the robot via bluetooth.

	UltraSonic Sensor Software				
Criteria	**The robot will follow any sounds that are closest to it.**	**The robot will follow sounds that the user's robot app emits.**	**The robot will freeroom without following any sounds.**	**The robot will follow the user, until the user stops moving.**	**The robot will follow any user that owns the robot app.**
Req. 70	10	10	0	10	10
Req. 90	0	10	0	10	3
Stand. 70	6	10	0	10	8

The robot will use ultrasonic sensor software to follow the user, until the user stops moving.

	Infrared Sensor Software			
Criteria	**The robot will follow anyone with a recognizable face**	**The robot will follow multiple different things**	**The robot will follow one specific person**	**The robot will randomly follow anything it sees**
Req. 10	8	7	10	0
Req. 90	4	3	6	0
Stand. 20	7	6	8	0

The Infrared Sensor will be implemented to follow one specific person, to ensure that the user always is close to the robot in case there is a need for items inside of it.

	Camera Broadcasts to the Phone			
Criteria	**The camera will save its video after completing its task to the phone.**	**The camera will live broadcast a video to the phone.**	**The camera will live broadcast a video to a website via the phone's**	**The camera will live broadcast a video to the phone +**

			internet. (remove if necessary)	save its video after completing its task to the phone
Req. 60	6	8	5	10
Req. 110	6	8	5	10
Stand. 20	10	10	10	10

The camera will broadcast a video to the user's phone, as well as optionally save the video to either the device or to a memory card on the robot.

	Operating System	
Criteria	**Apple IOS**	**Android**
Security	More Secure	Less Secure
App Ecosystem	Less simple and convenient	Simpler and more convenient
Support	Better support	Not as good as IOS support

Apple IOS will be the operating system used for designing the app. This system is considered very secure, with better support and an easier IDE.

	Implemented Language		
Language	**C++**	**C**	**Python**
Ease of Use	Easier than C	Easy	Easier than C and C++
Compilation Speed	Faster than Python	Faster than Python	Slower than C
Programming Model	Procedural & Object Oriented	Procedural	Object Oriented
Recognized by IOS and Android? (Y/N)	Y	Y	N

C will be the programming language used for the system. It is considered easy to use and understand, it compiles fast, and it is recognized by both IOS and Android.

Group 07 *Project Title: Lead the Way*

Major: **Team members:**

ITC *Jordan White*

CS CaiHong Novak

CS Derrick Thompson

CS Nicholas Mize

EE Samuel Basham

Test and Evaluation Master Plan

Design Requirement	***Test Method***	***Analysis Method***	***Performance Threshold***	***Performance Objective***
Req. 10	Experimentation	Measurement	The robot will be placed on a flat surface.	The robot will be able to follow the user without major issues.
Req. 20	Experimentation	Measurement	The robot's parts will not be hindered by the 1lb of storage	The robot will be able to maintain following the user at this weight capacity.
Req. 40	Measurement	Measurement	The robot will actively charge all components	The robot's capacity will not exceed 10Ah
Req. 50	Experimentation	Measurement	The robot will be able to move	The robot's maximum speed will not exceed 50

			around	cm/s
Req. 60	Experimentatio n	Experimentation	The robot will be able to send and receive a signal	The robot will be able to actively communicate with a device for a long period of time
Req. 70	Experimentatio n	Experimentation & Measurement	The robot’s speakers will be audible	The robot will have a decibel range of 60-70dB
Req. 80	Measurement	Measurement	The robots weight shall not affect the overall efficiency of its parts	The robot will be able to carry multiple items (still not exceeding)
Req. 90	Experimentatio n	Experimentation	The robot can detect a person	The robot can detect a person and make reactive “decisions” in its environment
Req. 100	Experimentatio n	Measurement	The robot will be able to last for as long as testing occurs	The robot will be able to last all day (24hr charge).
Req. 110	Experimentatio n	Observation	The robot has ample time to detect a fall	Once the robot detects the fall, it move in the other direction
Req. 120	Experimentatio n	Observation	Stored video of the user	Live video of the user

Design Constraint	***Test Method***	***Analysis Method***	***Performance Threshold***	***Performance Objective***
Const 10	Measurement	Measurement	The robot shall have a	The robot's height shall range from 30cm-45cm.

			height no more than 45 cm.	
Const 20	Measurement	Measurement	The robot shall have a depth no more than 45 cm.	The robot’s depth shall range from 30cm-45cm
Const 30	Measurement	Measurement	The robot shall have a width no more than 60 cm.	The robot’s width shall be no longer than 60 cm.
Const 40	Measurement	Measurement	The robot speed will not exceed 50 cm/s.	The robot’s speed shall not exceed 50 cm/s.
Const 50	Experimentation	Experimentation	The robot’s battery shall not exceed 10 Ah.	The robot’s range shall be 5Ah-10Ah
Const 60	Measurement	Measurement	The robot’s total price will not exceed $300.	The robot will be priced from a range of $200-$300
Const 70	Measurement	Measurement	The robot shall have a weight no more than 20kg.	The robot will have a weight range of 10kg-20kg
Const 80	Measurement	Measurement	The robot shall be louder no more than 70 decibels.	The robot will have a audio range of 60-70dB
Const 90	Measurement	Measurement	The robot shall have a temperature that is not too high/low for touch.	The robot will have a average temperature ranging from 0-35°C
Const 100	Experimentation	Measurement	The system shall have no more than 5	The system shall have a state of operation for turning on, off, stopping,

			states of operation.	going, and panicking.

Design Standard	***Test Method***	***Analysis Method***	***Performance Threshold***	***Performance Objective***
Std. 10	Observation	Observation	The robot will apply the software life cycle process.	The robot's software will be up to date with the software life cycle process.
Std. 20	Observation	Observation	The robot shall apply the safety requirements to reduce risks for the users.	The robot will meet the requirements to reduce risks of the user's safety.
Std. 30	Experimentation	Observation	The robot shall apply the safety requirements that reduce risks for mobile robots.	The robot will meet the guidelines that must apply to mobile robots.
Std. 40	Experimentation	Measurement	The robot shall apply the safety-related parts of control systems that will reduce risks for the user.	The robot will meet the required guidelines for related parts of control systems.
Std 50	Measurement	Measurement	The robot shall have a weight no more than 20kg.	The robot's max weight will range 15kg-20kg.
Std. 60	Measurement	Measurement	The robot shall have a speed no more than 50 cm/s.	The robot's max speed will range 40 cm/s - 50 cm/s.
Std. 70	Experimentation	Experimentation	The robot shall comply with one or more communication standards.	The robot complies with IEEE 802.11 the same as a laptop, printer or

				other device would.
Std. 80	Experimentation	Observation	The robot shall comply with electrical connection standards.	The robot complies with IEEE 2025.1 on electrical connection standards.
Std. 90	Experimentation	Observation	The robot shall comply with guidance and system navigation standards.	The robot complies with IEEE 1559-2022 As an inertial system.
Std. 100	Experimentation	Observation	The robot shall comply with human interaction standards.	The robot complies with ISO 10218-2 on human interaction standards.

Design Requirement	***Test Date***	***Location***	***Time***	***Condition***	***Results***	***Notes***
Req. 10						
Req. 20						
Req. 40						
Req. 50						
Req. 60						
Req. 70						
Req. 80						
Req. 90						
Req. 100						
Req. 110						

Req. 120						

Design Constraint	***Test Date***	***Location***	***Time***	***Condition***	***Results***	***Notes***
Const. 10						
Const. 20						
Const. 30						
Const. 40						
Const. 50						
Const. 60						
Const. 70						
Const. 80						
Const. 90						
Const. 100						

Design Standard	***Test Date***	***Location***	***Time***	***Condition***	***Results***	***Notes***
Std. 10						
Std. 20						
Std. 30						
Std. 40						
Std. 50						
Std. 60						
Std. 70						
Std. 80						
Std. 90						

Std. 100						

Test and Evaluation Methods

Requirements (verification of achievement):

Requirement #10:

The robot shall be able to follow the user for at least 1 minute. The test method is as follows: The user will be in front of the robot walking forward while the robot will follow the same direction the user is going. The result will be the behavior the robot showcases during the duration it follows the user. The threshold is the robot following the user for a minute.

Requirement #20:

The robot shall carry up to 1 lb of items in its storage. The test method follows: The user will put an item inside the robot's storage bin, and the robot can carry an item that weighs less than 1 lb. The results will be the observations of the items the user puts in the robot's storage bin. The threshold is the robot storing items that weigh less than 1 lb.

Requirement #30:

The robot shall have wifi capabilities. The test method follows: The user will be able to connect to the robot via wifi. The results will be observing the user's connection to the robot via wifi. The threshold is the user connecting to the robot via wifi.

Requirement #40:

The robot will emit auditory sounds. The test method follows: The robot will emit auditory sounds that will get the user attention. The results will be the demonstration of the robot emitting auditory sounds that will notify the user. The threshold is the user noticing the auditory sounds being emitted by the robot.

Requirement #50:

The robot shall be able to detect when the user is changing directions and adjust accordingly with the user. The test method follows: The robot will follow the same direction as the user; if the user decides to turn around, the robot will adjust and turn around just like the user. The result is observing how the robot adjusts its position by following the user's movements. The threshold is the robot detecting the user's directions and adjusting accordingly with the user.

Requirement #60:

The robot shall have a battery life of approximately 24 hours. The test method follows: The user will observe the robot's battery life by timing how long the battery will keep running. The result is demonstrated through the battery life using a timer to measure how long the battery will keep running. The threshold is the robot's battery life of approximately 24 hours.

Requirement #70:

The robot shall be able to detect drops in height to avoid falls that could be damaging. The test method follows: The robot will follow the user until it detects a drop in height, then it will either stop its movement or take a different path to follow the user again. The result demonstrates that the robot detects height drops, then it will avoid the fall by stopping or changing its path. The threshold is the robot detecting the drops in height to avoid falls that could damage it.

Requirement #80:

The robot shall have a camera video capture of the user. The test method follows: The user will observe the robot's camera's video by connecting the robot's camera to the user's robot app. The result demonstrates that the user can view the robot's camera video via the robot app. The threshold is the robot sending live camera videos to the user's robot app.

Constraints (verification of achievement):

Constraint # 10:

The robot shall be no more than 45 cm in height. The test method follows: Once constructed the robot's dimensions will be measured including height. A tape measure or the measure app on our mobile phones will be used.

Constraint # 20:

The robot shall be no more than 45 cm in depth. The test method follows: Once constructed the robot's dimensions will be measured including depth. A tape measure or the measure app on our mobile phones will be used.

Constraint # 30:

The robot shall be no more than 60 cm in width. The test method follows: Once constructed the robot's dimensions will be measured including width. A tape measure or the measure app on our mobile phones will be used.

Constraint # 40:

The maximum speed shall not exceed 50 cm/s. The test method follows: The robot will be placed behind a user and activated. Then the user will walk around slowly to ensure the robot is following and then they will increase their speed to 50 cm/s (1.112 mph) then move slightly faster to make sure the robot cannot accelerate further.

Constraint # 50:

The robot battery capacity shall be at most 10 Ah. The test method follows: The robot's battery will be demonstrated and observed to see if the battery meets the specifications of the requirement. The results will be the robot being powered by the battery's amps. The threshold is the battery's amps being at most 10 Ah.

Constraint # 60:

The total price of the system shall not exceed $300. The test method follows: Parts will be ordered, if $300 is exceeded then we simply won't receive all parts ordered and be told to find cheaper components.

Constraint # 70:

The robot shall weigh no more than 20 kg. The test method follows: Once fully constructed and battery installed and connected the robot will be placed on a scale to obtain an accurate reading for weight.

Constraint # 80:

The robot shall be no louder than 70 decibels. The test method follows: A user will use an app on their mobile device to measure the decibels the robot produces.

Constraint # 90:

The robot shall not reach a temperature too low/high for the user to touch. So no higher than 109 degrees fahrenheit and no lower than -3 degrees fahrenheit. (Not that it will reach those temperatures but those are the max and min for human touch to prevent pain or freezing). The test method follows: The robot will be observed in its different states of operation and its temperature measured in each state.

Constraint # 100:

The system will have no more than 5 states of operation. The test method follows: The robot will be activated and cycled through its 5 states while being observed to ensure it can only operate in one of those states.

Standards (verification of achievement):

<u>Std # 10:</u>

ISO/IEC 12207:2008 - Systems and software engineering -- Software life cycle processes", ISO, 2008. The test method follows: The battery life for the robot will be monitored throughout its use, and the time it takes for the batteries to completely drain will be recorded.

<u>Std # 20:</u>

ISO 13482 - Robots and robotic devices — Safety requirements for personal care robots. The test method follows: The robot will be cycled through its different states and all of its abilities will be tested to determine if it meets safety requirements while operational.

<u>Std # 30:</u>

AANSI/RIA R15.08-1-2020 American National Standard for Industrial Mobile Robots - Safety Requirements. The test method follows: The robot will be cycled through its different states and all of its abilities will be tested to determine if it meets safety requirements while operational.

<u>Std # 40:</u>

ISO 13849-1 - Safety of machinery — Safety-related parts of control systems. The test method follows: The robot will be observed in its different states and while following a user. It will also be observed while avoiding obstacles to determine if it complies with ISO 13849-1.

<u>Std # 50:</u>

Robots shall comply with one or more communication standards such as IEEE 802.11. The test method follows: The user will broadcast its phone to test the signal input/output of the robot.

<u>Std # 60:</u>

Robots shall comply with electrical connection standards such as IEEE 2025.1. The test method follows: The user will experiment on the robot to ensure it meets the electrical connection standards.

<u>Std # 70:</u>

Robots shall comply with guidance and system navigation standards such as IEEE 1559-2022. The test method follows: The user will experiment with the robot to ensure that it will be able to detect obstacles to react to.

<u>Std # 80:</u>

Robots shall comply with human interaction standards such as ISO 10218-2. The test method follows: The robot will be observed in every state of operation and while idle to ensure it is always safe for human interaction and repeated handling.

Group 07 *Project Title: Lead the Way*

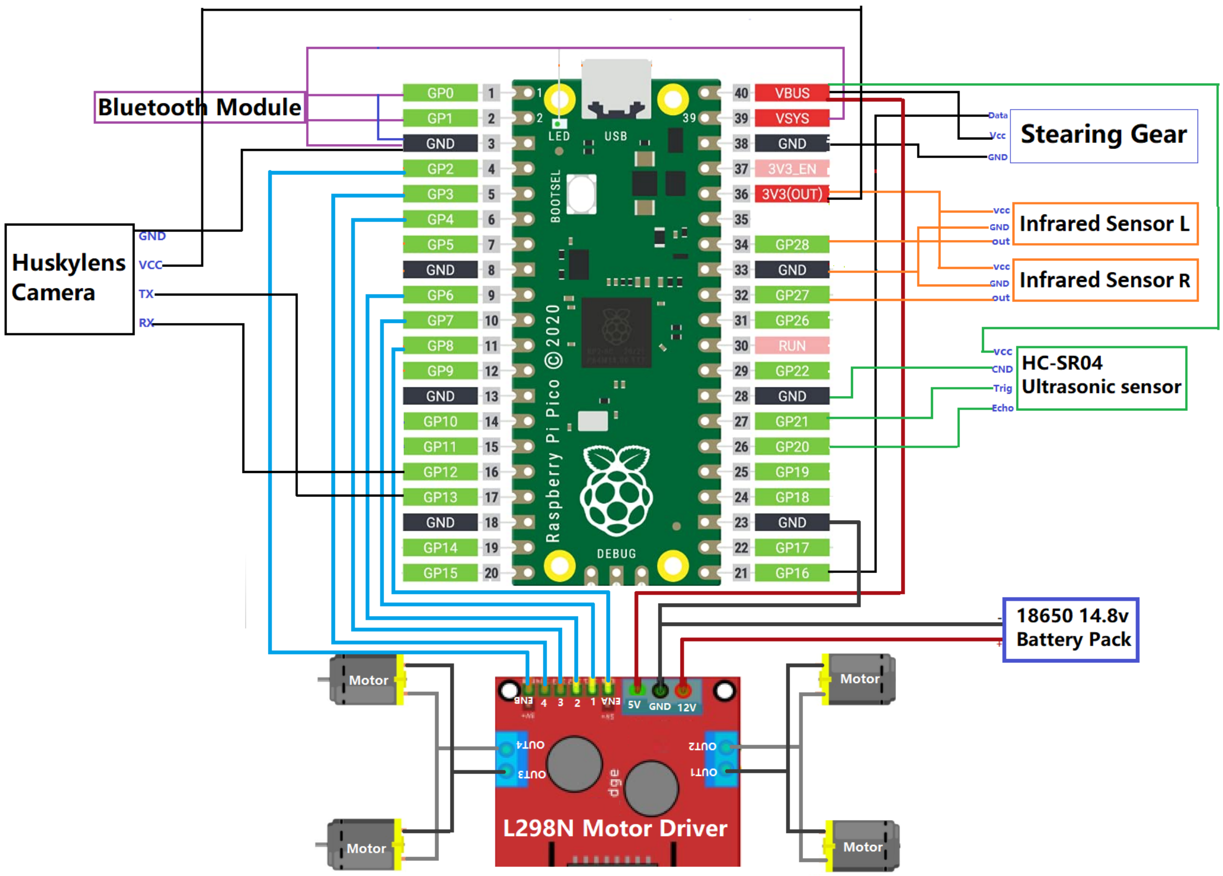
Major:	**Team members:**
ITC	*Jordan White*
CS	CaiHong Novak
CS	Derrick Thompson
CS	Nicholas Mize
EE	Samuel Basham

Implementation Plan

Interface Control

Hardware:

- The body is the foundation all other components will be built on.
- The Battery holder will house the batteries and will be placed directly on the body. The battery charger will not be built into the robot but will be used separately.
- The voltage regulator will be connected directly to the battery via the terminals in order to regulate the voltage. The regulator will also be connected to the driver expansion board.
- The 4 motors will be connected to the body via motor clamps and bolts. The motors will be connected to the wheels, 1 motor per wheel. The motors will all also be connected to the motor driver via the motor screw terminals and inputs on the driver, 2 motors to each motor driver.
- The steering gear will also be connected to the camera via camera mount
- The motor drivers will be inserted into the driver expansion board along with the microcontroller. There will be 1 driver on each side controlling two wheels each
- The microcontroller and motor driver will be connected together via pins so that the motor drivers will be able to control the motors correctly.
- The infrared sensors will be connected to the driver expansion board via gpio pins
- The ultrasonic sensor will be connected to the driver expansion board via gpio pins and will also be connected to the steering gear to help the robot avoid obstacles.
- The bluetooth module will be connected to the driver expansion board and linked wirelessly to the smartphone being used.
- The speaker will be connected via gpio pins to the driver expansion board.
- The wifi and camera module will be connected via pins to the driver expansion board as well as connected wirelessly to the smartphone.



Software:

- The smart phone controller will be connected to our robot app via bluetooth.
- The robot's Wi-fi will be connected to the user's smartphone to communicate instructions via robot app.
- The robot's camera will send video feed back to the user's smartphone via the robot app.
- The microcontroller software will be embedded into the robot giving the robot software control functions.
- The driver expansion board software will allow the robot to interface with wifi, camera, bluetooth ultrasonic sensor, and infrared sensors.
- The ultrasonic sensor software will allow the robot to follow the user by using ultrasound waves.
- The infrared sensors software will allow the robot to avoid objects that it detects using pulses that it outputs from its system.

Budget

	Vendor	Item #	Description	Qty	Price each	Total	Link
13	Robot Shop		Raspberry Pi Pico W	1	$9.98	$9.98	https://www.robotshop.com/products/raspberry-pi-pico-w
14	Robot Shop		Raspberry Pi Headers Kit	1	$1.53	$1.53	https://www.robotshop.com/products/raspberry-pi-pico-headers-kit
15	Robot Shop		Raspberry Pi Pico GPIO Expansion Board	1	$7.48	$7.48	https://www.robotshop.com/products/raspberry-pi-pico-gpio-expansion-board
16	Robot Shop		Huskylens Vision Sensor	1	$57.43	$57.43	https://www.robotshop.com/products/gravity-huskylens-ai-machine-vision-sensor
17	Robot Shop		12V 25Mm Gear Motor, 17rpm	4	$6.58	$26.32	https://www.robotshop.com/products/12v-25mm-gear-motor-17rpm
18	Amazon		Honbay L298N Motor Drive Controller Board	2	$6.00	$12.00	https://www.amazon.com/Controller-H-Bridge-Stepper-Mega2560-Duemilanove/dp/B01CC8XI60/ref=asc_df_B01CC8XI60/?tag
19	Robot Shop		M5Stack SG90 Servo Steering Gear	1	$5.50	$5.50	https://www.robotshop.com/products/m5stack-sg90-servo
20	Amazon		14.8V Li-ion Battery Pack Charger	1	$17.99	$17.99	https://www.amazon.com/Tenergy-Universal-TLP3000-Charger-Li-polymer/dp/B00JFCJP1Y/ref=sxin_25_sbv_search_btf?conter
21	Robot Shop		IR Break-Beam Sensor	1	$5.09	$5.09	https://www.robotshop.com/products/ir-break-beam-sensor-50cm
22	Robot Shop		Dual-Mode Bluetooth Module for Raspberry Pi Pico, SPP / BLE, Bluetooth 5.1	1	$4.49	$4.49	https://www.robotshop.com/products/hc-05-bluetooth-module-velleman
23	DigiKey		18650 14.8 V Lithium-Ion Battery Pack	1	$39.00	$39.00	https://www.digikey.com/en/products/detail/dantona-industries/L148A34-4-3-2W/16539000
24	Robot Shop		Thin Speaker - 0.5W	1	$1.20	$1.20	https://www.robotshop.com/products/thin-speaker-05w
25	Adafruit		3.3V 800mA Voltage Regulator	3	$1.25	$3.75	https://www.adafruit.com/product/2165
26	Adafruit		5V 1.5A Voltage Regulator	5	$0.75	$3.75	https://www.adafruit.com/product/2164
27	Robot Shop		Aluminum 3mm Sheet	1	$16.00	$16.00	https://www.robotshop.com/products/aluminum-3mm-sheet-4-5-5pk
28	Robot Shop		Mecanum wheels	1	$32.00	$32.00	https://www.robotshop.com/products/mecanum-wheel-65mm-high-hardness-plastic-wheel-robot-car
29	Robot Shop		6" M/F Jumper Wires (10pk)	1	$1.80	$1.80	https://www.robotshop.com/products/jumper-wires-78-m-f-10pk
30	Robot Shop		6" M/M Jumper Wires (20pk)	1	$2.10	$2.10	https://www.robotshop.com/products/6-m-m-jumper-wires-20pk
31	Amazon		Black 25mm DC Gear Motors Mounting Bracket(6pk)	1	$11.99	$11.99	https://www.amazon.com/JIUWU-Gearbox-Reduction-High-hardness-Anti-rust/dp/B07HHY2BJN/ref=asc_df_B07HHY2BJN/?tag=hyprod-20&linkCode=df0&hvadid=309775248366&hvpos=&hvnet
32	Inventory		HC-SR04 Ultrasonic sensor	1	$0.00	$0.00	SENIOR LAB INVENTORY
33	Robot Shop		Switch (For Testing Purposes)	2	$1.05	$2.10	https://www.robotshop.com/products/sfe-on-off-rocker-switch
34							
35							
36							
37					Shipping & Handling	$0.00	
38					Order Total	$261.50	

Link to Budget:
https://docs.google.com/spreadsheets/d/1optMn8kgoc9_cEQ5AND1erwXbBexBA90/edit#gid=176092227

Schedule

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION (DAYS)	PCT OF TASK COMPLETE
1	**Ordering Robot Parts**					
1.1	Research part suppliers	All	3/1/23	4/25/23	54	100%
1.2	Create a list of parts to order	Jordan/Caihong	3/18/23	4/25/23	37	50%
1.3	Parts ordered	Sam B	4/21/23	8/25/23	124	0%
1.3.1	Parts are received	Sam B	8/25/23	9/4/23	9	0%
1.4	Inspect parts	Derrick T	8/25/23	9/4/23	9	0%
1.5	Assemble Parts	Sam B	9/4/23	9/8/23	4	0%
1.6	Document parts in inventory	Niko	9/4/2023	9/8/23	4	0%
2	**Designing model/prototype**					
2.1	Create a working blueprint	Jordan/Sam	9/11/23	9/15/23	4	0%
2.2	Build prototype	Jordan/Sam	9/15/23	9/22/23	7	0%
2.3	Conduct user testing	Caihong	9/20/23	9/27/23	7	0%
3	**Hardware Development**					
3.1	Soldering on Microcontroller	Sam B	9/29/23	9/29/23	0	0%
3.2	Develop proper power supply system	Sam B	10/2/23	10/6/23	4	0%
3.2.1	Battery Management	Niko	10/6/23	10/11/23	5	0%
3.2.2	Stress testing all hardware components	Caihong	10/16/23	10/16/23	0	0%
3.3	Conduct integration tests (everything works together)	Caihong	10/16/23	10/20/23	4	0%
3.3.1	Refine hardware system	Jordan	10/20/23	10/25/23	5	0%
4	**Software Development**					
4.1	Define software architecture	Derrick/Niko	10/23/23	10/27/23	4	0%
4.2	Develop infared/ultrasonic software	Derrick T	10/27/23	10/31/23	4	0%
4.3	Develop motion tracking algorithm	All	10/23/23	11/10/23	17	0%
4.4	Develop app/app functionality	Caihong	10/23/23	11/6/23	13	
4.5	Develop camera facial recgonizition using robot kit template	Jordan	10/23/2023	11/6/23	13	
4.6	Test coverage and analysis	All	11/1/23	11/10/23	9	0%

PHASE ONE			PHASE TWO			
Augst 21st 2023	August 28th 2023	September 4th 2023	September 11th 2023	September 18th 2023	September 25th 2023	October 2nd 2023
M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F

Link to schedule:
https://docs.google.com/spreadsheets/d/1wYxIQrv7q7EING6AglAr-RFZDkjVbp0x-PuV44vSXhw/edit#gid=0

Risk Analysis

- **Schedule Risks:**

- Risk of schedule because of bad weather. Likelihood is moderate, but the severity of impact is high. Mitigations: Talk with members to get extra time to the schedule to make up lost time.

Bad Weather	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3				**X**	
	2					
	1					

- Risk of being sick. Likelihood is moderate, but the severity of impact is high. Mitigations: Inform the group members and advisors that they are feeling ill and to make extra time on the schedule.

Sick	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3					**X**
	2					
	1					

- Risk of members having trouble keeping up with their schedule. Likelihood is moderate, but severity of impact is high. Mitigations: Talk with members and keep them updated on their schedules. If they are having trouble keeping up with their schedule, they ask if other members can help with their part of the assessments.

Trouble with schedule	*Severity of Impact*					
		1	2	3	4	5

Likelihood of occurrence	5					
	4					
	3					**X**
	2					
	1					

- **<u>Mobile App Risks:</u>**
- Risk of Mobile app will not connect to the robot. Likelihood is moderate, but the severity of impact is high. Mitigations: We will asset our members and spend time helping them solve this issue.

No connection to robot	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3				**X**	
	2					
	1					

- Risk of not implementing a programming language to our robot's mobile app. Likelihood is moderate and severity is moderate. Mitigations: We will be implementing a programming language C/C++.

Programming language	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3		**X**			
	2					
	1					

- **<u>Processing Power Risks:</u>**

- Risk of processing low amounts of power to the robot. Likelihood is moderate and the severity is moderate. Mitigations: Talk with members to discuss how to process the right amount of power to the robot.We will talk with the instructor if we need to find new parts for the robot.

Low Power	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3		X			
	2					
	1					

- Risk of processing excessive amounts of power to the robot. Likelihood is low, but the severity is high. Mitigations:Check the voltage of the robot and decide if the robot's hardware has a small input voltage or if the robot's battery is too high.

Excessive Power	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3					
	2				X	
	1					

- **Human Risks:**
- Risk of robots harming humans. Likelihood is moderate, but the severity of impact is high. Mitigations: We will install infrared sensors in our robot to lower the chance of the robot harming a human.

Harming Humans	*Severity of Impact*					
		1	2	3	4	5
Likelihood	5					

of occurrence	4					
	3					X
	2					
	1					

- Risk of excessive decibels that can cause damage to an individual’s ears. The likelihood is moderate, but the severity of the impact is high. Mitigations: We will measure the decibels of the robot to lower the risk of harming a human.

Risk of excessive	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3				X	
	2					
	1					

- **<u>Security</u>**
- Risk of the robot being hacked by a cyber-attacker. The likelihood is low, but the severity of the impact is high. Mitigations: We will turn off the power of our robot and tell our instructor that our robot got hacked. Once the instructor gives us instructions, we can improve our robot’s security.

Risk of being hacked	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3					
	2					
	1					X

- Risk of the robot being stolen by a robber. The likelihood is moderate, but the severity of the impact is high. Mitigations: We will install a panic button on the robot app, alerting the user that a robber is stealing the robot.

Risk of being stolen	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3					**X**
	2					
	1					

- **<u>Risk of Costs</u>**
- Risk of going over the budget. The likelihood is low, but the severity of the impact is moderate. Mitigations: We will discuss the costs of our robot parts among our group. We can discuss what parts need to be exchanged if we need to change our budget.

Risk of costs	*Severity of Impact*					
		1	2	3	4	5
Likelihood of occurrence	5					
	4					
	3					
	2			**X**		
	1					

- **<u>Risk of System Performance</u>**
- Risk of failure with the systems performance. The likelihood is moderate and the severity of the impact is moderate. Mitigations: We will discuss how to improve our robot's system performance. We can take notes and ask our instructor how to improve our robot's performance.

Risk of system performance	*Severity of Impact*					
		1	2	3	4	5

Likelihood of occurrence	5					
	4					
	3			X		
	2					
	1					

Resumes:

Derrick Thompson

6950 Alter Road, Huber Heights, OH 45424
(937) 716-5552 E-mail: dprotoss@yahoo.com

EDUCATION

Bachelor's in Computer Science

Grad Date: Dec 2023

Wright State University, Dayton, Ohio

Ohio State University, Columbus, Ohio

August 2018-Fall 2021

RELEVANT COURSEWORK

- Intro Operating Systems
- Info System Analysis & Design
- Database Management
- C++ Software Development
- Network Fundamentals
- Cybersecurity
- HPC & Parallel Programming
- Operating Systems and Usage
- Intro Machine Learning
- Data Structures & Algorithms
- Java Software Development
- Comparative Languages

TECHNICAL SKILLS

- *Programming Language:* C++, Java, Python, HTML5, CSS, Lua, C#, SQL, bash,
- *Operating Systems:* Proficient in Windows 10, Basic knowledge in Linux
- *Software Applications:* Microsoft Office Products, Jupyter, DaVinci, BarTender

WORK HISTORY

Kroger – Marion, Ohio

Clicklist Employee September 2018 – April 2019

- Quickly and efficiently looking for items
- Resolving problems quickly
- Introduction to customer service

Ohio State University – Marion, Ohio January 2020
– March 2020
Student Worker
- Knowledge with C++
- Resolved student issues regarding projects
- Grading team projects

Chipotle – Marion/Fairborn, Ohio
Up front server May 2021
–October 2022
- Resolved customer issues.
- Reported customer issues and concerns to the manager.

RELEVANT PROJECTS
- Created a simple game using **Lua.**
- Worked in *Unity* with a team using **C#.**
- Built a GUI calculator using **Java**.
- Developed an organization tree program using **C++** and basic data structures.
- 2nd Place winners at *Make-IT-Wright Hackathon*, which included working in **Java** and **BarTender**.

Samuel Basham

1102 Salem Ave 1D
Dayton, OH 45406
(740) 352-9439
Basham.8@wright.edu
www.linkedin.com/in/samuel-basham-366013200

Electrical Engineering student searching for a co-op for any period of time to gain skills and knowledge in the EE field.

EDUCATION

Wright State University, Dayton, Ohio — *BS in Electrical Engineering*

August 2016 - Present

Pursuing a Bachelor of Science degree in Electrical Engineering. Have gained experience and become familiar with AutoCAD, MATLAB, Multisim, Pspice, C Programming, and Circuit analysis&design.

RELEVANT PROJECTS & EXPERIENCE

Electrical Engineering Co-op — *Honeywell Intelligrated*

Assisted engineers with various projects. Became familiar and comfortable with AutoCAD Electrical working on data extracts with schematics and learned how to use the program efficiently daily. Worked on site a few times assisting with inventory at a warehouse as well.

Electromagnetics Lab — *Ex. Microwave Circuit Power Model*

Used a simple microwave circuit where a signal generator was connected to an antenna and analyzed the impedance seen by the generator, the power delivered to the antenna, and the power dissipated by the generator.

Devices/Circuits Lab — *Ex. Zener Diode*

Learned the operations of Zener and LED diodes in various applications. Designed a DC voltage regulator to provide certain conditions and then built it using Multisim.

Devices/Circuits Lab — *Ex. BJT Amplification Circuits*

Learned design of BJT amplification circuits. Designed a voltage divider biased common emitter amplification circuit with given specifics. Performed DC as well as AC analysis then constructed the circuit in Multisim.

LANGUAGES

English, conversational proficiency in French

Skills

Microsoft Office, AutoCAD Electrical, Excellent Communication skills, detail oriented, collaborative, excellent organizational skills, data collection and analysis.

WORK EXPERIENCE

Honeywell Intelligrated, Mason, Ohio — *EE intern*

May 2022 - August 2022

Completed a co-op term gaining experience and assisting engineers with various projects. Became familiar and comfortable with AutoCAD Electrical working on data extracts with schematics. Worked on site a few times assisting with inventory at a warehouse as well.

JORDAN A. WHITE

EDUCATION

Bachelor of Science in Computer Science **2018-Present**
Wright State University, Dayton, Ohio

WORK EXPERIENCE

Computer Science **2018-Present**
Wright State University

- Computer programming, data analysis, technical writing, and web development

2019-Present
Dunkin

- Responsible for managing the donut case, communicating with customers, managing the front register, and restocking Dunkin supplies.

SKILLS

- Cooperation
- Communication
- Time Management
- Organization

RELEVANT COURSEWORK

- Java
- Python
- HTML5
- Web development

TRAINING AND CERTIFICATES

Yellow Springs Honor Student Certification **6 May 2018**

Nicholas D. Mize

mize.9@wright.edu

EDUCATION

Bachelor's of Science in Computer Science **Fall 2023**
Wright State University, Dayton, Ohio

WORK EXPERIENCE

Customer Service Rep./Pizza Maker **2016-2017**
Domino's, Dayton, Ohio

- Answer phones, help in store customers, fulfill orders which includes making food

Shipping and Assembly **2017-2019**
Tech Products Corp., Dayton, Ohio

- Assembled many vibration/shock control mounts, which includes using hydraulic presses
- Packaged and shipped vibration/shock control mounts

SKILLS

- Python
- Java/JavaFX
- Linux
- Networking
- HTML/CSS
- C/C++

RELEVANT COURSEWORK

- Intro to Computer Science I and II
- Computer Organization
- Operating Systems and usage
- Data Structures and Algorithms
- Databases and Modeling

TRAINING AND CERTIFICATES

Cisco Certified Network Associate **May 2017**

Caihong Novak(US citizen)

3901 Honeybrook Avenue, Clayton, OH

(937) 814-5109 E-mail: caihongnk@gmail.com

EDUCATION

Associate degree of Computer Science

Grad Date: May 2022

Sinclair Community College

Bachelor's in Computer Science
Grad Date: May 2024

Wright State University, Dayton, Ohio

RELEVANT COURSEWORK

- *Intro Operating Systems*
- *Network Fundamentals*
- *Info System Analysis & Design*
- *Data Mining*
- *Data Structures & Algorithms*
- *Java Software Development*
- *C++ Software Development*
- *Cybersecurity*

TECHNICAL SKILLS

- *Programming Language: C, C++, Java, Python, Ruby, HTML5, CSS, JavaScript, PHP*, *JQuery, MySQL, Matlab*
- *Operating Systems:* Windows XP,7,10 and Linux
- *Software Applications:* Microsoft Office Products,Github

RELEVANT PROJECTS

HTML, CSS, JavaScript,PHP, jQuery Projects:

http://caihongnk.57dfkljji5.zhihuanche.cn/
http://caihongnk.57dfkljji5.zhihuanche.cn/anotherPage

Java, JUnit Project:

This project base assignments' collection went through the whole course(Java development II). It is divided into source code and the JUnit test code. It covers the key concepts that are very import in Java:

It allow me to apply knowledge of Java Collection Framework to deal with data(primitive type as well as self-defined class type)Concepts of polymorphism and abstraction (Each single package is an assignment and I needed to implement a new interface or override the methods of an existing interface).Other concepts such as recursion, sorting algorithm,Exception handling and basic I/O concepts.

Java, GUI Design, MySQL, Agile Project:

I worked with 2 other students created a software development project using Agile for the CEG 4110 class.

The project is a simple library system.It is featured with capabilities to store book data in the MySQL database.

The user interfaces in this project allow users to manipulate data including adding, deleting and modification.

Project documents: https://github.com/WSU-DGsc##########e/main/doc

Project source codes: https://github.com/WSU-DGs##########ystem/tree/main/src

Java, Data Mining Project:

My project from the CS 4710 Data Mining class (Source codes not provide due to academic policy).

It is a very tough project that required thorough understanding the data mining concepts such as Entropy,Information Gain and Binning. And then apply the understanding into writing a program that able to do pattern mining, items classification.Here is the recorded YouTube link: https://youtu.be/NXKbunWKi2E

Microcontroller programming

Experiences programing 51 MCU,STEM32,raspberry pi pico using python / C++/C

Other Projects and Demo:

Projects Demo Link:

http://caihongnk.57dfkljji5.zhihuanche.cn/myProjectsDemoPage

YouTue Demo Link:

http://caihongnk.57dfkljji5.zhihuanche.cn/myYoutubeDemo