Senior Design
Final Fall Design Report

Driver 2.0

Vasu Bhog
ChaoYang Zhu
Chunjie Pan

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Project Description

Team Members

- Vasu Bhog - bhogvu@mail.uc.edu
- ChaoYang Zhu - zhucy@mail.uc.edu
- Chunjie Pan - pance@mail.uc.edu

Faculty Advisor

- Dr. Wen-Ben Jone - jonewb@ucmail.uc.edu

Background Description

Billions of people still drive on the road and have barely any assistance from smart devices to help them while driving. There is a continuous increase in crashes over the years, and there are more and more drivers that are getting on the road. Our project will aim at creating a simple interface-based application that will use computer vision and machine learning to detect dangerous situations and objects on the road. This will decrease the probability of crashes and injury, as well as increase the awareness of the driver.

Problem Statement

There have been millions of distracted drivers and car crashes over the years. Car crashes are continuously increasing, and the issue is with drivers that are not aware or distracted. We need to find a solution that everyday drivers can utilize instead of buying a completely new vehicle.

Statistics

- Average of 6 million car accidents in the U.S. every year
- More than 1.5 million people in the US are injured every year in car accidents

The table below shows the crashes from 2008 - 2017. The increase in drivers and vehicle purchases illustrate the inadequate technology in vehicles.

Year	Fatal	Injury	Property damage only	Total crashes
2008	34,172	1,630,000	4,146,000	5,811,000
2009	30,862	1,517,000	3,957,000	5,505,000
2010	30,296	1,542,000	3,847,000	5,419,000
2011	29,757	1,530,000	3,778,000	5,338,000
2012	31,006	1,634,000	3,950,000	5,615,000
2013	30,057	1,591,000	4,066,000	5,687,000
2014	30,056	1,648,000	4,387,000	6,064,000
2015	32,539	1,715,000	4,548,000	6,296,000
2016	34,748	2,116,000	4,670,000	6,821,000
2017	34,247	1,889,000	4,530,000	6,452,000

Credit for Statistics

Inadequacy of Current Solutions

There is no device that currently out there that detects objects, tired drivers, and road signs for drivers. There are currently only advanced cars that cost an additional hundreds of thousands of dollars that have sensors and cameras built in the vehicle. Not everyone can afford expensive vehicles, therefore a device that can detect and notify dangerous objects and distractions on the road will reduce the likelihood of a crash along with increasing the safety.

Background Skills and Interest

Background Skills: We have experience in full-stack web development, computer vision, and deep learning.

Interest: We are interested in adding to our skill sets and are looking forward to learning more about applications using Computer Vision.

Approach, Goals and Expectations

Primary Goals

- Create/Utilize devices such as Raspberry PI
- Utilize camera feed data to detect objects, drivers swaying, and road signs to enhance the drivers' safety
- Create an interface to help drivers in all conditions

User Stories and Design Diagrams

User Stories

- As a driver I want to be able to utilize the device to enable smart detection of dangerous road objects and conditions.
- As a passenger, I want to be able to help navigate and aid the driver using the device and ensuring that that the driver is aware.
- As a device owner, I will be able to utilize the advanced modeling that detects driver swaying and fatigue, as well as road sign detection.
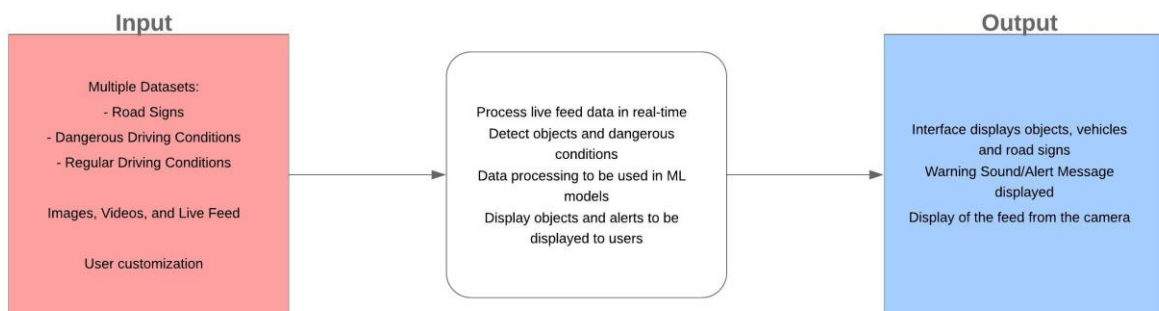
Design Diagrams

Diagram 1:

Diagram 2:

Diagram 3:
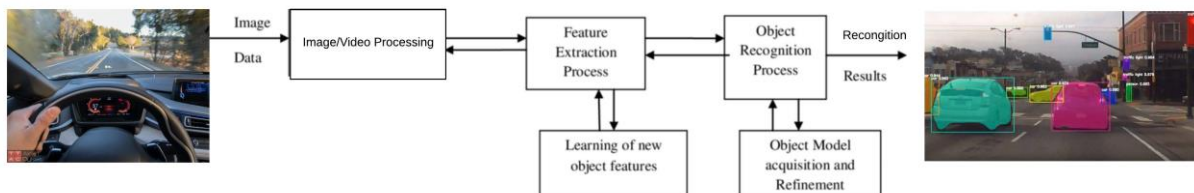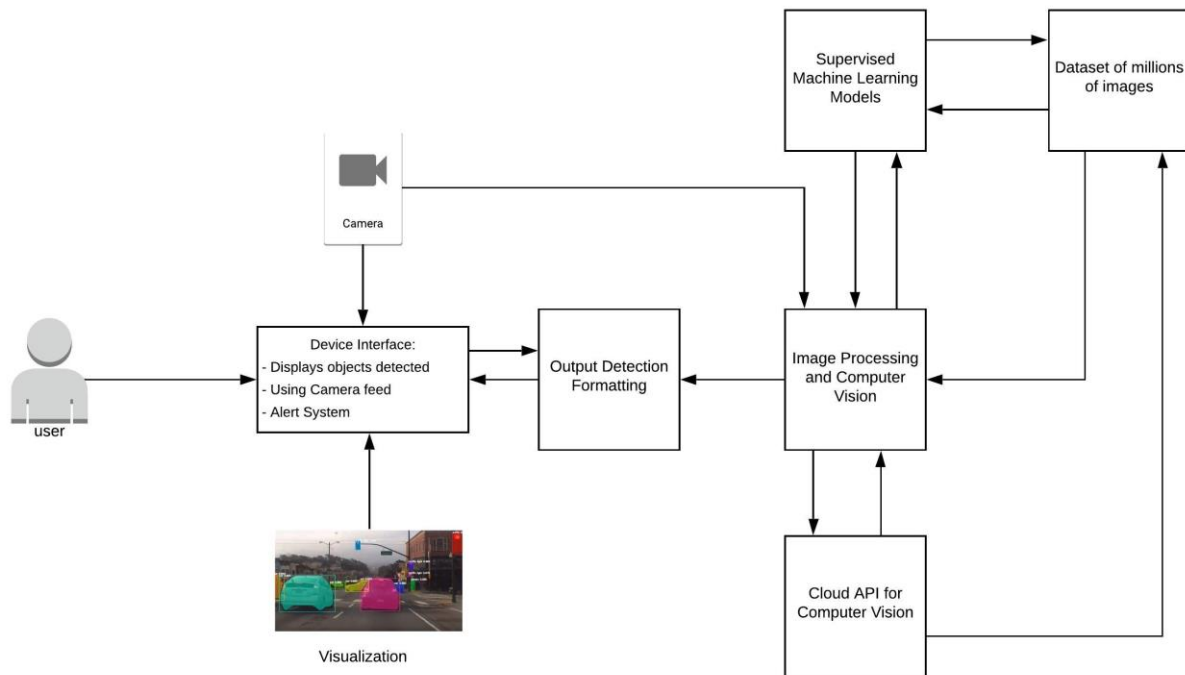

Design Description

Diagram 1:

- High-Level Design of the Input Layer, Computer Layer, and Output Layer.
- Able to illustrate the overall system design that will take place.
- Includes the amount of data, computation through ML models and output to the interface.

Diagram 2:

- A more concrete diagram illustrating from the user perspective.
- Illustrates the computer layer further.
- We will feed live feed road data into our image processing program that will be able to detect and use the ML models to output warnings to the user.

Diagram 3:

- An in-depth look at the internal system of the ML models and Computer Vision.
- The diagram will illustrate what the user should get back to the interface based on the computer layer.
- The diagram illustrates the different components of the machine learning model that will be used to first learn and then process the live feed data back to the user.
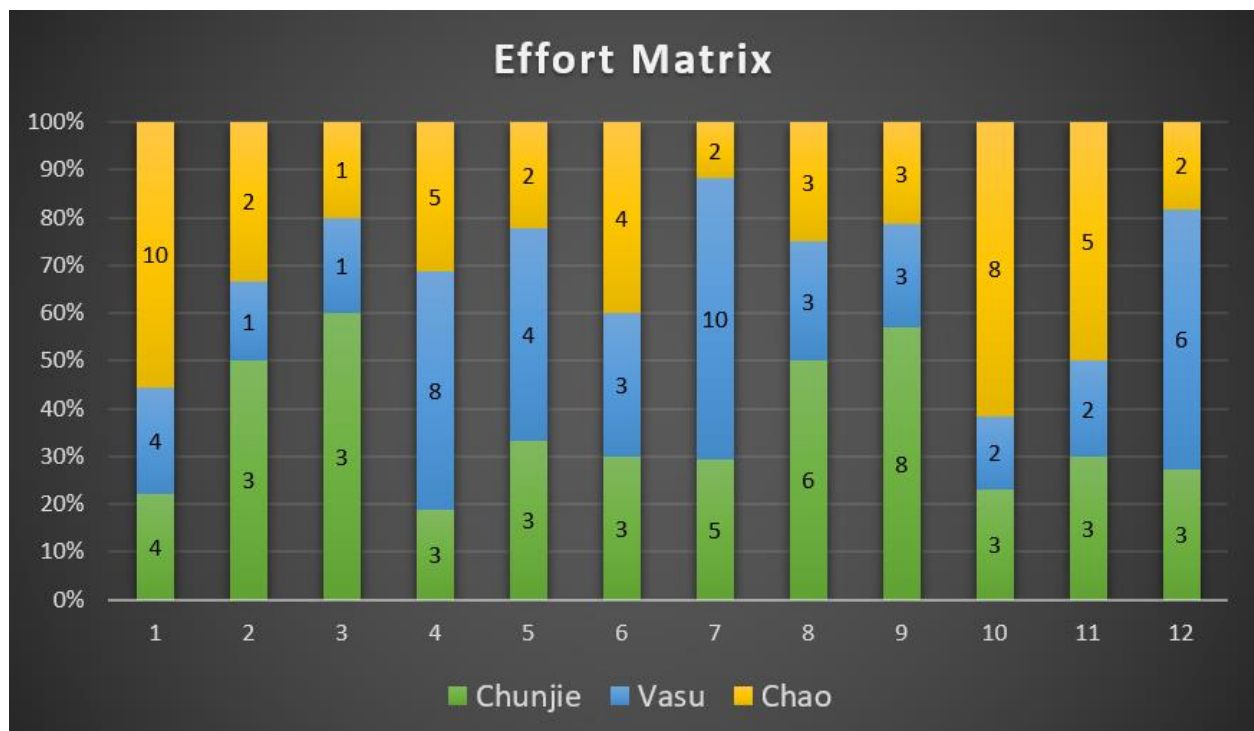
Project Tasks and Timeline

Task List

1. Understand OpenCV and practice object detection using Python or web application
2. Setup a camera to be connected to live feed driving data
3. Connect Camera with Raspberry Pi
4. Write program to detect objects as they move in the camera
5. Research methods to detect multiple objects in image, video, and live feed
6. Research how to train a machine learning model to detect road objects
7. Write neural network code to be used to learn and recognize dangerous car conditions
8. Train neural network with training and validation sets of dangerous objects
9. Create an alert interface/program when object is detected
10. Detect road swaying and dangerous driving through lane detection
11. Get full system to run on Raspberry Pi in a "live" environment.
12. Write code to notify user of alerted object through Raspberry Pi and interface screen

Timeline:

#	Task	Start Date	End Date
1	Understand OpenCV and practice object detection using Python or web application	11/18/2019	11/22/2019
6	Research how to train a machine learning model to detect road objects	11/25/2019	11/29/2019
5	Research methods to detect multiple objects in image, video, and live feed	11/25/2019	11/29/2019
7	Write neural network code to be used to learn and recognize dangerous car conditions	12/02/2019	12/20/2019
8	Train neural network with training and validation sets of dangerous objects	12/09/2019	12/27/2019
M1	Create a program that detect speed limit in a video	12/02/2019	12/27/2019
2	Setup a camera to be connected to live feed driving data	12/30/2019	01/03/2020

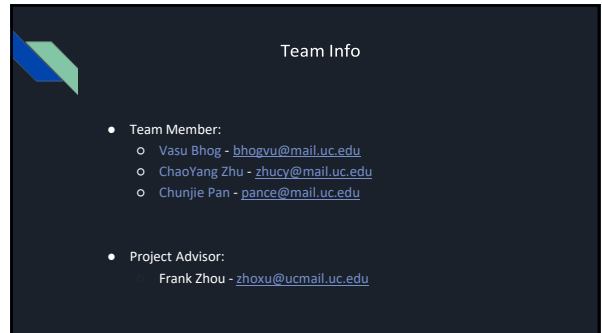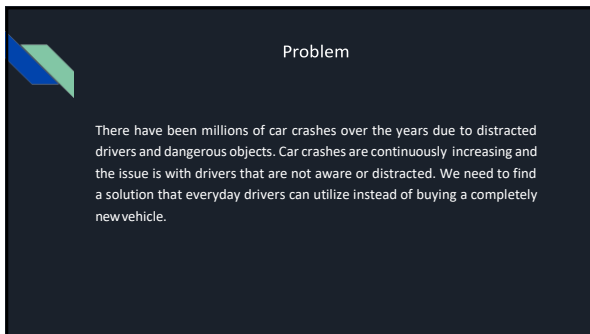| 4	Write program to detect objects as they move in the camera	01/06/2020	01/10/2020
M2	Connect the program to camera to read live feed data	12/30/2019	01/10/2020
3	Connect Camera with Raspberry Pi	01/13/2020	01/17/2020
11	Get full system to run on Raspberry Pi in a "live" environment	01/20/2020	01/24/2020
M3	Setup program with Raspberry Pi	01/13/2020	01/24/2020
12	Write code to notify user of alerted object through Raspberry Pi and interface screen	01/27/2020	02/07/2020
9	Create an alert interface/program when object is detected	02/10/2020	02/14/2020
M4	Create alert interface/program that trigger when object detected	01/27/2020	02/14/2020
10	Detect road swaying and dangerous driving through lane detection	02/17/2020	02/28/2020
M5	Implement more desired features	02/17/2020	03/20/2020

Effort Matrix

PowerPoint Presentation

Slide 1

Driver 2.0

Slide 2

Team Info

- Team Member:
  - Vasu Bhog - bhogvu@mail.uc.edu
  - ChaoYang Zhu - zhucy@mail.uc.edu
  - Chunjie Pan - pance@mail.uc.edu

- Project Advisor:
  - Frank Zhou - zhoxu@ucmail.uc.edu

Slide 3

Problem

There have been millions of car crashes over the years due to distracted drivers and dangerous objects. Car crashes are continuously increasing and the issue is with drivers that are not aware or distracted. We need to find a solution that everyday drivers can utilize instead of buying a completely new vehicle.

Slide 4

Solution

A device that can detect and notify drivers about dangerous objects and distractions on the road in order to reduce the likelihood of a crash along with increasing safety.

Slide 5

Project Abstract

Billions of people still drive on the road and have barely any assistance from smart devices to help them while driving. There is a continuous increase in crashes over the years, and there are more and more drivers that are getting on the road. Our project will aim at creating a simple interface based device that will use computer vision and machine learning to detect dangerous situations and objects on the road. This will decrease the probability of crashes and injury, as well as increase the awareness of the driver.

Slide 6

Goals statements

- Create/Utilize devices such as Raspberry PI to process driving data
- Utilize camera feed data to detect objects, drivers swaying, and road signs to enhance the driver's safety
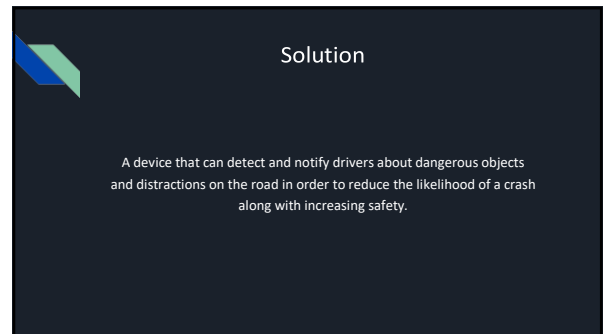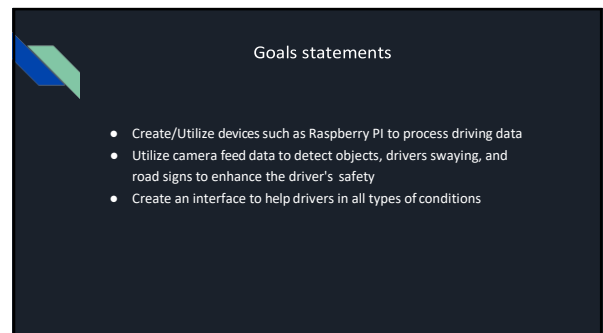- Create an interface to help drivers in all types of conditions

User Stories

- As a driver, I want to be able to utilize the device to enable smart detection of dangerous road objects and conditions.
- As a passenger, I want to be able to help navigate and aid the driver using the device and ensuring that that the driver is aware.
- As a device owner, I will be able to utilize the advanced modeling that detects driver swaying and fatigue, as well as road sign detection.
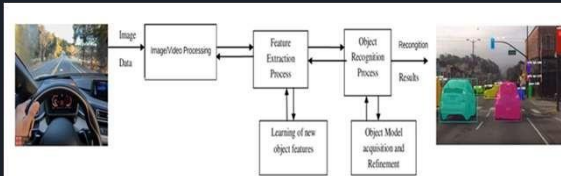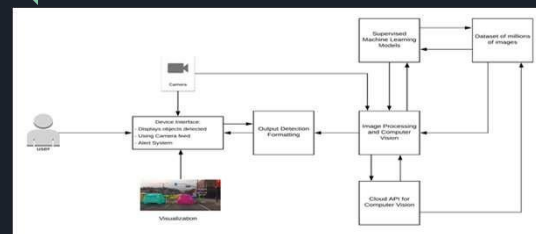
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Design Diagram
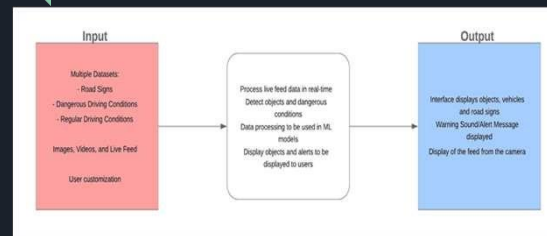
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Design Diagram 2

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In Depth Design Diagram

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Project Constraints

Economic Concerns

- Our solution will cost us money as we need to purchase parts to create the device. In order the users end cost would be low, we will utilize inexpensive devices. We are not limited to any organization or facility as we will be using open source frameworks.

Social Concerns

- Safety is of the utmost importance when it comes to driving therefore ensuring our project will be able to positively impact the safety of driving is our main focus.
- Our machine will help drivers use ML and Computer Vision to attain a higher level of safety through alerting the driver of oncoming danger.

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Current state of project

1. Discussed with Professor Frank about our project and got feedback from additional professors.
2. Researched the object detection and Raspberry Pi.
3. Learning OpenCV and it utilization with different programming languages.
4. Practicing object detection using Python and Java.

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Expected Accomplishments for the end of this term

- Understand OpenCV and practice object detection using Python/Java and Raspberry PI.
- Research how to train a machine learning model to detect road objects and dangerous conditions.
- Research methods to detect multiple objects in image, video, and live feed to improve the model and device.

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Timeline for the Project

Dates	Milestones	Tasks
Dec 02 2019 - Dec 27 2019	Create a program that detects objects in driving video data	1,2,3,4,5
Dec 30 2019 - Jan 10 2020	Connect the program to the camera to read live feed data	6,7
Jan 13 2020 - Jan 24 2020	Setup the program to be used with Raspberry Pi	8,9
Jan 27 2020 - Feb 14 2020	Create an alert interface and program that triggers when objects are detected	10,11
Feb 17 2020	Implement more desired features	12

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Timeline and Milestone 1

- Milestone 1:
  - Create a program that detects speed limit in a video/live feed

- Task:
  1. Understand OpenCV and practice object detection using Python or web application
  2. Research how to train a machine learning model to detect road objects
  3. Research methods to detect multiple objects in image, video, and live feed
  4. Write the neural network code to be used to learn and recognize dangerous car conditions
  5. Train the neural network with training and validation sets of dangerous objects

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Timeline and Milestone 2

- Milestone 2:
  - Connect the program to the camera to read live feed data

- Task:
  6. Set up a camera to be connected to live feed driving data
  7. Write a program to detect objects as they move in the camera

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Timeline and Milestone 3

- Milestone 3:
  - Setup the program with Raspberry Pi

- Task:
  8. Connect Camera with Raspberry Pi
  9. Get the full system to run on Raspberry Pi in a "live" environment

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Timeline and Milestone 4

- Milestone 4:
  - Create an alert interface/program that triggers when object detected

- Task:
  10. Write code to notify the user of the alerted object through Raspberry Pi and interface screen
  11. Create an alert interface/program when an object is detected

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Timeline and Milestone 5

- MileStone 5:
  - Implement more desired features

- Task:
  12. Detect road swaying and dangerous driving through lane detection

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Division of Work

Vasu:

- OpenCV detection and setup
- ML models
- Utilizing setup/models for final system

Chunjie:

- Rasperberry PI
- Camera live feed/Interface
- Connecting interface with final system

ChaoYang:

- Research for multiple object detection
- Enhancing neural network
- Connecting results to final system

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Expected Demo at Expo

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Expected Demo at Expo

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Credits

Follow our progress on our

Github Repo: https://github.com/VasuBhog/Senior-Project

Images used from: Google images

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Self-Assessment Essays

Vasu Bhog

Our project aims to answer the millions of crashes that still occur today due to distractions and dangerous objects while driving. As of today, there is research and companies that utilize cameras and sensors on vehicles to detect collisions and dangers. We will use computer vision to detect objects, road signs, and machine learning to analyze dangerous driving patterns. We will utilize our technical knowledge to develop an application and device that will be used to monitor driving conditions in any vehicle. We plan to use a small device such as a Raspberry PI and camera attachment to give us live camera feed data of the vehicle. Once we retrieve the data, we then will process it and illustrate to the user obstacles, road signs, and warnings that may occur.

Throughout my college career, I have learned a diverse set of technical and professional knowledge. I was able to learn specifically about computer vision and machine learning through courses I took abroad in France. I was able to get practical experience through a project that required the use of creating an application to detect objects using Java and OpenCV. I was able to understand the curriculum due to my previous technical knowledge and use of programming languages through Software Engineering courses. There have been many fundamental courses that allowed me to learn more about my interests today. I was able to develop many professional skills that allowed me to get the France opportunity as well.

My co-op and internship experiences intertwine with my degree in which I have a diverse set of technical and professional skills. I have worked on many different projects and roles ranging from data analyst to full-stack developer during my previous internships. I like to challenge myself and find projects that expand my technical knowledge and professional skills. I have been able to develop these skills through my co-op experiences at Microsoft, Fifth Third Bank and the research internship in France called UrbanLoop. I enjoyed learning from incredibly smart people and their perspectives on how to bring my knowledge to be used in an industry manner. I believe that all my internship experiences will benefit me greatly in successfully leading and developing our project.

I am extremely interested in this project as it deals with a revolutionary technology that can impact millions to billions of people worldwide. Computer vision and machine learning can solve many problems in today's fields of healthcare, transportation, and many others. I believe technology today should not be limited for only people who can afford it. The vehicle aid assistance that we plan to develop would be available to anyone to use in their conventional vehicles. It will allow drivers to rest assured that there are a detection and awareness in their smart device. I believe it is important for us to learn about these technologies along with the data that is available for us to utilize and create highly efficient models.

Our approach to solving this will be based on a learning structure and verification. We will begin with validating and processing images and videos of objects, road signs, and dangerous conditions on the roadway to aid the driver. Detection and validation will allow us to create reliable models for which we can use in our AI-enabled device. We will then utilize the raspberry PI and camera system to capture live feed. Once verification and system design are suitable for vehicles then we can test our product. I believe if we are able to satisfiable detect dangerous objects and distractions that could cause a crash, this would justify our project and success.

ChaoYang Zhu

There are millions of car accidents in the U.S. every year and cause millions of people injured every year. I believe, accidents occur mainly because of human behaves and the limitation of human's ability to react and process all the information in a short amount of time. As technology rapidly grows, we invent the self-driving vehicle and other technology to help the driver. However, not everyone can afford to can a smart vehicle. For our project, we will be focusing on computer vision and deep learning to create a project to help process information for the driver with an external camera and Raspberry Pi and show them on an interface. The goal is to break the limitation for the older vehicle to have a smart assisting drive system.

As mentioned in the first paragraph, the project involves computer vision and deep learning. For computer vision, we will be focusing on graphic processing. For this reason, all our team members are currently taking Computer Graphic I and self-studying with this knowledge, we want to use this project as a learning experience as well. For deep learning, every member has taken deep learning or machine learning previous, we use those experience to help develop the program and improve our skill in deep learning as well. For the interface for the system, I have taken User Interface I previously and created a web application as the final assignment for Python course. All that knowledge will help us solve the problem we might face and complete the project.

For my pass four co-op experiences, I have involved in diverse roles. Roles include application developer and research assistant. During co-op at Innomark Communications, I was an application developer in the IT department. My primary works were web app development for both front-end and back-end. The job involved using interface design and system (back-end) structure design. My last co-op was at Cincinnati Children's Hospital Medical Center as a biomedical developer, my goal at CCHMC was to create a program to analyze the collected data from the participant. The data was collected with Tobii Eye Tracker, which requires me to understand the row data's mean with the graphic shown to the participant. This will help me to

understand the data/graphs captured with the camera and reformat them into the form that drive's need and desire.

As someone who does not like to drive, I always want to have as much assistance as possible from our technology. One of the common problems while driving is not seeing the road sign on the side or other objects such as the vehicle or small animals. Our first step will be road sign detection for images and videos processing, then we will try live feed for detecting road sign. After we complete the basic functionality, we will start to create a user interface for live feedback. This will complete the minimal requirement for our project. Then we can start adding more futures we want, such as the vehicle or small animal detection.

Our goal is to complete the minimal requirement for the project that can be in use for a live test on the vehicle. To accomplish this, we need to be able to detect the road sign while it is changing size (as we get closer to it) in the video. Our team will sit down in a meeting to complete this task. Since I have a lot of experience in interface design and web application development, I will be doing more for programming the interface for the user. I believe we will be able to complete the basic functionally for the project by mid next semester and start to implement more future for the rest of the semester. Base on the problem we might face while programming the futures, I believe we will be able to complete the prototype that can be in use for testing.

Chunjie Pan

The project aims to harness the power of computer vision and machine learning to detect dangerous and object on the road. The end project will utilize camera feed data, utilize Raspberry PI as platform and use Amazon Web Services to process image. Nowadays, the number of vehicles on road is increasing every day and there is a continuous increase in crashes over the years. However, there are barely any smart devices installed in vehicle to help driver recognized the dangerous on the road. For most people, they must buy a completely new vehicle to obtain smart assistant. The project will help people get smart assistant by installing a low-cost and small size device in their current vehicles.

As a Computer Science major, the curriculum at UC has played an important role in gaining the necessary expertise to develop the project. Data Structures (CS 2028) helped me understand concepts such as Object-Oriented Programming. Linear Algebra (MATH2076) helped me understand vector and matrix operations which are very important in machine learning and computer vision. Software Engineering (EECE 3093) introduced me to concepts such as agile methodology. Design & Analysis of Algorithms (CS 4071) and Machine Learning (CS 6037) improved my programming through concepts such as complexity and using neural networks in the machine learning.

I have gained a lot of software development experience through four co-op rotations. During my first co-op rotation, I worked in the UC College of Engineering and Applied Science as a research assistant. I gained the skill to design and implement a digital circuit simulator and displayed excellent team work skill and communication skill. For my second rotation, I worked at Siemens Innovation Center. I was a web application developer and created a web application from scratch with teammates. I have gained hands-on development experience of software. I also learned how to use the database and connect database to software efficiently. For my third rotation, I worked at the Institute of Automation, Chinese Academy of Sciences. I was an embedded software developer. I completed a PDF reader application alone and it was used in a printer system. I was also brought on as the development lead for the programmable motion control software project. I designed a set of programming language and interrupter functions. During this co-op, I gained embedded software developer experience and better understanding on the Linux system. During my last co-op, I worked at UC as a research assistant, I learned new technology that might be used in the project.

I have always been interested in computer vision, cloud computing and machine learning. I really like this project because it will not only provide a cost-effective drive assistant option for drivers but also decrease the probability if crashed and injury as well as increase the awareness of the driver. Of cause, I was also seeking a project that would also help improve my career options by giving me experience valuable to employers.

This project will be divided into three main parts: getting data from camera and sending the data to Amazon Web Service; using machine learning to recognize objects in each image; detecting dangerous from that information. As a team, we will work through all this task together. For my part, the focus will be on embedded development and machine learning. I will evaluate my contributions by measuring the accuracy and feedback received by teammate and advisors. The expected result of the project will be a small device with interface that can detect dangerous situations and objects on the road. I will know that I have done a good job if the device performance is well above baseline of our expectation.

Professional Biographies

Vasu Bhog

Contact Information

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LinkedIn: https://www.linkedin.com/in/vasubhog/

Work Experience

MICROSOFT, Program Manager Intern
May 2019 – August 2019

- Developed Python programs and utilized Azure Cognitive Services to illustrate user feedback about Azure Data Studio through user engagement from Twitter and GitHub
- Spearheaded initiative to improve SQL Tools telemetry through a new Nova telemetry platform ensuring GDPR compliance and accuracy
- Created PowerShell Cmdlet used in the SQLServer PS Module to operationalize and execute SQL Notebooks
- Coordinated with engineering, Microsoft partner teams, and third-party teams to release the new version of Azure Data Studio

URBANLOOP, Command and Control Software Developer Intern
January 2019 – May 2019

- Received a scholarship to study abroad in Nancy, France
- Created an optimized planned solution for an intelligent control system using Wago PLC, sensors, and e!Cockpit programming
- Created a live-tracking GUI using Python Tkinter to track each pods location on the loops
- Implemented a computer vision application using Java and OpenCV to detect road signs on videos and live feed

GOOGLE via Vaco, Google Cloud Platform Student Innovator
July 2018 – December 2018

- Selected as one of 200 students nationwide as a Google Cloud Platform (GCP) Innovators

- Promoted GCP's various functionalities across UC's campus by coordinating and hosting events for students and faculty
- Demonstrated the process of creating an application using GCP's Machine Learning to peers and faculty members
- Effectively communicated and provided real-time feedback on product development to Google's Management Team

FIFTH THIRD BANK, Software Developer Co-op
May 2018 – August 2018

- Developed code to enhance security and customer verification for Fifth Third Bank's commercial
- Core Developer on Blockchain POC using SQL, Java, and, Angular JS
- Main Developer on Web Virtual Reality POC using HTML, JavaScript, and A-Frame Framework
- Aided in research, design, development, and testing for WebVR and commercial banking site

FIFTH THIRD BANK, Data Analytics Co-op
January 2017 – May 2017 | August 2017 - December 2017

- Extracted data using SQL and analyzed it in Unix and SAS environments
- Responsible for importing, manipulating, and analyzing data using SAS
- Assisted the Audit Division through automation and launched new testing programs
- Effectively presented data analytic results using Tableau

Projects Sought

- Computer Vision with the use of Machine Learning and AI. Areas of interest: Healthcare, Accessibility, and Self-Driving Cars
- AR/VR application and development
- Artificial Intelligence Applications

ChaoYang Zhu

Contact Information

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Co-op Work Experience

Biomedical Developer Intern, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio
May 2019 – Aug 2019

- Using MATLAB to create a script to analyze the data from Tobii Studio (Eye Tracker).
- Using MATLAB to create a script to analyze the data from Neurobehavioral Systems' Presentation Software.
- Using PsychoPy package to create an experiment to collect data.
- Built friendly relationships with colleagues to enhance the work environment and experience.

Research Assistant, University of Cincinnati, Cincinnati, Ohio
Jan 2019 – Apr 2019

- Used PTV Vissim to develop a highway transportation simulation.
- Used Visual Studio to implement the human behavior for the simulation.
- Built friendly relationships with colleagues to enhance the work environment and experience.

Application Developer Intern, Innomark Communications, Fairfield, Ohio
Sep 2017 – Dec 2017 & Jun 2018 – Aug 2018

- Used Visual Studio, TFS, and Microsoft SQL for developing environment.
- Used C#, HTML, CSS, jQuery, MySQL, SQLite to complete diverse projects, such as Win Form Application and Web Application.
- Used Model-View-Controller (MVC) framework to design and complete multiple Web Application.
- Used professional communication skill to present ideas to partners and supervisor, also to report daily progress to supervisor.

- Built friendly relationships with colleagues to enhance the work environment and experience.

Research Assistant, University of Cincinnati, Cincinnati, Ohio
Jan 2017 – May 2017

- Used C++ to design and improve a program to process the logic circuit.
- Used professional communication skill to present projects and ideas to partners and supervisor.
- Built friendly relationships with colleagues to enhance the work environment and experience.

Project Sought

- Computer Vision
- Artificial Neural Network

Chunjie Pan

Coop or other experience and responsibilities

- Research Assistant, University of Cincinnati, Ohio, Jan 2019 – April 2019
    - Developed the Simulation of Connected Vehicle Applications
    - Designed road network module in Vissim software.
    - Created Connect and Autonomous Vehicle behavior and developed the simulation manager module in C++ and C# respectively
- Embedded Software Development Inter, Institute of Automation, Chinese Academy of Sciences, May 2018 – Aug 2018
    - Completed a pdf reader application alone including resize, rotation, insertion, crop, convert and, etc May 2018 – Aug 2018
    - Completed a programmable motion control software alone from scratch including more than 5 models
    - Created functions to allow user to program their own specifications
    - Primarily used Qt in Linux
- Software Developer, Siemens Qingdao Innovation Center, Aug 2017 – Dec 2017
    - Created an internal software from scratch including more than 9 models
    - Connected database to software and web page

- - Coded background functions for webpage and developed webpage frontend
  - Primarily used C#, JavaScript, CSS, HTML, MySQL and MVC framework
- Research Assistant, University of Cincinnati, Ohio, Jan 2017 – May 2017
  - Designed and implemented a digital circuit simulator for digital

Skills/expertise areas

- Programming: C#, C++, JAVA, Python, .NET, CSS, HTML, JavaScript
- Operating System: Linux, Windows
- Database Programming: SQL, MySQL

Areas of interest

- Cloud computing
- Database applications
- Artificial Intelligence
- Robot

Type of Project sought

- Web application which use distributed computing architecture.
- Object detector used in vehicle
- Intelligent intersection controller

Budget

Expected Expenses

Item	Price
Raspberry Pi	$149.00
Raspberry Pi Interface	$79.95
ML model Accelerator	$95.00
Total	$323.95

Donations

Item	Donor	Price
GoPro Camera	Vasu Bhog	$300

Billable Hours

Vasu Bhog

Date	Hours	Activity
8/28/2019	2	Met with other teammates to discuss different project ideas and then ended up on a Computer Vision project
8/30/2019	1.5	Assignment 1 Due Biography
9/04/2019	3	Met with teammates to discuss the finalize project idea and begin working on project abstract and description
9/05/2019	1.5	Met with Dr. Wen Ben to discuss our project and see his recommendations and suggestions
9/06/2019	2	Researched our project further in the aspects of hardware and software to understand if this project is feasible

Date	Hours	Description
9/08/2019	2	Assignment 2 Due Project Description with teammates
9/15/2019	1.5	Assignment 3 Due Self-Assessment
9/20/2019	3	I helped Pan research equipment for the project, like raspberry pi, camera, and intel accelerator
9/22/2019	4	I focused on creating the User Stories and Design Diagrams for our project that was for Assignment 4
10/09/2019	2	I helped assign certain tasks associated to our Task Lists Assignment 5
10/13/2019	4	Did more research into which camera would work best for our project and found that we could use a camera I already have
10/15/2019	2	Worked on Assignment 6 Milestones, Timelines, and Effort Matrix with the team
10/26/2019	8	I worked on researching OpenCV and looking at previous Java programs I created to relearn important image processing techniques
11/12/2019	4	Worked on Assignment 8 Presentation and recorded the presentation (editing, and recording) that would be presented in front of class
12/05/2019	4	Worked on updating our Github and creating a Github Wiki to illustrate our final report
12/10/2019	4	Worked on Assignment 9 Final Report
Total Hours	48.5	

Chunjie Pan

Date	Hours	Activity
8/28/2019	2	Met with other teammates to discuss different project ideas
8/30/2019	1.5	Assignment 1 Due Biography
9/04/2019	3	Met with teammates to discuss our project ideas
9/05/2019	1	Met with Dr. Wen Ben to discuss our project
9/06/2019	2	Researched on project topic (hardware and software) to find out the level of difficulty of our project. If it is way too hard, we will change our project
9/08/2019	2	Assignment 2 Due Project Description
9/15/2019	1.5	Assignment 3 Due Self-Assessment
9/20/2019	5	Researched equipment for the project, like raspberry pi, camera, and intel accelerator
9/22/2019	1.5	Assignment 4 Due User Stories and Design Diagrams
10/09/2019	2	Assignment 5 Due Task Lists
10/13/2019	3	Did more research into which camera would work best for our project
10/15/2019	2	Assignment 6 Due Milestone, Timeline, and Effort Matrix
10/26/2019	6	researched OpenCV
10/27/2019	7	Did more research into OpenCV and wrote a small OpenCV project
10/28/2019	3	Added more features into my small project
11/12/2019	2	Assignment 8 Due Presentation
12/10/2019	4	Assignment 9 Due final report
Total Hours	46.5	

ChaoYang Zhu

Date	Hours	Activity
8/28/2019	2	Met with teammates to discuss different project ideas and decided to go with Computer Vision project
8/30/2019	1.5	Assignment 1 Due Biography
9/04/2019	3	Met with teammates to collect every member's project ideas
9/05/2019	1	Met with Dr. Wen-Ben to present our idea and get feedback
9/06/2019	2.5	Researched on project topic (hardware and software) to find out the level of difficulty of our project. If it exceeds the difficulty we can handle, we will change our project
9/08/2019	2	Assignment 2 Due Project Description
9/15/2019	1.5	Assignment 3 Due Self-Assessment
9/20/2019	3	Helped Pan to research equipment for the project, like raspberry pi, camera, and intel accelerator
9/22/2019	2	Assignment 4 Due User Stories and Design Diagrams
10/09/2019	2	Assignment 5 Due Task Lists
10/13/2019	3.5	Helped on research the best camera that fit the project
10/15/2019	2	Assignment 6 Due Milestones, Timelines, and Effort Matrix
10/26/2019	8	Researched on OpenCV with team
11/12/2019	5	Assignment 8 Due Presentation and uploaded presentation
12/05/2019	5	Worked on updating our Github and creating a Github Wiki to illustrate our final report
12/10/2019	3	Assignment 9 Due Final Report
Total Hours	47	

Total Team Billable Hours

Team Member	Hours	Amount due at $75/hr.
Vasu Bhog	48.5	$3,637.50
Chunjie Pan	46.5	$3,487.50
ChaoYang Zhu	47	$3,525.00

Appendix

Code Repository: https://github.com/VasuBhog/Senior-Project

OpenCV: https://www.learnopencv.com/

Previous OpenCV Projects: https://github.com/VasuBhog/Twizy-Project