The Semi-Autonomous Car

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A semi-autonomous car that uses microcontrollers to wirelessly send video, audio, and feedback data to a virtual reality headset and control system to dissuade impaired driving.

EXECUTIVE SUMMARY

Driver-assistance systems and automotive safety features are nothing new to daily life of those who own a road vehicle or not. Systems such as anti-lock braking and cruise control are standards to 'safe' vehicles. More advanced systems, such as lane centering or a blind spot monitor have become more and more common as well, taking care to account for human error and correcting poor decisions made. However, the rise of fully-automated vehicles and artificial intelligence has consumers hesitant to place their lives and the lives of others inside and outside the car in the hands of ones and zeros. The semi-autonomous car aims to find a compromise between the two sides.

The inspiration behind an integrable remote-controlled vehicle system came from the group's personal experiences with impaired driving, whether it is that someone is too tired, intoxicated, or anything that would cause a similar impairment. Ideally, the driver of the vehicle would contact a friend at home who would 'log in' to the car's control system and be able to pilot the car and drive it to the on-board driver's destination. Realizing that this situation is not always the case and that the impaired driver often cannot make that decision for themselves, the focus was shifted to a more regulated system: truck driving. The design then became something that a trucking company can use to monitor their employees and ensure that the employees were following all laws and regulations and, if used properly, would allow drivers to pilot a truck from a headquarters and would not have to live the feared "trucker lifestyle". This could increase employment rates in a troubled industry and expedite shipped goods to keep up with the ever increasing online-shopping demand. This is not to say that the design cannot be used on a personal vehicle to combat drunk driving, only that the design can be used for much more than taking care of a friend: it can save an industry.

The design calls for the ability of the impaired driver behind the steering wheel, the on-board driver, to be able to safely and seamlessly transfer control of the car to a different person, the home driver, and still have a functioning vehicle. The design is a safety feature that, one way or another, transports the on-board driver to their destination without endangering a single life. In order to achieve this goal, we had to simulate the act of driving the car for the home driver to prevent the feeling of a risk-free environment and putting the on-board driver, as well as pedestrians, in danger. Original design features included a high definition, 360° video and audio transmission in real-time, with the idea that the home driver could wear a set of virtual reality (VR) goggles and see everything that the on-board driver could see and hear their surroundings., as well as a control system that emulated a steering wheel and accelerator and brake pedals. While this may create an environment that is similar to physically being in the car, even a perfectly capable driver could make mistakes; so, we decided to add precautionary measures including proximity-based auto-braking and lane control using machine vision.

Many factors have affected the ability to 'roll-out' the project as a fully-formed product, namely the resources that are available for use. The current project uses Wi-Fi as a signal medium for video and controls, however even using 5GHz Wi-Fi band, the signal is not enough to send packets this size in real-time when 5G global networking could do the same job, at a higher resolution and with lower latency. 5G is not currently available so the scope of the project had to be limited. It should also be noted that the team consists of four electrical engineers, and the full scope of the project calls for integration to an existing car and critical data to be sent wirelessly. The team members are not mechanical engineers, nor are they cyber-security specialists. The full scope of the project had to be limited to concepts that the team members were capable of achieving with resources available and current level of education. The 'final' product that is produced is a small-scale model of what could be achieved with the proper resources and mechanical engineers and computer scientists to ensure the safety of the consumer who puts their well-being into the hands of the semi-autonomous car.

***Abstract* - The semi-autonomous car is an integration system that can be implemented to any semi-truck that will create a semi-autonomous vehicle, sending video and feedback data to a control system in real-time, increasing the efficiency of the trucking industry.)**

Truck driving has many ongoing issues that have yet to find a viable alternative. Through means of modern technology, we strive to find creative solutions that will help resolve the issue of truck driving efficiently. It is evident that truck driving can cause take a toll on the drivers and in turn hurt the trucking business. The solution we aim to focus on is to shift the responsibility of driving from the impaired driver to a capable person while also transporting the semi-truck's passengers and cargo. From this, we hand the controls to an unaffected driver who will drive the impaired passenger with a focus on remote pilot capabilities.

Although the technology to properly implement this technology for commercial purposes is not available to the average consumer (such as 5G networking, universal communication between trucks, etc.), stepping stones can be made to move in the direction of achieving this goal. By using microcontrollers that are capable of wireless transmission and a virtual reality headset, a small-scale model of the final product can be made to give entrepreneurs an idea of the life-saving technology that will be available.

This service is a solution we plan to implement to tackle the issues of truck driving. The purpose is to create a solution that will increase employment rates by operating a vehicle while also transporting the driver, passengers, cargo, and vehicle safely. In doing so, an able-bodied driver will have to take control of the vehicle in a fast and convenient manner without being present in the vehicle.

***Keywords* - Autonomous, virtual reality, semi-autonomous car, wireless, Raspberry Pi, Arduino, impaired driving, machine vision, real-time, artificial intelligence, Wi-Fi, microcontrollers, remote control**

I. INTRODUCTION

Technology is rapidly changing, and companies are now working on autonomous self-driving vehicles. There are issues with having artificial intelligence gain complete control of the driving. This project brings back the human factor into autonomous driving. Imagine being able to drive another person's vehicle from a remote location just by using a monitor and a remote.

Having a semi-autonomous vehicle will resolve the societal issues that come with truck driving, such as efficient hours of service, distracted driving, high compliance, and accountability. This service will provide the impaired driver the option to have someone remotely access their vehicle and drive to their destination. Therefore, preventing any possible consequence of driving long hours and increasing efficiency of service hours. There are various components that will be going into making this design idea into a reality.

In order to address our societal problem, we are implementing a semi-autonomous car that efficiently switches shifts between drivers to safely get them to their destination. This semi-autonomous car will then be controlled wirelessly from another location. At this location, someone will be able to control the car with a remote steering wheel which takes over the steering, acceleration, and braking. With the use of sensors and programmed code, the car is then retro-fitted to meet road safety standards. With current technology, we hope to create a viable alternative to designated driver programs to tackle the societal problems that come from truck driving.

The semi-autonomous car is set to feature hands-free driving by way of wireless communication from a remote location. This communication will be through use of Wi-Fi that takes advantage of high-speed data transmission. This communication and data transmission will be used by Raspberry Pi microcontrollers. Each microcontroller will be able to communicate with each other using on-board Wi-Fi modules. Each Raspberry Pi will be responsible for major aspects of the project such as: steering wheel control, functions on the car, and the communication between the camera and headset. The Wi-Fi bands we will take advantage of will be what is available on campus. We are using the campus's Wi-Fi due to the fact it is the fastest way of high-speed transmission and convenience of being readily available.

A major aspect of this project is the wireless transmission of live video feed from the camera to the monitor. A monitor will be used to display camera footage from the car. This camera will feature dynamic movement for the user to see around the vehicle as it in motion. With the monitor, the user is able to see the road around the vehicle. As it is the most difficult part of the project, we will continue to improve communication between both modules and reduce the latency to achieve a smooth video feed.

The next major feature will be controlling the vehicle through use of a remote steering wheel and pedals. The remote steering wheel will send data and control the steering wheel on the vehicle. This will be implemented using actuators to control the steering on the semi-autonomous car. As we input data into the steering wheel, we will transmit the same data wirelessly to the car to control the steering. To control the gas and brake pedals, we will utilize the voltage level of the prototype vehicles speed controller. On an actual vehicle, we would implement force sensors to record input data with each pedal. This data transmission will be through the same Raspberry Pis that communicate to and from the vehicle.

A feature we decided to be an important aspect of this project is the safety precautions that will be implemented in the event of a failure or error. In case of an error through communication or possible collision, we hope to include a preventative measure that prioritizes the passenger's safety. An example of a failsafe measure, we will implement auto-braking to address a failed connection between car and remote-user. This auto-braking will stop the vehicle and then set off a chain of commands to determine the best course of action depending on the event.

On the vehicle, we will control the steering, acceleration, and braking. We will be using a stripped-down remote-controlled car to take advantage of an already-made vehicle for our demonstration. On the RC car, we will mount the camera and microcontrollers. The microcontrollers will be used to control the RC car, camera, and all transmission back and forth to the remote controller.

This approach was our most confident solution that incorporated an electrical engineering background.

II. SOCIETAL PROBLEM

Impaired driving is an ongoing issue that has yet to find a viable alternative. Through means of modern technology, we strive to find creative solutions that will help resolve this issue of driving while impaired. It is evident that impaired driving can cause severe consequences to parties involved, such as serious injuries and death. The solution we aim to focus on is to shift the responsibility of driving from the impaired driver to a capable person while also transporting the car's passengers and cargo. From this, we hand the controls to an unaffected driver who will drive the impaired passenger with a focus on remote pilot capabilities. This service is a solution we plan to implement to tackle the issues of impaired driving. The purpose is to create a solution that will prevent an impaired driver from operating a vehicle while also transporting the driver, passengers, cargo, and vehicle safely. In doing so, an able-bodied driver will have to take control of the vehicle in a fast and convenient manner without being present in the vehicle.

Impaired driving presents itself in many forms. Impaired driving can be defined as operating a motor vehicle while simultaneously being affected by alcohol, legal (and illegal) drugs, drowsiness, certain medical conditions, and even distracting elements inside the car such as a cell phone or rowdy passengers [1]. Drivers most often take advantage of the legal limit of drinking as a precaution instead of a mandatory law that states the human limit of sobriety. People often disregard the need of a designated driver because of their over-confidence while under the influence. We often cannot comprehend the actual limit where we feel under the influence. Another factor that contributes to drivers to operate a vehicle under the influence, is simply not wanting to leave their vehicle behind. Clearly, driving under the influence should not be the option in any case.

Using the knowledge of electrical engineering, we strive to address the technological disparity of remote designated driving to combat impaired driving. The idea of being unable to find someone to drive you home is a constant issue because you may not be able to find an unaffected driver to transport you home. A system where we give the responsibility of designated driving to a friend, family or an experienced unaffected driver ensures that the driver can trust their driver to take them home safely. The user has the option to choose who they trust to drive them home. Although in the event there isn't a designated driver present, our product is intended to be a service that provides a professional driver for the user. This service utilizes semi-autonomous driving to let another driver take control of the vehicle for designated driving. We want to provide the user a remote-piloting service to address the issue of impaired driving.

Trucking companies and truck drivers face various challenges when it comes to their business. More online shopping creates more demand for faster shipping. Companies need more employees to be able to keep up with the rising demand, as well as keep the employees at their company. Many employees are hesitant to live the trucker lifestyle of driving cross-country for long hours and not being able to settle down, while current employees are senior citizens and are constantly retiring. This product reduces the need for the lifestyle, bringing in more new employees, as well as letting the company monitor their employees, reducing the frequency of accidents.

A. *Efficient Hours of Service*

According to the FMCSA, truck drivers are allowed a period of 14 consecutive hours to driver, with a maximum of only eleven hours of driving, only after being off-duty for ten consecutive hours. With this integration system, a truck driver would ideally only stop for food and to refuel the truck, all while the truck is transporting while the driver is off-duty. Only one driver needs to be on the truck for basic maintenance purposes and other drivers can take over the car while 'on-board' driver is off-duty.

B. *High Compliance and Accountability*

Employees will be able to comply with industry work standards, not having to feel the pressure of living the 'trucker lifestyle' and management will be able to supervise and regulate the truck driving much more effectively. A central control headquarters, much like NASA and Mission Control, will provide constant supervision and possibilities for the drivers, on-board or at home, while the sensors and video data from the truck will provide the necessary data for accountability.

C. *Dissuade Distracted Driving*

According to Trucks.com, there are 3 types of distractions: visual, cognitive, and manual [2].

1) *Visual*

Looking away from the road at something that catches the driver's eyes, causing the driver to be unaware of what is going on in front of or around the truck, usually from using a cell phone while driving.

2) *Cognitive*

A distraction that causes the driver to be absent-minded while driving, not actively thinking about traffic, talking to a passenger, concern over work issues, etc.

3) *Manual*

When the driver takes their hands off the wheel for any reason, including eating, fiddling with the radio, or reaching across the cabin.

III. DESIGN IDEA CONTRACT

Although the technology to properly implement this technology for commercial purposes is not available to the average consumer (such as 5G networking, universal communication between cars, etc.), stepping stones can be made to move in the direction of achieving this goal. By using microcontrollers that are capable of wireless transmission and a virtual reality headset, a small-scale model of the final product can be made to give entrepreneurs an idea of the life-saving technology that will be available.

This service is a solution we plan to implement to tackle the issues of impaired driving. The purpose is to create a solution that will prevent an impaired driver from operating a vehicle while also transporting the driver, passengers, cargo, and vehicle safely. In doing so, an able-bodied driver will have to take control of the vehicle in a fast and convenient manner without being present in the vehicle.

Technology is rapidly changing, and companies are now working on autonomous self-driving vehicles. There are issues with having artificial intelligence gain complete control of the driving. This project brings back the human factor into autonomous driving. Imagine being able to drive another person's vehicle from a remote location just by using a VR headset and a remote.

Having a semi-autonomous vehicle will resolve the societal issue of impaired driving. This service will provide the impaired driver the option to have someone remotely access their vehicle and drive them home safely. Therefore, preventing any possible consequence that comes with impaired driving. There are various components that will be going into making this design idea into a reality.

In order to address our societal problem, we are implementing a semi-autonomous car that takes the impaired driver home. This semi-autonomous car will then be controlled wirelessly from another location. At this location, someone will be able to control the car with a remote steering wheel which takes over the steering, acceleration, and braking. With the use of sensors and programmed code, the car is then retro-fitted to meet road safety standards. With current technology, we hope to create a viable alternative to designated driver programs to tackle the societal problem of impaired driving.

The semi-autonomous car is set to feature hands-free driving by way of wireless communication from a remote location. This communication will be through use of Wi-Fi that takes advantage of high-speed data transmission. This communication and data transmission will be used by

Raspberry Pi microcontrollers. Each microcontroller will be able to communicate with each other using on-board Wi-Fi modules. Each Raspberry Pi will be responsible for major aspects of the project such as: steering wheel control, functions on the car, and the communication between the camera and headset. The Wi-Fi bands we will take advantage of will be what is available on campus. We are using the campus's Wi-Fi due to the fact it is the fastest way of high-speed transmission and convenience of being readily available.

A major aspect of this project is the wireless transmission of live video feed from the camera to the headset. A visual feed headset will be used to display camera footage from the car. This camera will feature dynamic movement for the user to see around the vehicle as it in motion. With the headset, the user is able to turn their heads to see the road around the vehicle. As it is the most difficult part of the project, we will continue to improve communication between both modules and reduce the latency to achieve a smooth video feed.

The next major feature will be controlling the vehicle through use of a remote steering wheel and pedals. The remote steering wheel will send data and control the steering wheel on the vehicle. This will be implemented using actuators to control the steering 3 on the semi-autonomous car. As we input data into the steering wheel, we will transmit the same data wirelessly to the car to control the steering. To control the gas and brake pedals, we will utilize the voltage level of the prototype vehicles speed controller. On an actual vehicle, we would implement force sensors to record input data with each pedal. This data transmission will be through the same Raspberry Pi's that communicate to and from the vehicle.

A feature we decided to be an important aspect of this project is the safety precautions that will be implemented in the event of a failure or error. In case of an error through communication or possible collision, we hope to include a preventative measure that prioritizes the passenger's safety. An example of a failsafe measure, we will implement auto-braking to address a failed connection between car and remote-user. This auto-braking will stop the vehicle and then set off a chain of commands to determine the best course of action depending on the event.

On the vehicle, we will control the steering, acceleration, and braking. We will be using a stripped-down remote-controlled car to take advantage of an already-made vehicle for our demonstration. On the R/C car, we will mount the camera and microcontrollers. The microcontrollers will be used to control the RC car, camera, and all transmission back and forth to the remote controller.

This approach was our most confident solution that incorporated an electrical engineering background. Other possible solutions involved identifying alcoholic levels to determine impairment or preventing the impaired driver to operate the vehicle. These were ways we thought could have been viable alternatives. Our final solution was to implement a system where the impaired driver could be taken home through use of their own vehicle.

IV. FUNDING PROVIDED

All components of this project were funded by each team member. Large amounts of research were done to find the appropriate material to use in this project. Table I shows the funding provided for each part of the project.

V. PROJECT MILESTONES

This project is intended to span two semesters and the tasks and work breakdown structure for the duration of the project was initially estimated at the beginning of the Fall semester. As this project has progressed through the Fall semester, the timeline was updated to reflect the upcoming tasks, goals and challenges that lie ahead to produce the final product.

1) Milestone 1:

Video Feedback and VR: Because our project is designed to use cameras as a sensor to be used on the car, it was determined that as a proof of concept, we should attempt to demonstrate that we can control our robot through mainly using machine vision. As a breadboard proof of our system, we demonstrated visual control of our car driving through the hallways. This was a very important milestone as it demonstrated the base functionality of the visual feedback. For this proof of concept to work, we needed to be able to demonstrate an assembled car, functioning communication with the control system, functional processing of image sequences, and basic control through machine vision. While most subsystems were in very rudimentary stages of implementation, their implementation demonstrated that we are prepared to meet our project goals and milestones.

2) Milestone 2:

Control System Implemented: After we have demonstrated visual feedback of our car, we are to set to work on implementing all the features listed in the feature set. When all aspects of the control system have been implemented, Milestone 2 is considered complete. The primary focus of this milestone is to get functioning data coming from the two motors. These controls are to be used in tandem for producing better usable results. Achieving this milestone begins a long and involved testing and debugging phase of our project.

3) Milestone 3:

Chassis: After the control system have been verified to produce usable data within a certain percent error from expected data, we are to begin combining the two motor movements to establish a moving object. This approach will enable us to tune our system for more precise driving information. The testing and debugging phase involved in this will be extensive, but once the controls are tuned, our system will be ready for the next phase.

4) Milestone 4:

Sensors and Machine Vision: After our chassis is fitted and adjusted to make room for additional sensors, our next focus is on the machine vision and sensory feed. This milestone will take our fused, known good data and bring it into a central guidance system. It will also use this sensory data to form a safe path.

5) Milestone 5:

Project Completed: Once all subsystems are working in tangent with one another, we undergo another system testing and debugging phase. When this phase is completed, the overall project can be determined to be completed.

VI. WORK BREAKDOWN STRUCTURE

In order to ensure success in completing this project, the workload was broken up between all team members. This was done by assigning specific tasks to each member based on their technical background knowledge. This project involves designing, building, and implementing a software algorithm to use on an RC car.

1. Video Feed

The original plan for the video feed was to use a 360 degrees camera to record video and transmit the video from server-Raspberry Pi 3 to client-Raspberry Pi 3 via the CSU Sacramento Wi-Fi channel eduroam, specifically for its 5GHz channels and exceptional bandwidth. However, what was not accounted for was the bottleneck created by the architecture

TABLE I: ESTIMATED COSTS

Item	Estimated Cost
Raspberry Pi B	$35
Raspberry Pi B+ (x2)	$90
Ultrasonic Sensor	$12
RC Car	$200
Batteries (x2)	$60
DC Brushed Motor	$21
Servo Motor	Included with price of car
Ribbon Cable (Long)	$8
Ribbon Cable (Short)	$6
Pi Camera (x2)	$32
MicroSD (x3)	$18
Protoboard (x4)	$5
LEDs (1 case)	$12
Piezo Buzzer	$2
Power Bank	$40
Steering Wheel	$100
Gas and Brake Pedal	Included with price of steering wheel
MCP3008 (ADC)	$3
Potentiometer (x2)	$4
Total	$648.00

of the Pi, significantly throttling the upload speed of the compressed video and causing latencies between 200ms and 330ms. To test this factor, a stopwatch was placed in front of the client's respective screen, and the car's camera recorded both the screen and the stopwatch. The latency was determined by recording the difference between the time on the stopwatch and the time on the client's screen. The goal is the stabilize this latency at least at 250ms. The original metric's goal was 150 milliseconds of delay, however considering the bottlenecks, remaining time in the semester, and financial state, the goal has been pushed to 250ms and the speed of the car has been limited to 5 miles per hour to account for lost time between actual events and delay in transmission.

Of course, it is possible to have a much smaller transmission delay, considering at the very least recreational drones that use first-person viewpoint cameras and are used to pilot the drone through the air. After some research, it is possible to use the mostly analog transmission devices to send video. Unfortunately, this would be too easy to do, considering the fact that these systems are marketed to those who don't have experience with electronics nor pursue a degree in electronics.

At the same time, printed circuit boards could be manufactured to Team 9's design specifications to achieve metrics, or FPGA boards may be implemented. These options have been cast aside due to complexity of the tasks and timeline of the project.

- Estimated Research Time: 40
- Estimated Implementation Time: 55
- Estimated Cost: $100
- Assignee: Eric Dean
- Deliverable: Video feed has been cut down to 200 milliseconds. An update with the firmware has affected what were able to display, 288x352 resolution. To combat this setback, we had to revert to a previous version of Raspbian in order to keep our resolution which also gave us our low latency.

2. Control System

The control system for the vehicle will be calibrated to accurately represent steering and acceleration controls of a larger scale car. The testing will be conducted to make sure that each component of the control system is fully understood.

The components within the control system aspect of the project are the steering wheel and pedals which are used to send pulse-width modulated signals to the electronic speed controller and steering servo motor. This communication is done through Wi-Fi from two microcontrollers.

A major test to conduct for the control system is to measure and record power consumption of the ESC and brushless dc motor. For our senior design showcase, a concern we have for our project is how fast the power was consuming for general operations. We need to be able to use the vehicle for the length of a car ride. We want to be able to constantly use the vehicle for an hour.

When testing the steering wheel, we will be focusing on the responsiveness and accuracy of the control communication. For responsiveness, actions will be measured by their delays at the point of contact to action implementation. A general result that we desire from the steering wheel is how fast it bounces back to center position. This action must be observed alongside the steering servo to measure its delay. We need the steering servo to be as fast as the steering wheel when it moves back to the center. The buttons on the steering wheel must also need to be debounced so we get the desired actions from each button press. The gas and brake pedal will need to be tested and programmed to respond to minimal touch or a full forced press. The measurements we need from the steering wheel and pedals are the time delay from action to response and how accurate the motors move as the steering wheel and pedals move.

For conducting tests on the Electronic Speed controller, we are looking for the accuracy and braking of its operation. In terms of accuracy, we need to control the vehicle correctly as in sending correct pulse width modulated signals to achieve desired speeds. The braking system of the electronic speed controller will be done digitally meaning we will achieve an electronic stop by sending a pulse width modulated signal determining a stop. To conduct the test on the steering servo motor, we will focus on the accuracy and responsiveness to return back to center position. The tests will be measured alongside the tests for the steering wheel. We need these two components to relay matching data within reasonable time delays. The test will consist of stopwatches to record the time which an action is implemented. The servo must be able to rotate to the desired configuration.

The last test that determines the functionality of the control system is its wireless communication. We will test how fast data is sent through TCP/IP communication. The code for the wireless communication incorporates time delays to allow for completed data streams. The time delays need to be right after the previous data is received. A test will be done to address connectivity issues and dead zone located along the hall of third floor Riverside.

- Estimated Research Time: 45
- Estimated Implementation Time: 20
- Estimated Cost: $210
- Assignee: Thanak Prom
- Deliverable: A wireless control system between the steering wheel and the car.

3. Safety Features

- Signal Lights/Horn

Turn signals and horn will need activate when the appropriate button is pressed on the steering wheel. Testing will be needed to determine the responsiveness and accuracy of the components. We would also need to check if there are any mishaps when the components are being used such as, other components not getting enough voltage due to the turn signals/horn being active. Each component will have to be independent of one another in order to work properly.

- Estimated Research Time: 5
- Estimated Implementation Time: 20
- Estimated Cost: $150
- Assignee: Gery Dawson Martinez
- Deliverable: This feature will be considered complete when incorporated with the steering wheel and car in order to simulate horn, blinkers, and brake lights
- Lane Control

A feature that is based on machine vision system for assisting our R/C for lane-control of a traveling vehicle on a road. The system uses will use image processing that will detect edges. This information will define an edge, the histogram of edges that we will gather will then provide the edge orientation angle. This will allow the vehicle to auto correct itself and stabilize in the middle of the lane. The system will then adapt to with the random and dynamic environment of a road scene and keep the vehicle from exiting the lane. The camera that will provide the image processing will then communicate with the actuators on the vehicle and correct the alpha angle to adjust back in the lane. In this project, a machine vision system that will use to auto-correct in the lane will be tested and calibrated by creating two lanes on both sides of our vehicle and we will drive the RC car and let the machine system auto correct and stabilizing the car in the center of the lane.

- Estimated Research Time: 20
- Estimated Implementation Time: 40
- Estimated Cost: $200
- Assignee: Mark Neidenthal
- Deliverable: This feature will be considered complete when machine learning is used to ensure that the car stays in between two lanes.

- Proximity-Based Auto-Braking

The distance sensor will be able to give data that will be interpreted to control the vehicle's motor. The distance sensor will have to input data in a timely manner in order to send over to microcontroller in order to provide the correct instructions to the motor and/or actuators. Testing will need to be done to determine how fast the information is being inputted and how much power it is using continuously. We would have to measure the actual distance the distance sensor will read versus what was programmed into the microcontroller.

- Estimated Research Time: 40
- Estimated Implementation Time: 30
- Estimated Cost: $40
- Assignee: Gery Dawson Martinez
- Deliverable: This feature will be considered complete when the car enters auto-braking within 234 millimeters of an object.

TABLE II: MAN HOURS

Task	Estimated Hours	Assigned to
Video Feed	95	Eric
Control System	85	Thanak
Signal Lights/ Horn	25	Gery
Lane Control	70	Mark
Auto-Braking	70	Gery
Hardware Assembly	40	All
Discussion/ Documentation	150	All
Total	535 hours	

VII. RISK ASSESSMENT

When beginning the project, the team ran a risk assessment analysis as a way to evaluate what features of the project would be the catastrophic to the project's completion should the feature not be achievable as a method of deciding which features should stay, be removed, or be tested despite incredible difficulties.

After several months of testing and research for the project, at the beginning of the second semester a new risk

Risk Matrix

Probability		Minimum to No Impact (1)	Impact can be tolerated (2)	Limited impact (3)	May Jeopardize Project (4)	Will Jeopardize Project (5)
5	Certain			Accelerometer Gyroscope		
4	Highly Likely		Audio Sync W/ Video	Machine Vision		
3	Likely	Horn	Audio	Website	Video Delay Control Failure	
2	Low Likelihood		Website Access			Steering Wheel Power Failure Gas/Brake Pedal
1	Not Likely	VRH - Compatiability Phone WiFi			WiFi Access	RC Car function Camera Hardware Failure
		IMPACT				

FIGURE 1: ORIGINAL RISK MATRIX

Risk Matrix 2.0

Probability		Minimum to No Impact (1)	Impact can be tolerated (2)	Limited impact (3)	May Jeopardize Project (4)	Will Jeopardize Project (5)
5	Certain					
4	Highly Likely		Software Update Incompatability	Machine Vision		
3	Likely	Horn		Website	Video Delay Control Failure	
2	Low Likelihood		Website Access		Poor Data Processing	Steering Wheel Power Failure Gas/Brake Pedal
1	Not Likely		Poor Campus WiFi		WiFi Access	RC Car Function Camera Hardware Failure
		IMPACT				

FIGURE 2: REVISED RISK MATRIX

assessment analysis was performed to again determine what needed to be removed from the project and what needed to be achieved at any cost.

As one can see, the new matrix promises a much more achievable design, albeit many of the original features had to be altered or removed depending on the resources available and the implementation time estimated after months of research. Both matrices are shown in Figures 1 and 2.

Part of the design is to perform a risk assessment and provide a mitigation plan for the items that were discovered to have a risk of negatively impacting the project. The following section will address the critical risk factors and measures we have taken to address those risks. For each risk an associated value of Low, Medium, High, or Very High is assigned depending on the overall impact this will have on our project. Our estimated probability of this event occurring is assigned using the same scale. This allows us to focus on which risks need the majority of our attention in order to mitigate them. The following risk assessment chart outlines the risks and likelihood of failure of our feature set as perceived by our team. Note: Risk assessment is in the following format (Likelihood, Impact)

A. Software Update Incompatibility:

There is a chance that the software update can render most of our features unusable. (High Chance, Low Impact)

Steps taken to address risks: We have researched how to update to a safe version to allow for all of our features to be used while also using the new configurations.

B. Machine Vision:

There are complex algorithms involved to make the machine vision work and using the camera to process this will put strain on our microcontrollers. (High Chance, Medium Impact)

Steps Taken to address risks: 1) We started early to achieve clear machine vision and we put the machine vision and video feedback on different Raspberry Pi's.

C. Website:

The website is where we will view our video feedback that is coming from the car. (Medium Chance, Medium Impact)

Steps Taken to address risks: 1) We have tested the website to handle multiple users and as long as we keep the user count to a minimum of 2 users, we are able to operate in a good range.

D. Video Delay:

Our video feedback transmits a delay that will introduce hazardous conditions. (Medium Chance, High Impact)

Steps Taken to address risks: 1) We conducted tests that will minimize the delay we experience through video. We keep our video feedback on a single Raspberry Pi.

E. Control Failure:

We experience a control failure when our expressed input is not used for the car. (Medium Chance, High Impact)

Steps Taken to address risks: 1) We have taken steps to minimize the disconnection and implemented a way to make the car park after a control disconnect.

F. Poor Data Processing:

The processing power of the Raspberry Pi is not impressive, but it can introduce a problem when we want smooth operation. (Low Chance, High Impact)

Steps Taken to address risks: 1) We have created code that will process the data at a fast and efficient manner.

G. Steering Wheel:

We are using a video game steering wheel for our car and the quality of the wheel is good, but we cannot rely on the integrity of the circuit inside. (Low Chance, Very High Impact)

Steps Taken to address risks: 1) We have retrofitted the steering wheel and used the buttons and potentiometers directly.

H. Power Failure:

Complete power failure due to hardware or software complications. (Low Chance, Very High impact)

Steps Taken to address risks: 1) We are using the same battery on the car and power bank to power every aspect of our project. These battery components are trustworthy and made from a reputable company. We haven't found issues with our batteries.

I. Gas and Brake Pedal:

Complete failure of the gas and brake pedal for vehicle movement. (Low Chance, Very High Impact)

Steps Taken to address risks: 1) We have stress tested the pedals and used different kinds of force in order to wear the pedals. They are still operable to this day.

J. RC Car Function:

RC Car failure based on its onboard pre-assembled parts. (Very Low Chance, Very High Impact)

Steps Taken to address risks: 1) We have used the most important aspects of our RC car and with our small project, we can use the chassis without issue.

K. Camera Hardware Failure:

The camera is very small and can experience hardware failure either from circuit malfunction or physical harm. (Very Low Chance, Very High Impact)

Steps Taken to address risks: 1) The camera did end up failing and we ordered additional cameras in place of them. These cameras fail when we do not take precaution in removing or replacing the parts.

VIII. DESIGN OVERVIEW

A. Video

Low-latency video transmission is an integral part of this project. It is crucial that the remote pilot can 'see' what is happening around the car as instantaneously as possible simulating the environment for the remote pilot.

1. *Hardware Configurations*

The project uses two Raspberry Pis to do the main computations and the data transmissions. Both Pis are overclocked to perform these tasks faster. The CPU frequency is increased from 1200 MHz to 1400 MHz. The GPU, which handles the camera's DSI connection is left at 400 MHz, but the available memory is increased from 64MB to 512MB, leaving the same amount as RAM for the rest of the computer. This is done to allow the GPU plenty of headroom and decrease chances of video loss. Both Pis are also connected to CSU- Sacramento's official Wi-Fi 'eduroam' utilizing the 5GHz channels provided for faster data transmission as well as greater bandwidth and less traffic that occurs on the 2.4GHz channels.

2. *Camera Specifications*

The camera used on the on-board Pi is a standard for the computer, rated at 5MP and capable of recording a resolution of 2952x1944. The camera that is used for the project uses a 160º viewing lens to account for visual peripherals that would have been lost using a regular lens. The camera connects to the Pi via a Display Serial Interface (DSI) and a ribbon cable that connects directly to the GPU of the Pi, which is a more direct route than the bottlenecked USB ports that the Pi offers, ultimately lowering the video latency.

3. *Software Specifications*

- *Pixel Detection Threshold:* Changed from 1500 to 1, this value is what sets the threshold for how many pixels can change between frames for the Pi to begin transmitting video. The value is set to 1 to ensure that video is always being transmitted without stopping.
- *Post-Capture Frames:* This value is set to 300 so that if the pixel threshold ever falls below 1, for any reason, the Pi will continue to transmit another 300 frames of video. The software is set to record video at 30 frames per second, therefore video will still be transmitted 10 seconds of zero-pixel change, which is safe to assume that the car has stopped and is no longer running. The value can be increased to any value, but 300 seemed to be enough.
- *Compression:* The compression codec used is HEVC, which stands for High Efficiency Video Coding, at a percentage of 75%. This is used by the software to compress each jpeg frame to a smaller package to be delivered to the website, decreasing video delay. 75% is the default value for compression and is subject to change as the project continues.
- *Miscellaneous:* In a final effort to optimize the code for video transmission, all parameters in code that are not used for transmission have been deleted from

the file. The software reads the code line by line and every line of code that is undefined, set to zero, or is unused in the video code has been deleted so that the code will only process data and variables that need to be defined, and ignoring all other ones and zeroes.

B. *Controls*

A control system is needed to allow the remote piloting of the vehicle, including the steering wheel, acceleration and brake pedals, and indication lights on the chassis of the car.

1. *Component Specifications*

The steering servo is a standard torque servo used for electric touring car steering duties. This servo is capable of rotating a full 180 degrees but due to its mechanical orientation, we are only able to achieve less than 120 degrees. It accepts a voltage between 4.8V to 6V. It has a torque of 0.325 ft-lbs and a high speed at 55.5 RPM when applied 6V. The ESC (Electronic Speed Controller) is a unit that allows for forward and reverse motion. The ESC needs a power source between 6V to 8.4V. It also has an onboard voltage regulator which was used for a receiver we had on the vehicle. The acceptable PWM frequencies are in 1Khz. These ESCs are used with 15T motors which we also have onboard. The 15T brushed dc motor is the one we are using to move the vehicle. This motor needs to be connected to the ESC. We use the ESC to send desired voltages to the motor in order to achieve movement.

2. *Software Specifications*

For the project, the components are used through programming in Python. These programs allow us to adjust its output by feeding the acceptable values. The steering servo motor is controlled in the same python program as the electronic speed controller. We split up the processes involving the two components but they both are fed through the same Wi-Fi communication.

C. *Safety Features*

These features include the vehicle's turn signals and horn, as well as a proximity-based auto-braking system that uses an ultrasonic sensor to collect data, and lane control that is implemented with machine vision to counteract video latency and small imperfections in control systems.

IX. DEPLOYABLE PROTOTYPE STATUS

The final prototype has the majority of what we promised in our design idea contract. Adjustments had to be made in order to have a deployable prototype. Some of the adjustments made was the video feed, distance sensor, rear camera, and accelerometer. The video feed was cut down to a latency of 200 milliseconds and a broadcasting resolution of 288x352 instead of 150 milliseconds at 480p. A new Raspbian firmware update caused some complications that didn't allow the camera modules to work properly. To combat this issue, we had to use an older version of Raspbian. We had to use a camera that gives us about 180 degrees front view instead of the 360-degree camera. The Samsung 360 camera was too time consuming to figure out to integrate into our project, thus using a simple webcam. We eliminated the accelerometer since the VR headset was also eliminated due to bottlenecking issues that increased latency.

Lastly, it was decided to not use LiDAR and to use a ultrasonic distance sensor. The LiDAR would use an excessive amount of processing power and doesn't provide useful data for this project. The ultrasonic distance sensor is economical and provides the data needed in this project.

X. DEPLOYABLE PROTOTYPE MARKETABILITY FORECAST

Many improvements could be made to this project. Using a different microcontroller, like an FPGA, could be implemented to order to best combat issues we have faced.

When this project is implemented onto a full-scale vehicle than using multiple sensors (ultrasonic distance sensor, LiDAR, radar, etc.) would increase the productivity of the safety features.

Using a VR headset would improve the experience of the remote driver. Instead of using a webcam, a 360-degree camera could be used which would transmit video feed to the VR headset.

XI. CONCLUSION

Having a semi-autonomous vehicle will resolve the societal issues that come with truck driving such as efficient hours of service, distracted driving, high compliance, and accountability. This service will provide the impaired driver the option to have someone remotely access their vehicle and drive to their destination, therefore preventing any possible consequence of driving long hours and increasing efficiency of service hours.

With current technology, we hope to create a viable alternative to designated driver programs to tackle the societal problems that come from truck driving. Unfortunately, due to time constraints, resources available and status of education, the project was unable to rise to the team's original expectations. This approach was our most confident solution that incorporated an electrical engineering background. There is much room for improvement and the team will continue to improve and develop this project, even after the senior design semester is over. As for senior design, the semi-autonomous car has been completed to the scope that was redefined in the risk matrices and for the purposes to be used.

The video latency has been brought down to 200ms and stabilized at less than 250ms, while also being at a resolution that is acceptable and drivable. Control systems and safety systems have been combined to create a master code that allows the remote pilot to control the car, but safety features are given priority over the remote pilot to ensure the driver's safety. Safety systems include proximity-based autobraking that samples from an ultrasonic sensor as well as a machine vision-based lane control system.

Original design features that had to be removed include 360º video and the VR headset that is needed to view the live stream, as well as audio to be synced with the video, and the LiDAR. The processing that each component required was too much for the Raspberry Pi to transmit at low latencies and caused the fundamental features to perform at sub-par levels.

After completion of the project, the team believes that a fully integratable system is not (or should not) be available with the current technology standards. It is not safe to market this product without proper safety standards, especially video delay, as well as the testing to reinforce them. Not to mention the fact that anyone can access the car's data feed or gain control of the control system data.

Overall, the project's final form is less than what the original design called for, but our team was ambitious and overestimated the abilities of the resources used for this project. However, with our positive approach we are able to take alternative methods in order to achieve within our design criteria. We aimed to at least reach our desired results while completing the required data range of our feature set.

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[2] "The U.S. Trucking Industry's Top 10 Issues." Trucks.com, Trucks.com, 15 July 2016, www.trucks.com/2015/11/26/us-trucking-industrys-top-10-issues/.

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GLOSSARY

Artificial Intelligence - the theory and development of computer systems able to perform tasks that normally require human intelligence

IoT – internet of things; a system of interrelated computing devices, mechanical and digital machines

Latency - The delay between when a command is sent and when the same command is used.

Machine vision - technology and methods used to provide imaging-based automatic inspection and analysis

Microcontrollers - a small computer on a single integrated circuit

RC – remote controlled; component of an electronic device used to operate the device from a distance, usually wirelessly

VR – virtual reality; interactive computer-generated experience taking place within a simulated environment

Wi-Fi – technology for radio wireless local area networking of devices based on the IEEE 802.11 standards

APPENDIX A. USER MANUAL

This project requires very specific hardware and software in order to operate. It is assumed that the user is familiar with the Raspbian and Linux terminal commands as well as C/C++ and Python programming. The system is designed to be operated wirelessly with a common Wi-Fi connection.

A. Operating Requirements:

The Semi-Autonomous car must be operated on a flat, smooth, hard surface with minimal obstructions. Lighting conditions must be ample with full visibility. *Caution*: The drive motor will output insufficient amount of torque if the battery is low. Be sure to charge the battery to a voltage level higher than 7.2V. At this voltage level, the motor will operate in forward and reverse without issues.

B. Vehicle

Required Materials
- Laptop with VNC
- Power Bank (2 USB ports)

For the Pis on the car, you need to plug in the batteries on the car. The lipo battery needs to be connected to the ESC (Electronic Speed Controller) and the power bank with two USB ports need to be connected to the two onboard Pis. The two onboard Pis will be used for the video feed and wireless control with machine vision.

To start up the virtual handshake:

1) Log into the Pi through VNC Viewer or HDMI.
2) On the Raspbian OS desktop, navigate to Terminal.
(Terminal has an icon similar to command line)
2) In Terminal, type in *cd ~*
3) Then type *sudo pigpiod*
4) Afterwards *python socket.server.py*
5) You should see "Socket awaiting messages"
If you don't, repeat steps 2-4.
6) Wait for Steering Wheel connection
7) Once connected, turn on the ESC.
You should hear some beeps.
8) The car is ready for operation.

C. Steering Wheel

Required Materials
- Monitor (HDMI compatible)
- Power Adapter
- HDMI cable
- USB Keyboard
- USB Mouse

Alternatively:
- Laptop with VNC Viewer

TABLE III: BILL OF MATERIALS

Item	Estimated Cost
Raspberry Pi B	$35
Raspberry Pi B+ (x2)	$90
Ultrasonic Sensor	$12
RC Car	$200
Batteries (x2)	$60
DC Brushed Motor	$21
Servo Motor	Included with price of car
Ribbon Cable (Long)	$8
Ribbon Cable (Short)	$6
PiCamera (x2)	$32
MicroSD (x3)	$18
Protoboard (x4)	$5
LEDs (1 case)	$12
Piezo Buzzer	$2
Power Bank	$40
Steering Wheel	$100
Gas and Brake Pedal	Included with price of steering wheel
MCP3008 (ADC)	$3
Potentiometer (x2)	$4
Total	$648.00

To use this product, you will need to plug in the power adapter to the steering wheel and use either a monitor with an HDMI cable or connect using VNC Viewer on the laptop.

For the Pi on the steering wheel, you need to access the desktop environment on Raspbian. You can do this by powering up the Pi and making sure it loads to the desktop. To start up the virtual handshake:

1) Log into the Pi through VNC Viewer or HDMI.
2) On the Raspbian OS desktop, navigate to Terminal.
   (Terminal has an icon similar to command line)
2) In Terminal, type in *cd ./home/pi/Desktop*
3) Then type *python server.client.py*
4) You should see “Connected”
   If you don’t, repeat steps 2 and 3.
5) Wait for the car to respond.
6) Once connected, make sure the steering wheel has
   a response by turning the steering wheel.
7) The car is ready for operation.

APPENDIX B. HARDWARE

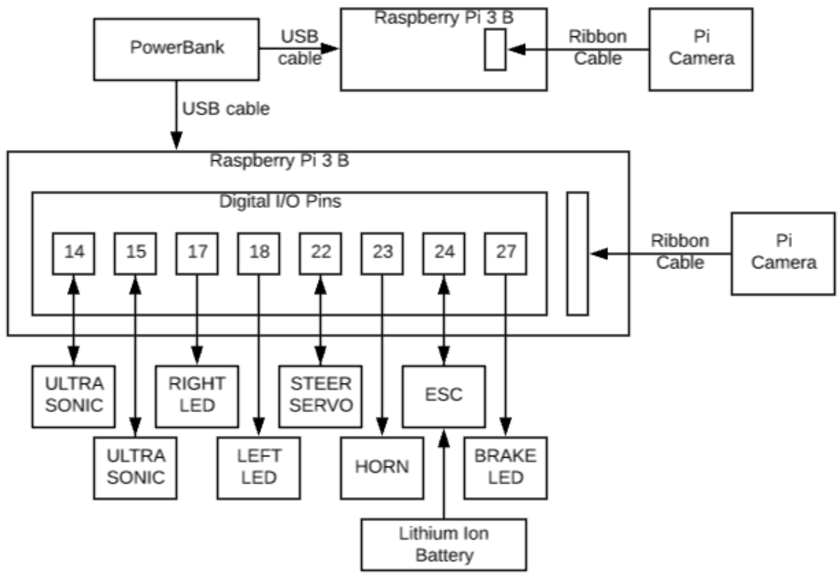


FIGURE 3: VEHICLE SYSTEM HARDWARE FLOWCHART

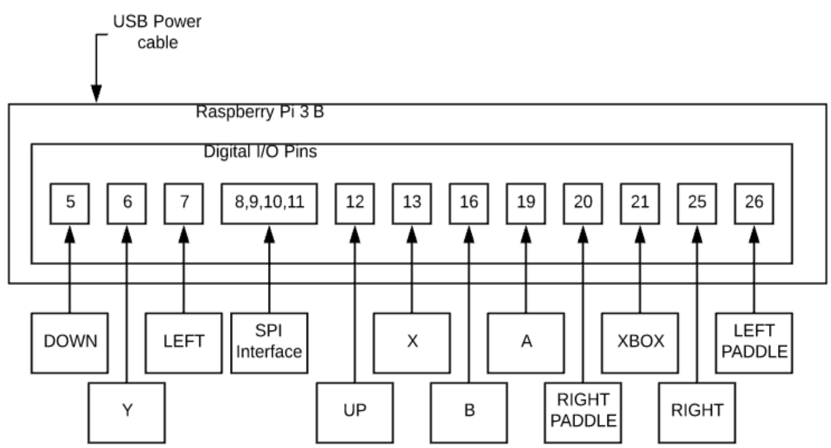


FIGURE 4: CONTROL SYSTEM HARDWARE FLOWCHART

A. Camera Module V2
B. Wide Angle Camera
C. Raspberry Pi 3 Model B
D. Raspberry Pi 3 Model B+
E. Steering Wheel (reconfigured from original design)
F. HPI SF-1 Servo (Standard Torque)
G. SC-15 Electronic Speed Control with Reverse
H. Firebolt 15T Motor (540 Type)
I. Ping Ultrasonic Sensor

All hardware specs are listed below in the Appendix

Car Pi

		3.3V	5V		
		GPIO 2	5V		
		GPIO 3	GND		
		GPIO 4	GPIO 14	ULTRA	(BROWN)
		GND	GPIO 15	ULTRA	(RED)
(YELLOW)	R LED	GPIO 17	GPIO 18	L LED	
(GREEN)	BRAKE LED	GPIO 27	GND		
(PURPLE)	STEER	GPIO 22	GPIO 23	HORN	(BLUE)
	(WHITE)	3.3V	GPIO 24	MOTOR	(GREY)
		GPIO 10	GND	(BLACK)	
		GPIO 9	GPIO 25		
		GPIO 11	GPIO 8		
		GND	GPIO 7		
		ID SD	ID SC		
		GPIO 5	GND		
		GPIO 6	GPIO 12		
		GPIO 13	GND		
		GPIO 19	GPIO 16		
		GPIO 26	GPIO 20		
		GND	GPIO 21		

FIGURE 5: WIRE PINOUT OF VEHICLE RASPBERRY PI

Car Main Board

	OUT	IN	IN	IN
(BLACK)	GND	GND	GND	
(WHITE)	3.3V	3.3V	----	
(GREY)	MOTOR	STEER	MOTOR	
(PURPLE)	STEER			GND
(BLUE)	HORN			HORN
(GREEN)	BRAKE			BRAKE
(YELLOW)	R LED			R LED
(ORANGE)	L LED			L LED
(RED)	ULTRA			ULTRA
(BROWN)	ULTRA			

FIGURE 6: WIRE PINOUT OF MAIN VEHICLE BOARD

Steering Wheel Pi

		3.3V	5V		
		GPIO 2	5V		
		GPIO 3	GND		
		GPIO 4	GPIO 14		
		GND	GPIO 15		
		GPIO 17	GPIO 18		
		GPIO 27	GND		
		GPIO 22	GPIO 23		
	(RED)	3.3V	GPIO 24		
	(GREY)	GPIO 10	GND	(BLACK)	
	(BLUE)	GPIO 9	GPIO 25	RIGHT	(PURPLE)
	(GREEN)	GPIO 11	GPIO 8	(WHITE)	
		GND	GPIO 7	LEFT	(GREY)
		ID SD	ID SC		
(WHITE)	DOWN	GPIO 5	GND		
(ORANGE)	Y	GPIO 6	GPIO 12	UP	(RED)
(YELLOW)	X	GPIO 13	GND		
(BLUE)	A	GPIO 19	GPIO 16	B	(GREEN)
(GREY)	LEFT P	GPIO 26	GPIO 20	RIGHT P	(PURPLE)
(BLACK)		GND	GPIO 21	XBOX	(WHITE)

FIGURE 7: WIRE PINOUT OF STEERING WHEEL RASPBERRY PI

Steering Wheel Main Board

	OUT
(RED)	3.3V
(ORANGE)	-----
(YELLOW)	-----
(GREEN)	SCLK
(BLUE)	MISO
(GREY)	MOSI
(WHITE)	CE0
(BLACK)	GND

IN	
3.3V	(GREY)
STEER	(GREY)
GND	(PINK)

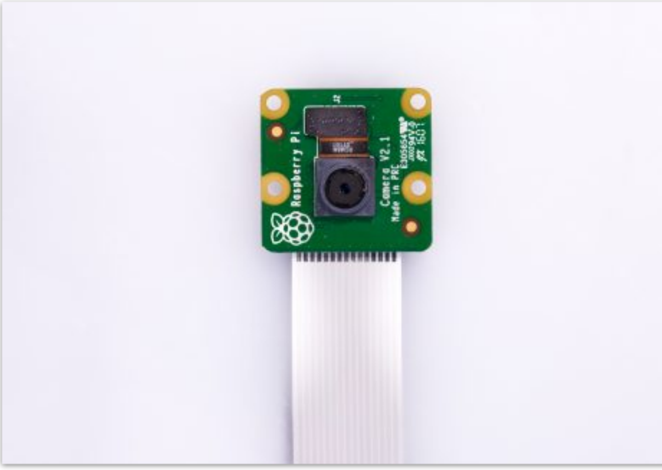
IN	
BRAKE	(YELLOW)
3.3V	(GREEN)
ACCEL	(ORANGE)
GND	(BLACK)

FIGURE 8: WIRE PINOUT OF STEERING WHEEL MAIN BOARD

Steering Wheel Button Board

	OUT / IN
(PURPLE)	RIGHT
(GREY)	LEFT
(WHITE)	DOWN
(RED)	UP
(ORANGE)	Y
(YELLOW)	X
(GREEN)	B
(BLUE)	A
(PURPLE)	RIGHT P
(GREY)	LEFT P
(WHITE)	XBOX
(BLACK)	GND

FIGURE 9: WIRE PINOUT OF STEERING WHEEL BUTTON BOARD



Camera Module V2

The Raspberry Pi Camera Module v2 replaced the original Camera Module in April 2016

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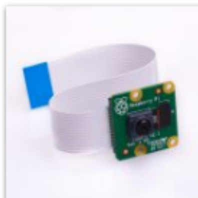
or Buy for Business






GETTING STARTED | SPECIFICATIONS

The Raspberry Pi Camera Module v2 replaced the original Camera Module in April 2016. The v2 Camera Module has a Sony IMX219 8-megapixel sensor (compared to the 5-megapixel OmniVision OV5647 sensor of the original camera).

The Camera Module can be used to take high-definition video, as well as stills photographs. It's easy to use for beginners, but has plenty to offer advanced users if you're looking to expand your knowledge. There are lots of examples online of people using it for time-lapse, slow-motion, and other video cleverness. You can also use the libraries we bundle with the camera to create effects.

You can read all the gory details about IMX219 and the Exmor R back-illuminated sensor architecture on Sony's website, but suffice to say this is more than just a resolution upgrade: it's a leap forward in image quality, colour fidelity, and low-light performance. It supports 1080p30, 720p60 and VGA90 video modes, as well as still capture. It attaches via a 15cm ribbon cable to the CSI port on the Raspberry Pi.

The camera works with all models of Raspberry Pi 1, 2, and 3. It can be accessed through the MMAL and V4L APIs, and there are numerous third-party libraries built for it, including the Picamera Python library. See the Getting Started with Picamera resource to learn how to use it.

The camera module is very popular in home security applications, and in wildlife camera traps.

1)

Wide Angle FOV160° 5-Megapixel Camera Module for Raspberry Pi

brand: SAINSMART | ★★★★★ 1 review

$21.99 ~~$26.99~~ SAVE $5.00

This camera module features with 5MP (2592×1944 pixels) and 160 degrees viewing angle. It is compatible with both Raspberry Pi model A and model B.

- With OV5647 sensor, native resolution of 5 megapixel
- The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor
- Supports 1080 p @ 30 fps, 720 p @ 60 fps and 640 x480 p 60/90 video recording
- With IR filter, full Color in daylight

Raspberry Pi 3 Model B

Single-board computer with wireless LAN and Bluetooth connectivity

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GETTING STARTED | SPECIFICATIONS | COMPLIANCE | NOTICES

The Raspberry Pi 3 Model B is the earliest model of the third-generation Raspberry Pi. It replaced the Raspberry Pi 2 Model B in February 2016. See also the Raspberry Pi 3 Model B+, the latest product in the Raspberry Pi 3 range.

- Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
- 1GB RAM
- BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
- 100 Base Ethernet
- 40-pin extended GPIO
- 4 USB 2 ports
- 4 Pole stereo output and composite video port
- Full size HDMI
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- Micro SD port for loading your operating system and storing data
- Upgraded switched Micro USB power source up to 2.5A

OBSOLESCENCE STATEMENT

The Raspberry Pi3 Model B will remain in production until at least January 2022.

Raspberry Pi 3 Model B+

1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and Power-over-Ethernet support (with separate PoE HAT)

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or Buy for Business




GETTING STARTED | SPECIFICATIONS | SOFTWARE & OS | COMPLIANCE

The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range.

- Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
- 1GB LPDDR2 SDRAM
- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
- Extended 40-pin GPIO header
- Full-size HDMI
- 4 USB 2.0 ports
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- 4-pole stereo output and composite video port
- Micro SD port for loading your operating system and storing data
- 5V/2.5A DC power input
- Power-over-Ethernet (PoE) support (requires separate PoE HAT)

Racing Wheel Overdrive for Xbox One

$99.99

QTY

1

Add To Bag

WISHLIST SHARE

HORI brings the best in build-quality, customization options, and authentic racing simulation with the Racing Wheel Overdrive. HORI's Tokyo design team has brought all the features and quality of a full-size racing wheel at an aggressive price. Massive 270 degree turn-ratio - Completely programmable & adjustable - Xbox One compatible. The Racing Wheel Overdrive clamps securely to your table or racing wheel stand with sturdy clamps and steel parts. The full size pedals are built to last. Change from 270 degree to 180 degree turn ratio on the fly and fine tune other settings such as dead zone, pedal sensitivity and more. Get in the race with the all new RWO: Racing Wheel Overdrive for Xbox One. Officially licensed by Microsoft. The product is not compatible with Xbox 360 and Windows PC.

Features:

- Officially Licensed by Microsoft
- Full-size racing wheel and pedals optimized for authentic racing simulation
- 270 degree turn radius with adjustable output options
- Mount security with sturdy clamp system

SHOW DISCONTINUED KITS

#80559 - HPI SF-1 SERVO (STANDARD TORQUE)

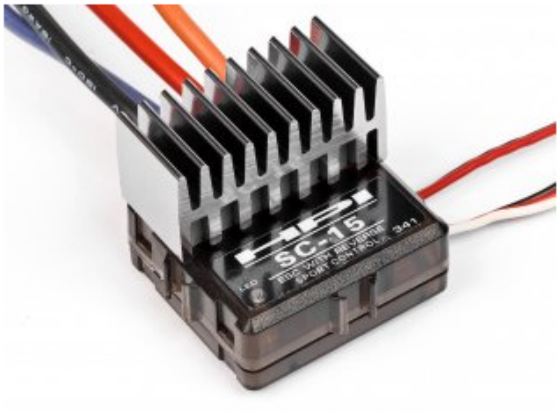
Standard Servo/Futaba J Connector/Not Recommended for Savage Steering

Discontinued, replacement part: #104105

Standard Parts

The SF-1 servo is useful for electric touring car steering duties, nitro car/truck throttle and brake, and other applications that don't require large amounts of torque or fast speeds. It's perfect for the Savage Reverse Module and Reverse Mixer Pro! It features standard screw hole spacing and a 25 tooth spline.

NOTE: NOT WATERPROOF! Before driving in wet conditions, make sure that all electronics fitted to the vehicle are safe to use (marked as water-resistant or waterproof), or that they are fully enclosed and protected from water and moisture (such as in a sealed receiver/battery case). Fans mounted on speed controllers are not water resistant - we recommend to disconnect the fan from the ESC before driving in wet conditions and allow it to dry fully before reconnecting the fan power. Lubricate exposed metal drivetrain parts such as bearings, outdrives and diff shafts before driving in wet conditions. Motors are not intended for submerged use and may be damaged if used when under water. After driving in wet conditions, make sure to rinse off dirt and any corrosive liquids like saltwater with plain water and re-lubricate metal drivetrain parts.



THIS PART FITS THE FOLLOWING KITS / PARTS:

SHOW DISCONTINUED KITS STD

#341 - SC-15 ELECTRONIC SPEED CONTROL WITH REVERSE

Sprint 2 Sport / E-FIRESTORM / for use with motors down to 15 turn

Discontinued, replacement part: #105906

The standard ESC (Electronic Speed Controller) in the Sprint 2 Sport street car, this unit can handle any motor with 15 or more turns of wire, allowing you to fit any 'stock' motor, and even mild modified motors! The digital proportional circuitry provides smooth, precise control in a variety of conditions. The SC-15 also features reverse, so it's easy to back out of trouble!

Equipped with a standard stick pack battery connector and 'bullet' connectors for the motor, this ESC can easily replace the standard ESC in many other RTR cars! The large heatsink dissipates any heat build-up and the external power switch lets you mount the ESC in just about any position on your electric car or truck! Fits a wide range of electric vehicles. Suitable for brushed motors as large as 540-size (standard 1/10th scale motors), with 15 turns or more - please check your motor before using with this ESC. Full instructions and warranty information included. Not for brushless motor use.

THIS PART FITS THE FOLLOWING KITS / PARTS:

Blitz	STD
E-Firestorm 10T	STD
Sprint 2 1969 Chevrolet Camaro Z28	STD
Sprint 2 Drift 2010 Chevrolet...	STD
Sprint 2 Drift Nissan 350Z	STD
RS4 Sport 3 BMW M3 E30	STD
RS4 Sport 3 Drift Subaru BRZ	STD
RS4 Sport 3 2015 Ford Mustang Spec...	STD
RS4 Sport 3 Drift 2015 Ford Mustang	STD
RS4 SPORT 3 RTR KEN BLOCK 1965 FORD	STD
JUMPSHOT SC	STD
RS4 SPORT 3 DRIFT WORTHOUSE JAMES...	STD
RS4 SPORT 3 1969 FORD MUSTANG...	STD
Wheely King 4x4	OPT
E10 Drift Nissan S13 Discount Tire	OPT
RS4 SPORT 3 Creator Edition	OPT
E10 TOURING MICHELE ABBATE...	OPT

SHOW DISCONTINUED KITS

#1146 - FIREBOLT 15T MOTOR (540 TYPE)

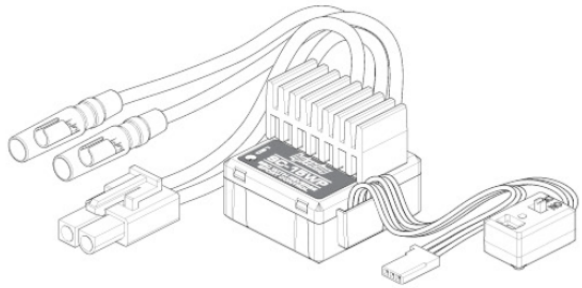
Genuine HPI quality spare part for easy maintenance and repairs. Fits right into all HPI electric cars and trucks! The lower the number of turns, the more powerful the motor is - this motor is much more powerful and the Saturn 27T and 20T motors! **Note:** Before purchasing this motor, **you must make sure that your electronic speed controller (ESC) is capable of handling motors as powerful as 15-turn motors**. ESCs that are not rated for powerful motors will be damaged and will need to be replaced. The #341 SC-15 Electronic Speed Control is able to power 15-turn motors, however the #340 EN-1 is not.

NOTE: Before driving in wet conditions, make sure that other electronics fitted to the vehicle are safe to use (marked as water-resistant or waterproof), or that they are fully enclosed and protected from water and moisture (such as in a sealed receiver/battery case). Fans mounted on speed controllers are not water resistant - we recommend to disconnect the fan from the ESC before driving in wet conditions and allow it to dry fully before reconnecting the fan power. Lubricate exposed metal drivetrain parts such as bearings, outdrives and diff shafts before driving in wet conditions. Motors are not intended for submerged use and may be damaged if used when under water. After driving in wet conditions, make sure to rinse off dirt and any corrosive liquids like saltwater with plain water and re-lubricate metal drivetrain parts.

En De Fr 日本語

Instruction
Anleitung
Instructions
取扱説明書

105906 SC-15WP WATERPROOF ELECTRONIC SPEED CONTROL
SC-15WP ELEKTRONISCHER FAHRTENREGLER (WASSERDICHT)
CONTROLEUR ELECTRONIQUE DE VITESSE ETANCHE SC-15WP
SC-15WP ウォータープルーフスピードコントローラー



Specification Eigenschaften Caractéristiques 製品仕様

ESC
- Power source : 6.0V~8.4V
- Current rating : Forward 200A, Reverse 100A
- Voltage regulator: 5.0V (circuit board protection)
- PWM frequency : 1 Khz
- System : Forward / Brake / Reverse (no reverse, linear neutral brake)
- Adaptive motor : 15T and up (7.2V), 17T (8.4V)
- Size : 33.5x34.5x27.5mm
- Weight : 50g

Regler
- Stromversorgung: 6.0V~8.4V
- Strombelastbarkeit: Strombelastbarkeit: Vorwärts 200A, Rückwärts 100A
- Spannungsregulator: 5.0V (Platinenschutz)
- PWM Frequenz: 1 kHz
- System: Vorwärts / Bremse / Rückwärts (kein Rückwärts, lineare Neutral-Bremse)
- Verwendbare Motoren: 15T und mehr (7.2V), 17T (8.4V)
- Größe: 33.5x34.5x27.5mm
- Gewicht: 50g,

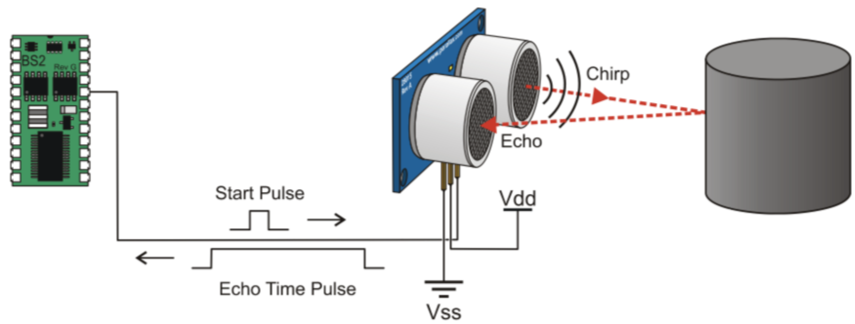
Contrôleur électronique de vitesse
- Alimentation : 6.0V~8.4V
- Ampérage nominal : avant 200 A, arrière 100 A
- Régulateur de tension : 5.0 V (protection du circuit électronique)
- Fréquence des impulsions : 1 Khz
- Système : marche avant / frein / marche arrière (pas de marche arrière, frein neutre linéaire)
- Moteur d'adaptation : 15T et plus (7.2V), 17T (8.4V)
- Dimensions : 33.5x34.5x27.5mm
- Poids : 50g

スピードコントローラー
- 使用電源：6.0V~8.4V
- FET定格電流：前進 200A、後進100A
- レギュレーター電圧：5.0V(保護回路装備)
- PWM周波数：1Khz
- 動作方式：前進／ブレーキ／後進 (後進無、リニアNブレーキ設定可)
- 適応モーター： 15Tまで (7.2V)、17Tまで(8.4V)
- 寸法：33.5×34.5×27.5㎜
- 重量：50g

PING))) Ultrasonic Distance Sensor (#28015)

The Parallax PING)))™ ultrasonic distance sensor provides precise, non-contact distance measurements from about 2 cm (0.8 inches) to 3 meters (3.3 yards). It is very easy to connect to microcontrollers such as the BASIC Stamp®, Propeller chip, or Arduino, requiring only one I/O pin.

The PING))) sensor works by transmitting an ultrasonic (well above human hearing range) burst and providing an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width, the distance to target can easily be calculated.



Features

- Range: 2 cm to 3 m (0.8 in to 3.3 yd)
- Burst indicator LED shows sensor activity
- Bidirectional TTL pulse interface on a single I/O pin can communicate with 5 V TTL or 3.3 V CMOS microcontrollers
- Input trigger: positive TTL pulse, 2 µs min, 5 µs typ.
- Echo pulse: positive TTL pulse, 115 µs minimum to 18.5 ms maximum.
- RoHS Compliant

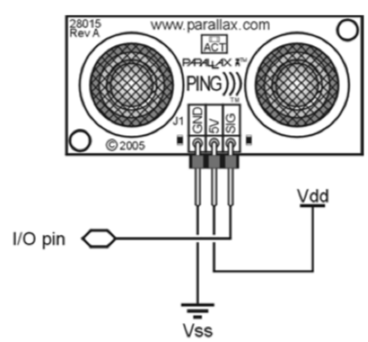
Key Specifications

- Supply voltage: +5 VDC
- Supply current: 30 mA typ; 35 mA max
- Communication: Positive TTL pulse
- Package: 3-pin SIP, 0.1" spacing (ground, power, signal)
- Operating temperature: 0 – 70° C.
- Size: 22 mm H x 46 mm W x 16 mm D (0.84 in x 1.8 in x 0.6 in)
- Weight: 9 g (0.32 oz)

Pin Definitions

GND	Ground (Vss)
5 V	5 VDC (Vdd)
SIG	Signal (I/O pin)

The PING))) sensor has a male 3-pin header used to supply ground, power (+5 VDC) and signal. The header may be plugged into a directly into solderless breadboard, or into a standard 3-wire extension cable (Parallax part #800-00120).



APPENDIX C. SOFTWARE

Motion Software for (Linux), downloadable from GitHub
Lane Control Software written by team
Control (including safety feature) Software written by team

socket.server.py

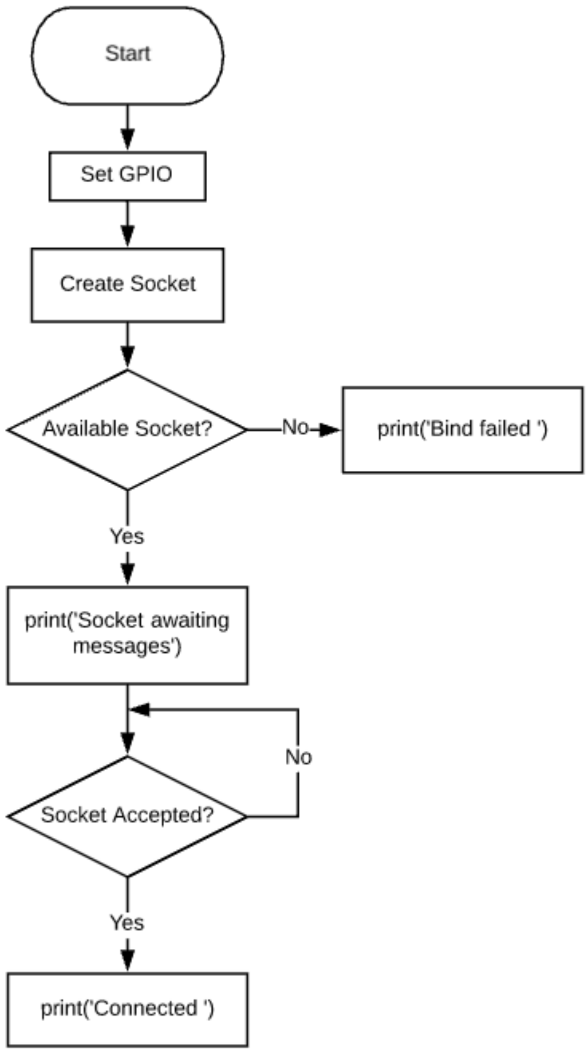


FIGURE 10: VEHICLE SYSTEM SOCKET CONNECTION FLOWCHART

socket.client.py

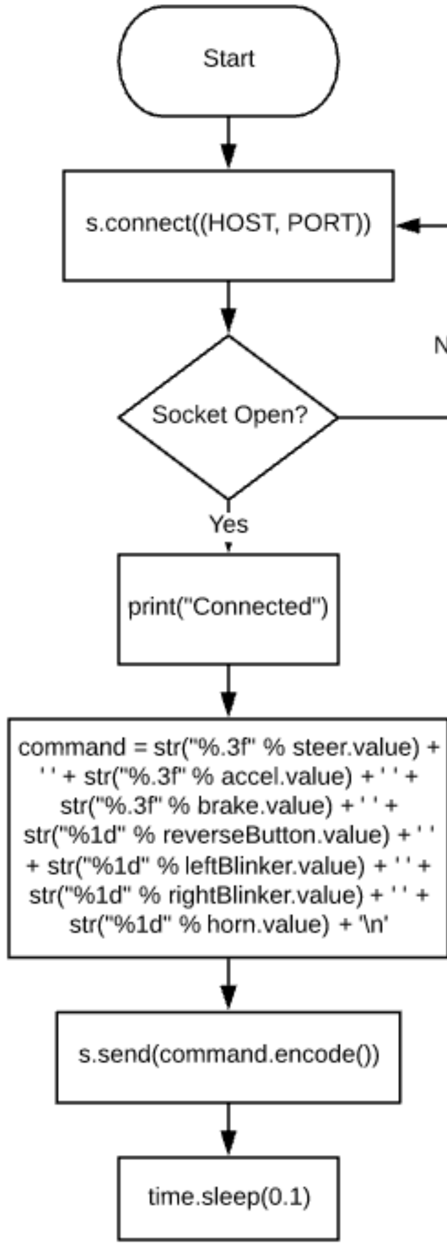


FIGURE 11: CONTROL SYSTEM SOCKET TRANSFER FLOWCHART

socket.server.py
while True: loop

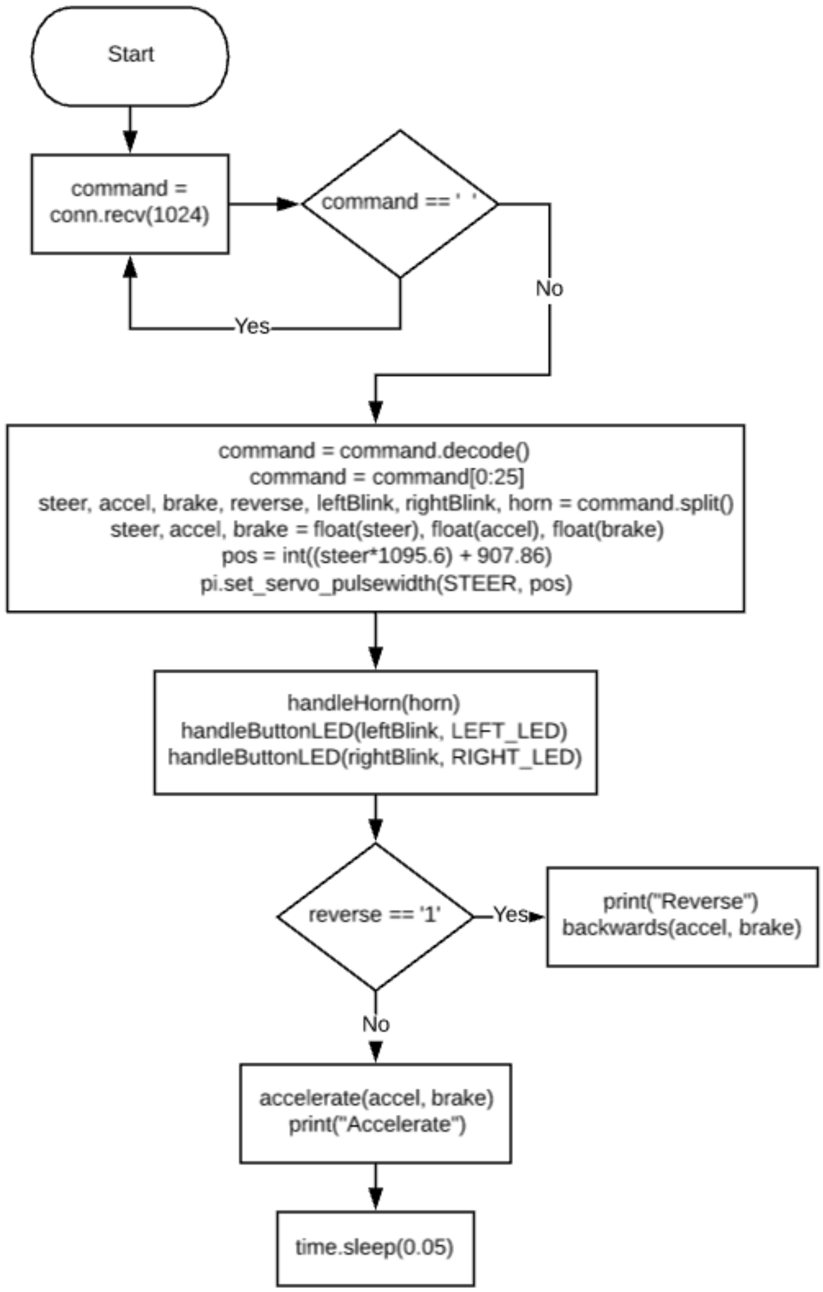


FIGURE 12: VEHICLE SYSTEM MAIN LOOP FLOWCHART

def accelerate(gas, brake)

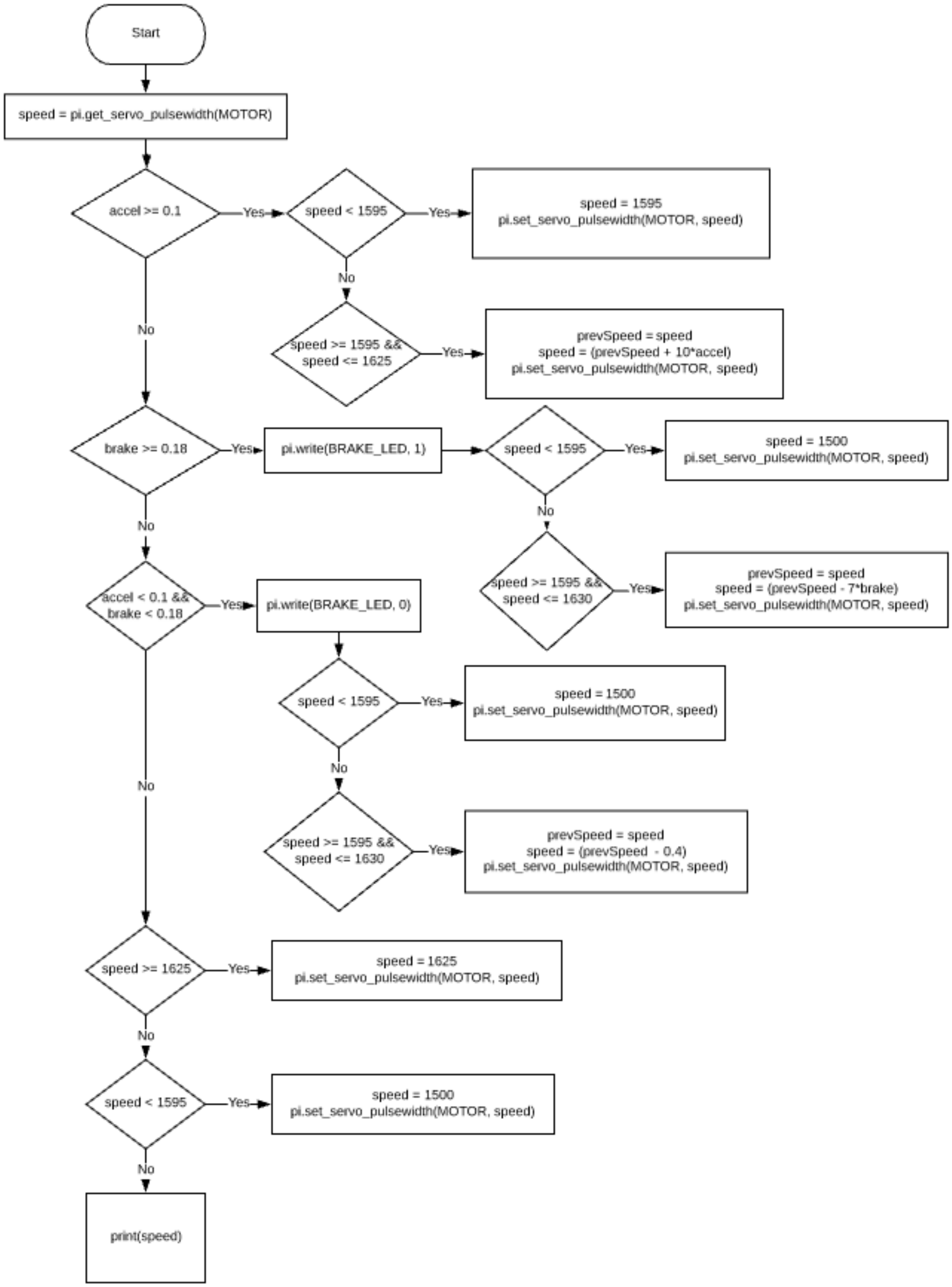


FIGURE 13: VEHICLE SYSTEM ACCELERATION FLOWCHART

def backwards(gas, brake)

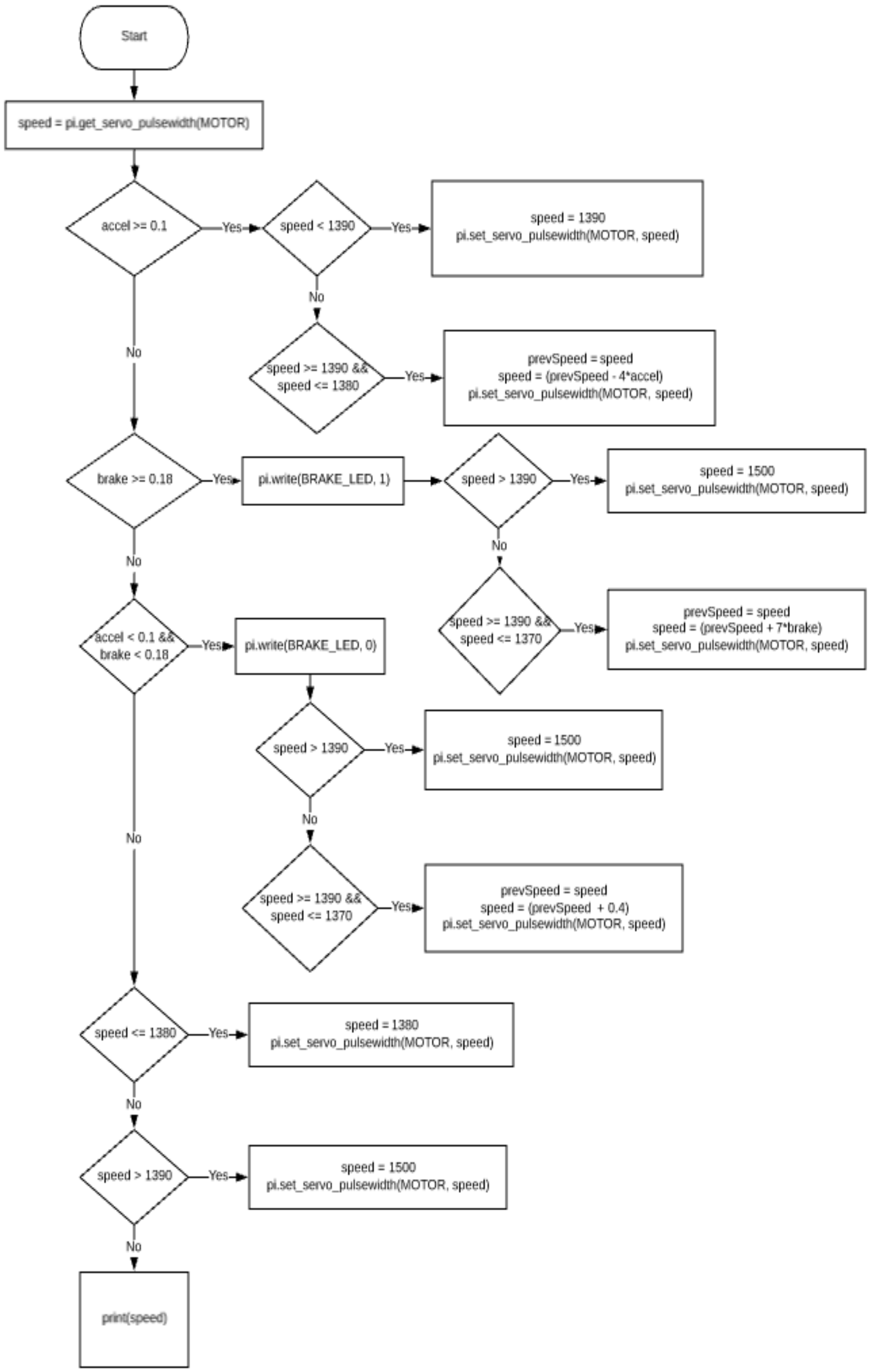


FIGURE 14: VEHICLE SYSTEM REVERSE FLOWCHART

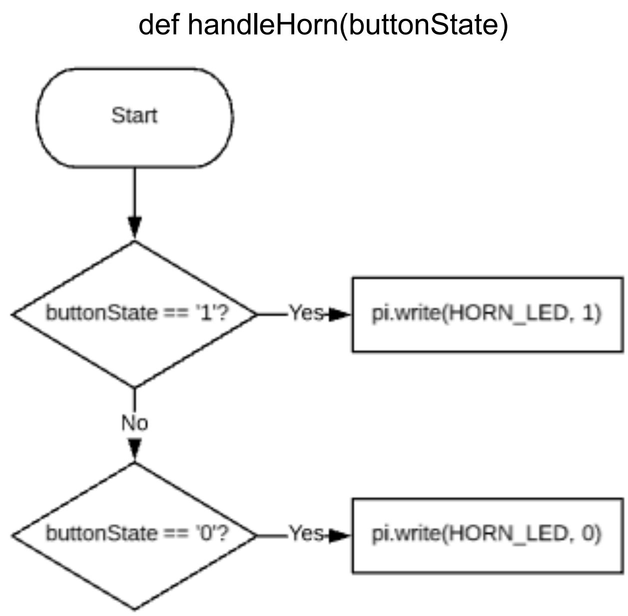


FIGURE 15: VEHICLE SYSTEM HORN FLOWCHART

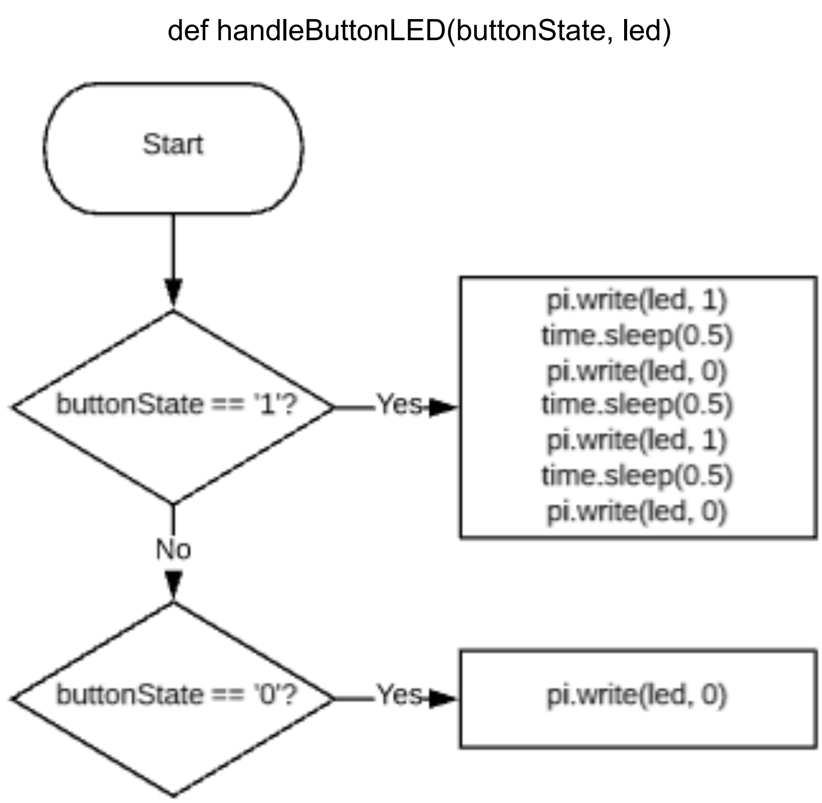


FIGURE 16: VEHICLE SYSTEM LIGHT FLOWCHART

APPENDIX D. MECHANICAL

The mechanical portion of this project is limited to the RC chassis. The RC car structure consists of its existing control system and chassis. The team retrofitted the RC car with spacers in order to hold the Raspberry Pis in place. There was not a lot of retrofitting that needed to be done to this project, on the mechanical side.

APPENDIX E. VENDOR CONTACTS

As a team, we did not see a need to contacting multiple vendors for our project. The research that each team member did proved to be enough to come to a consensus of what would be needed for the project. Some insight on how to approach certain aspects of the project could have been helpful to reduce the amount of research done; such as using specific microcontrollers, sensors, and cameras.

We did however have a team member talk to a representative from Tesla. They suggested using an IMU, ultrasonic sensors, and machine vision for lane control and possibly also auto-braking. They also suggested to stay away from LiDAR and radar due to power consumption issues, as well as processing limits, that our project would run into.

APPENDIX F. RESUMES

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ERIC DEAN

Seeking a position designing electrical and electronic products to apply my creative mindset to solve real-world problems, applying my 4 years of educational background and 5+ years of electrical experience to everyday demands

SKILLS

Experience with:

- AutoCAD
- Quartus
- SOLIDWORKS 2017
- NI Multisim
- SPICE simulations
- MATLAB 2017
- Microcontroller usage
- Arduino IDE
- Microsoft Word, Excel
- Python, C/C++
- Advanced Design Systems 2016
- Developing strategy and problem solving
- Excellent time management
- Developing interpersonal relationships
- Bilingual – Spanish
- Maintaining a clear head under pressure
- Initiative to finish project

EDUCATION

AUGUST 2016 – MAY 2019

B.S. IN ELECTRICAL AND ELECTRONIC ENGINEERING, CSU SACRAMENTO

Maintaining a 3.5 GPA during undergraduate prerequisite courses and upper division classes, forgoing a Minor in Mathematics to focus on design projects

AUGUST 2012 – JULY 2016

GENERAL EDUCATION, LOS RIOS COMMUNITY COLLEGE DISTRICT

Maintained above a 3.0 GPA while taking core classes as well as the start of a B.A. in Music before beginning lower division courses for a BS in Electrical Engineering

WORK EXPERIENCE

SEPTEMBER 2018 – CURRENT

STUDENT TUTOR, ELECTRICAL ENGINEERING AND LOWER DIVISION COURSES

Help solidify engineering concepts to engineering students in upper and lower division courses, particularly network analysis and electronic devices

APRIL 2013 – CURRENT

SERVER, THE CLIFF HOUSE OF FOLSOM BREWHOUSE GRILLE

Prioritizing tasks, effective communication with guests and coworkers, improvising when faced with challenges, development of leadership skills, time management, and training new employees

OCTOBER 2017 – CURRENT

PRIVATE TUTOR, K-12 MATHEMATICS AND GENERAL EDUCATION

Explaining concepts in diverse ways, curriculum reinforcement, and tailoring lessons to individual needs, mentoring students to instill confidence in intellectual abilities

JUNE 2014 – AUGUST 2015
SALES CONSULTANT, MASCOT, ORANGETHEORY FITNESS (PALLADIO)
Opening new accounts for clients, knowledge of company marketing strategies, attending organized community events to motivate and encourage participation, promoting sales

PROJECTS

Programmable keyboard using an Arduino Uno to receive input from an IR remote (numbers pressed), send serial data through the USB port on a Raspberry Pi. The Pi uses a Python program to write the data to a text file, and a C program to read the text file, sending the data to a Digilent Max32 microcontroller that assigns musical notes to each number pressed and plays the notes on a speaker connected to headphone jack connected to board.

Currently working on a semi-autonomous car that uses microcontrollers to wirelessly send video, audio, and feedback data to a virtual reality headset and control system to dissuade impaired driving.

EXTRA-CURRICULAR ACTIVITIES

Member of Tau Beta Pi - The Engineering Honor Society– Upsilon Chapter Spring 2018
Recipient of Daniel Moreno Music Scholarship, August 2012

SPECIAL INTERESTS

Plays acoustic and electric guitar, electric bass, drums, piano, and harmonica
Customizing electric guitar features and hardware
Recording music individually and as a group member
Upgrading stock audio systems in vehicles and homes
Hobbyist projects using microcontrollers such as Arduino and Raspberry Pi

Gery A. Dawson Martinez III

EDUCATION

CALIFORNIA STATE UNIVERSITY, SACRAMENTO **EXPECTED: MAY 2019**

B.S. ELECTRICAL & ELECTRONICS ENGINEERING

San Joaquin Delta College **December 2017**

A.S. Mathematics for Transfer

SKILLS

Windows and macOS, Raspbian, Python, C, Verilog,

Microsoft Office, MATLAB, OrCAD, Altera Quartus, NI Multisim, JDE Enterprises, Max32, Analog Discovery Kit

EXPERIENCE

NETWORKSOUND - EL DORADO HILLS, CA **DEC 2017 - PRESENT**

ELECTRONIC AUDIO TECHNICIAN/PCB DESIGNER INTERN

- Edits schematics & designs new Printed Circuit Boards for new products
- Assembles and solders about 20 Printed Circuit Boards (PCBs) every work day to meet customer specifications
- Tests audio products to ensure they meet professional audio standards

JACKSON FAMILY WINES - AMERICAN CANYON, CA **MAR 2017 - MAR 2018**

INVENTORY AND HANDLING ASSISTANT

- Inventoried wine into branch plant using JDE and moved to proper location on a daily basis
- Picked and prepared about 800 wine orders for shipment per work day
- Verified logs in comparison to physical stock on a weekly basis

PROJECTS

SEMI-AUTONOMOUS VEHICLE **AUG 2018 - PRESENT**

- Project involves using micro-controllers to wirelessly send video, audio, and feedback data to a virtual reality headset and control system to dissuade impaired driving
- Researches, plans, and executes the use of microcontrollers and sensors needed for project
- Responsible for incorporating brake lights and turn indicators to simulate a car on the test vehicle

AUTOMATIC PET FOOD/WATER DISPENSER **JUL 2018 - AUG 2018**

- Activates when an email is received. When activated, the dispenser opens and closes over a set interval
- Designed and built the water dispenser using a servo motor and other components
- Configured Python script to run commands to control water dispenser via email

MAMBA BNC TO FIBER CONVERTER **MAR 2018**

- A unit that converts Multichannel Audio Digital Interface (MADI) BNC to bi-directional single-mode or multi-mode fiber
- Researched components that best fit the product and designed electrical schematics to create a bill of materials
- Created Printed Circuit Board (PCB) files in order to send to a manufacturer

LEADERSHIP / EXTRACURRICULAR ACTIVITIES

SOCIETY OF HISPANIC PROFESSIONAL ENGINEERS - CSU SACRAMENTO

VICE PRESIDENT **JUL 2018 - PRESENT**

- Maintains business professional relationships with companies and speakers sponsoring SHPE
- Represents the ideas, goals, and values of SHPE to the Engineering and Computer Science Joint Council (ECSJC) and represents SacSHPE to the Mathematics, Engineering, Science Achievement (MESA) Engineering Program

COMMUNICATIONS EXECUTIVE **JAN 2018 - JUN 2018**

- Responsible for taking meeting minutes during the officer meetings, as well as sending out an informative newsletter to members

MARK NIEDENTHAL

Summary

Innovative Electrical Engineer specialized in operations management that improves efficiency while meeting deadlines and budget requirements. Operations Supervisor possessing comprehensive knowledge of project and program management techniques. Natural leader driven to motivate teams to exceed business goals and targets while under pressure.

Highlights

Hiring and Retention

Procedure Development

Training and Development

Microsoft Office Suite Expert

Recruiting

Fluent in Tagalog

Personnel Records

Maintenance Scheduling Tools

New Hire Orientation

Analog and Digital Electronics Design

Exceptional Interpersonal Skills

Oscilloscope

OSHA Inspection

Strong Presentation skills

Employee Scheduling

Operations Research

MAXIMO

MATLAB

Multisim

SPICE

Advanced Design System Verilog

Accomplishments

Certified by Skycoaster Inc. to inspect while maintaining a Skycoaster site.

Leading innovator to ensure guest service is best in the company.

Recognized as friendliest and safest Rides Department in the company.

Spearheaded an employee engagement program, resulting in a 60% decrease in annual employee turnover. Boosted customer satisfaction ratings by 5% in under 12 months.

Experience

Operations Supervisor 07/2009 to Current Six Flags Discovery Kingdom Vallejo, CA Communicates with corporate Engineers to update on ride functions and procedures. Achieved 99.9 or higher in the previous 5 years of corporate safety audit. Lead a team of over 450 employees. Conducts in class and on the field training to translate corporate policies. Maintains a department budget of over 4 Million dollars. Recruited, hired and trained 100 new employees for Rides and Operations.

Optimized the overall customer experience through Guest Service Survey (GSS). Mentored, coached and trained 450 team members. Identified inefficiencies and made recommendations for process improvements for ride throughput. Developed and shared best practices across the company, including other theme park companies. Development of Standard Operating Procedures to include ATSM, OHSA, and company regulations.

Education

Bachelor of Science: Electrical and Electronic Engineering Sacramento State College Double Major in Applied Physics

Relevant Coursework

Signals and Systems Circuits Systems and Logic Design Microprocessors Applied Electromagnetics Electricity and Magnetism Thermodynamics and Statistics Materials Science

Thanak Prom

EDUCATION

California State University Sacramento **May, 2019**
BS, Electrical & Electronics Engineering *Stockton, CA*

WORK EXPERIENCE

City of Lodi Public Works **July 2017 – August 2018**
Engineering Intern *Lodi, CA*

- Designed city sitemap plans of City construction
- Drafted traffic utility light staging plan for all traffic boxes
- Conducted Traffic Engineering studies based off gathered field data
- Assisted the survey team in mapping and topographical surveys

Drake Haglan & Associates **January 2016 – July 2017**
Engineering Technician *Rancho Cordova, CA*

- Drafted roadway plans based on Engineer's Design
- Assisted in the utility coordination for roadway design and construction staging
- Quantified and estimated roadway projects plan sheets

City of Lodi Public Works **July 2014 – January 2016**
Engineering Intern *Lodi, CA*

- Conducted Traffic Engineering studies based off gathered field data
- Assisted the survey team in mapping and topographical surveys

David's New York Style Pizza **March 2014 – September 2014**
Pizza Chef /Dishwasher *Stockton, CA*

- Prepared and cook a variety of foods within allotted order time
- Operated large-volume cooking equipment such as ovens, grills, and deep-fryers

PROJECTS

(S.A.C.) Semi-Autonomous Car **August, 2018 - Present**
Electrical Engineering Senior Product Design Project *Sacramento, CA*

- A semi-autonomous car that uses microcontrollers to wirelessly send video, audio, and feedback data to a virtual reality headset and control system to dissuade impaired driving.
- Responsible for the safety design and sensors for Automobile safety precautions

Candy Sorting Apparatus **January, 2017 – May 2017**
Microprocessor Lab Final Project *Sacramento, CA*

- Programmed and designed an apparatus that conducted sorting algorithms based on color light sensor values

SKILLS

- **Skills:** AutoCAD; Civil3D; ArcGIS; Inventor; Photoshop; Excel; MatLab; Pspice; Arduino; Spin; Python; C, C++, JAVA, Assembly language; Soldering; MIG, SMAW & Oxy-Acetylene Welding;