DashCam Defender

Design Document

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Development Standards & Practices Used

Software practices

- Make code correct first and fast second
- Always test your code
- Agile Methodology
- Integration with hardware
- Simple design
- Pair programming
- Continuous integration

Hardware practices

- Integration with software
- Always test and make sure it is working
- Agile Methodology

Summary of Requirements

- Knowledge in mobile development
- Hardware development
- Database Design

Applicable Courses from Iowa State University Curriculum

- ComSci 309
- CPRE 288
- COMS 228
- SE/CPRE 185
- COMS 363
- CPRE 310

New Skills/Knowledge acquired that was not taught in courses

- Hardware Assembly
- Dart Programming Language
- Flutter Framework
- Hardware / Software integration
- API Calls
- Angular

1. Introduction

1.1. Acknowledgement

We thank Dr. Joseph Zambreno for his consultation as our senior design advisor. We acknowledge the development done by our team members Evan Timmons, Cobi Mom, Danny Yip, Scott Vlasic, Durga Darba, and Ismael Duran.

1.2. Problem and Project Statement

The roads as we know it are full of reckless drivers. What if there was a way to automatically detect when you are near a reckless driver? The solution that we are proposing is the ability for everyday consumers to come together and crowdsource information on reckless drivers. This is done by utilizing DashCam Defender, a product designed by us to automatically scan license plates and report reckless drivers when they are encountered instantly. Reporting is supported by a public facing website and app. This way, users can look up and report reckless drivers from multiple fronts.

1.3. Operational Environment

Since the product will be mounted on the windshield, it needs to be able to handle the fluctuation in temperatures that may occur in the car. Therefore, we will have to construct a container to protect the device from severe weather when the car is unattended as well as from consumer damages. This container must also be able to handle rough road conditions and keep the camera stable. Another condition we must consider is the camera's ability to capture data given poor weather. To ensure this, we will have to use a camera that returns images in 1080p or higher.

1.4. Requirements

Project requirements

- Dash camera that can record in 1080p
- A powerful enough computing board that can process the machine learning application
- A computation board that can work with peripherals

Functional Requirements

- A license plate reader that can accurately read license plates from nearby cars
- A platform where the user can report and view information

UI requirements

- Have an aesthetically pleasing but simplistic application for the user
- Have a driver mode focused on simplicity for maximum road attentiveness

1.5. Intended Users And Uses

We have three major intended users for our product:

- Police Departments
    - Police can lookup license plates and their last known locations to solve crimes faster
- Everyday Drivers

    - The everyday driver can report poor drivers and get alerts to notify them of when they are in the presence of a poor driver.
- Insurance Companies
    - Insurance companies can use driver ratings and dashcam footage to adjust their rates and claims

1.6. Assumption And Limitations

Assumption:
The end product will be able to work under a certain degree of poor weather. It will not be able to work if the weather is too harsh, where the camera is not able to capture clear pictures. The end product will be used in the United States.

Limitations:
The end product will be a dashcam and a mini pc in the client's car, completing the Dashcam Defender apparatus. The cost to produce the end product shall not exceed one hundred and fifty dollars. The system will not require more than 12 Volts. (The most common voltage output found in an Automobile Auxiliary Power Outlet)

1.7. Expected End Product And Deliverables

Hardware Product

- The expected physical product is that we have a dash camera and a computational board that can communicate with each other
- The computation board is integrated with ALPR (Automated License Plate Recognition)
- The computation board can send data to a mobile device

Mobile Application

- An aesthetic mobile application
- A driver mode screen
- The application should be able to send data to a server
- User should be able to view information like cars encountered

2. Specifications and Analysis

2.1. Proposed Approach

Our proposed approach is to find existing resources that will help us fill in for things that we need. A mobile application will be developed utilizing the Flutter Framework. We chose Flutter because of its great layout design and versatility to create an android application and IOS application with one project. The camera and mini PC have to work together and the other half of the team will work on that. The mini PC we are going to use is the NVIDIA Jetson TX2. We chose the Jetson because a Raspberry Pi isn't powerful enough to run machine learning applications. The camera we are going to use is a standard 1080p camera. Our solution to analyze license plates is to use an open-source Automatic License Plate Recognition software called OpenALPR.

2.2. Design Analysis

Currently we have a mock database to test the connection between the hardware and the software. From here, we need to move into figuring out how to organize and send the information to fill the tables in the database. Our final version of the product will be doing this automatically, so we need to ensure the information can be processed efficiently. On the hardware side, our goal is to be able to read license plates at a rate of 5 per minute. On the software side, the program has to be able to multithread efficiently enough to process each license plate and store the information separately. The main strength of the project is in the database and the pushing and pulling of the data from it. The weakness, currently, is in the way we are pushing the data when the device doesn't have easy access to the internet.

2.3. Development Process

We are going to be following the Agile Methodology for our development processes. Specifically, we're going to split up into two separate teams of three; one team focused on software and the other focused on hardware, following the principles of Agile development. We think Scrum is the best choice for the development process because it will allow us to create small goals that are attainable as well as foster communication and collaboration within each group. We'll incorporate 2 week sprints because it aligns with the submissions of the bi-weekly reports. We will keep track of the work to be done in sprints in Trello.

2.4. Conceptual Sketch

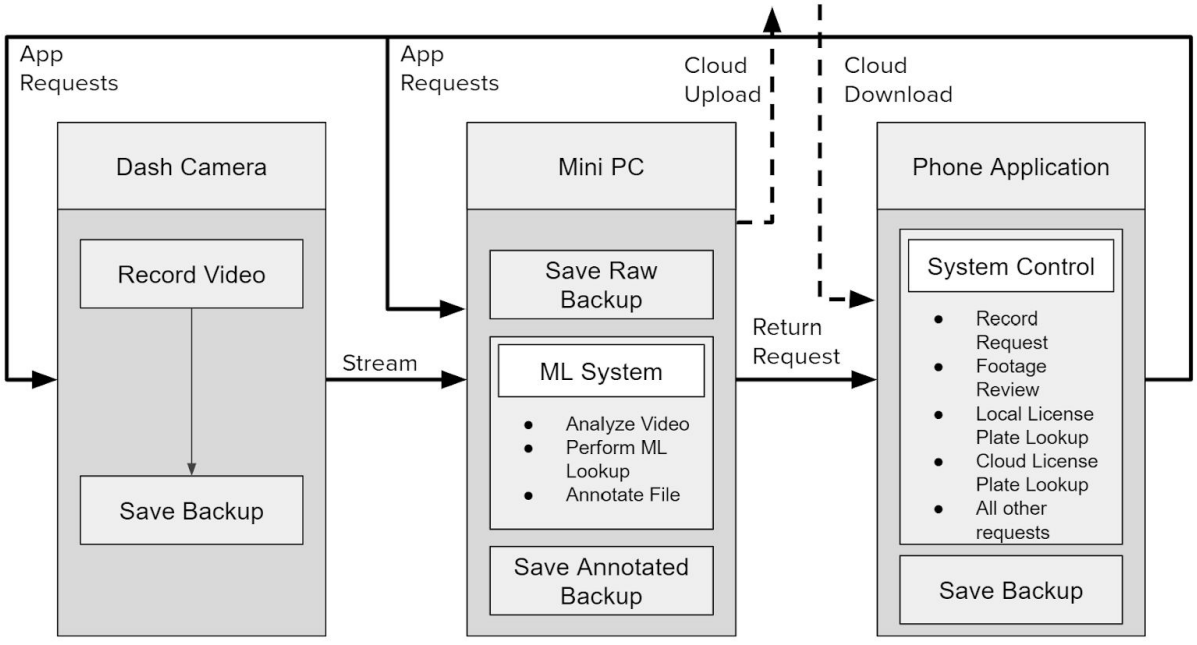

Figure 2.1: System Level Conceptual Sketch made by Evan Timmons

3. Statement of Work

3.1. Previous Work And Literature

OpenALPR - We're utilizing this service for license plate recognition because it has an acceptable pre-trained model on license plates.

3.2. Technology Considerations

Strengths

- Computer power on NVIDIA Jetson TX2 is adequate for our use case
    - 256-core NVIDIA Pascal™ GPU architecture with 256 NVIDIA CUDA cores
    - Quad-Core ARM® Cortex®-A57 MPCore
    - 8GB 128-bit LPDDR4 Memory
    - 32GB eMMC 5.1 storage
- *OpenALPR* is accurate enough (99%) for our use case
- *Flutter* allows for speedy development with one single codebase
    - Maintains native performance

Weaknesses

- *OpenALPR* is not 100% accurate, so edge cases can be tricky
    - *OpenALPR* is self-rated to be 99% accurate
- Cellular service in rural areas is not sufficient for constant data uploading. It will only be able to upload the data once it receives a sufficient internet connection. This will be dependent on the company of mobile data.
- The camera quality will not be as good in bad weather conditions
    - e.g. rain, snow, hail, etc.

Possible solution

- Create our own license plate recognition system that is more accurate
    - Requires training our own model
    - This will take a large amount of time with a lot of data required
- Only upload data while connected to a reliable source
    - This allows devices with data caps to upload only when connected to Internet

3.3. Task Decomposition

Hardware

- Hook external camera to *NVIDIA Jetson*
- Connect *NVIDIA Jetson* to *OpenALPR*
- Connect *NVIDIA Jetson* to mobile application
- Test runs

Software

- Develop *Flutter*-based mobile application

    - The mobile application is for the user to be able to connect their phone to the mini-PC to be able to interact with each other. The mobile application accesses the information about drivers as well as sends information to a server.
- Develop PostGRES database
    - Set up API to connect to database
    - Create security roles
    - Talk with subteams about what to store
    - Create high level diagram
    - Allow API to have public access
    - Create security when making api calls
    - Work with subteams to ensure POST and GET calls work properly
- Connect mobile application with *NVIDIA Jetson*
    - Connecting the mobile application and the Jetson is to send information from the jetson to the phone, then for the application to send or store information from the PC. It accesses the dash camera via the mobile application.

3.4. Possible Risks And Risk Management

Distracted Driving

- Use of mobile application while driving can be distracting to the driver
- To manage, we are utilizing a simple interface to minimize distracted driving

Hardware Compatibility

- *NVIDIA Jetson's* built in camera is not compatible with *OpenALPR*
- To manage, we're hooking up an external camera instead

Privacy Concerns

- The data we are working with is personal and will stay personal
- To manage, we are going to have a clear and robust data management policy
- There is a risk that user personal information will be stolen. We secure the personal information by having each user have their own account, which requires a unique username and password. This will be able to protect the privacy of users.
- We will prevent users from searching other user's footage. We will only allow users to search for the rating of other users, or the last location of the user if the user allows us to show their location.

Technical Risks

- We don't have any experience in machine learning. Developing machine learning that recognizes car plates might cost us some time and resources to learn on it. We will encounter this issue by spending more time to learn it online.

Software Risks

- If this mobile application has too many users using it at the same time, the database might be overloaded. We need to fix this by upgrading the server to be capable for all users to use it at the same time.

- Our team doesn't have much experience in developing software in Flutter or using the Dart language. We will learn it as we go.

3.5. Project Proposed Milestones and Evaluation Criteria

Key Milestones (in chronological order)

- Hardware Assembly completed
    - *NVIDIA Jetson* and external camera hooked up successfully
    - Designed and built enclosure for hardware
    - Completed power source for in-vehicle use
- Database Setup completed
    - Created initial test tables
    - Understood database design based on subteam requirements
    - Created users on the virtual machine to make database calls
    - Created API to speak with the database
    - Made API public so that that different subteams can access it
    - Began integration with the mobile app
    - Began stress testing the api through the app
- Mobile application completed
    - *Flutter* based mobile application with all requirements ready to go
    - A driver mode option for the safety of the driver
    - Is able to send information to the database/server
    - The application is able to receive information from the server successfully
    - IOS and Android mobile application are both working successfully
- *OpenALPR* working with *NVIDIA Jetson* w/ camera
    - Able to successfully feed video data into *OpenALPR* and detect license plates
    - OpenALPR tested to ensure maximum performance achieved based on hardware
    - Able to analyze 720p video at full 60fps
- Web Application
    - Fully functionally angular prototype
    - Search function to filter through 1000+ available videos
    - Search time of less than 2 seconds
    - Multi user capacity of 100 simultaneous instances
    - Testing suite implemented with Jasmine and Karma
- Complete working product
    - Able to interface with recorded data inside mobile application

3.6. Project Tracking Procedures

- *GitHub* for version control
    - 7ombers of our team will be doing work on separate branch
    - Code will be reviewed before merging
- *Trello* for backlog and tasks to be done during bi-weekly sprints
    - Trello will help with keeping track of progress of task

- Task will be divided into section of To-do, in-progress and finished task
- Each task will have a description and checklist work what need to be done to complete the task
- Each task will be assigned to team member

- *Google Drive* for document sharing
  - Document that need to be stored in a google drive folder that is accessible for every team member
  - Everyone will be able to edit the document

3.7. Expected Results and Validation

- Fully functional hardware consisting of *NVIDIA Jetson* w/ camera that interacts with our *Flutter* based mobile application and *OpenALPR* to successfully read license plates from a user's car ride.
- Going to verify these expected results with real life examples.
- Mobile application will be verified by generating an android and ios emulator to run on it. (see section #6.3 (figure 6.1~ 6.5) for more details on the mobile application User interface) These UI are the most important UI. We might still need some other UI to make our mobile application better. For example, UI for users to rate other vehicles, to search for other vehicles, and settings.
- Web application result (see section #6.3 (figure6.6~ 6.10) for more details on the mobile application User interface)

4. Project Timeline, Estimated Resources, and Challenges

4.1. Project Timeline

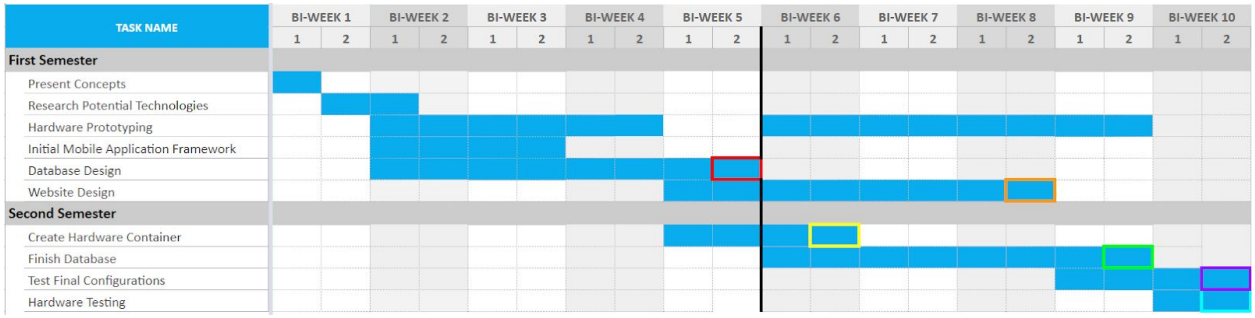

Figure 4.1: Timeline of milestones

Comleted Database	
Fully Functional Website	
Designed and Manufactured Hardware Encapsulation	
Database Populated with Data	
Completed Hardware Testing	
Test full Project Functionality	

Figure 4.2: Color keys

Our Gantt chart for the project is shown above. In column one, the tasks are divided into two subsections, one for each semester. Tasks are mainly grouped by the semester of which they begin. We highlighted the key deliverables with unique colored outlines and explained them right below the chart.

Uniquely, our project has been hindered by the COVID19 pandemic. As a result, our tasks have been divided to account for the inability to host physical meetings. Notably, hardware prototyping was put on hold until our team is able to meet again next semester as we are unable to order new parts to continue the prototyping phase.

4.2. Feasibility Assessment

For a completed project, we would like to have the mobile application, web application and hardware completely developed and tested. Due to a variety of factors, mainly time and access to hardware, this is not likely feasible. Our hope is that we are able to complete enough of each part of the project to have a working prototype with all core features. However, it is likely that not every component will be completed. The software part (mobile application and web application) are more feasible because we can distribute work, and work on the different parts, then merge it back. We just needed to have more virtual meetings, and we did not need any equipment from the lab. While the hardware is not feasible because we need equipment, and we would need to work on it in the lab. We can't work in the lab, and we can't meet face to face to work on the hardware part due to COVID-19.

4.4. Personnel Effort Requirements

Tasks to be Completed	Estimated Time to Complete
Present Concepts	The presentation of concepts only took our team 1 week to complete and was done during the first bi-weekly period
Research Potential Technologies	Researching technologies took our team a week to complete and another week to order the hardware components we had decided on.
Hardware Prototyping	Hardware prototyping is estimated to take 14 weeks to complete over two semesters. This task will involve creating a prototype from the NVIDIA Jetson TX2 and testing it in the environment of a vehicle.
Initial Mobile Application Framework	Initial mobile application framework took 4 weeks to complete and allowed our software team to get a better feel of Flutter.
Database Design	Database design began our second biweek and will continue for 8 weeks until biweek 5. The main goal will be to establish communication between both the mobile app and the web app.
Website Design	Website design is estimated to take 8 weeks over two semesters. The web app team will learn angular and create a web app that will allow users to view recordings from driving sessions and search license plate numbers to find specific recordings.
Create Hardware Container	Our hardware container will take us approximately 4 weeks to do and will account for stress testing of the finished product. We will need to research more into what materials to use for the enclosure so that there are no hardware performance issues as well as determining the proper dimensions the enclosure needs to be.
Test Final Configurations	Testing our final configurations is estimated to take around 8 weeks during only the final semester. Testing final configurations will consist of testing usability and load testing of the mobile application and web application. This will include making sure the user

	experience is solid and that there are no performance issues or bugs within either application.
Finish Database Design	Finishing the database will take us 8 weeks to complete, beginning semester 2, and will take into account memory management and speed of getting information.
Hardware Testing	Hardware testing is estimated to take 2 weeks only during the final semester. Testing will consist of ensuring that OpenALPR is working on the NVIDIA Jetson TX2 and that the camera is recording driving sessions at 1080p and sending those recordings to the database.

Table 4.3: Requirements for personal efforts

4.5. Other Resource Requirements

The costs needed for these requirements are further detailed in section 4.3

Resource Requirements	Comments and Alternatives
Fuel	While we have vehicles that we can use for testing free of charge, we will have to pay for the fuel costs that will be accrued after driving for miles of testing
Driver	This can be anyone on the senior design team who holds a valid driver's license
3D Printed Components	The parts should not be a large expense as we can pay for the price of the materials used.
OpenAlpr	This software is open source and has been lightly tested by the team. There is a higher performing paid alternative that could be used.
NVIDIA Jetson TX-2	OpenALPR site gave provided benchmarks with the Jetson which we think meets the specifications of our project. Based on benchmarks we should be able to run OpenALPR up to 30 fps on this board, and it also has all I/O needed (WiFi, bluetooth usb etc)
Sandisk 256GB SD Card	OpenALPR is typically not throttled by storage speed, this SD card provides a large amount of

	memory for testing, while also maintaining a cheap price
Unzano HD Webcam 1080p	A usb camera that will plug and play with Ubuntu and will work with OpenALPR software. The camera is 1080p (required for project) and has long distance manual focus (uncommon for webcams and required for project)
Logitech K400 Plus Wireless Touch TV Keyboard	Combo keyboard and mouse that can be used in a vehicle for prototype testing
Ultra-thin Monitor 7 Inch HD Portable Display Screen	Small monitor that can be used for prototyping and to emulate the product within the car.

4.6. Financial Requirements

There are many different hardware components and peripheral devices that are required for our project to be successful. Using the ETG to order these parts, we have come to the conclusion that the total financial resources required for our project is $450. This includes parts such as the NVIDIA Jetson TX2, a 1080p web camera, a SD storage card, and display monitor.

Resource Requirements	Cost
Fuel	~$50
Driver	$0
3D Printed Components	~$30
OpenAlpr	$0
NVIDIA Jetson TX-2	$299
Sandisk 256GB SD Card	$54
Unzano HD Webcam 1080p	$25.99
Logitech K400 Plus Wireless Touch TV Keyboard	$24.97
Ultra-thin Monitor 7 Inch HD Portable Display Screen	$45.99

Total Costs (estimate)	~$530

5. Testing and Implementation

5.1. Interface Specifications

We are going to use black box testing on our system if some part is not complete yet.

To test the mobile application we are going to develop unit tests using Flutter's own unit testing library. To help us out with mocking dependencies, we are going to use the Mockito library that is compatible with Flutter.

Our hardware development was cut unexpectedly short by the COVID-19 pandemic. However, we did manage to run OpenALPR, an open source software that will be used in our project, on the board. Eventually, the development board, an NVIDIA Jetson TX-2, will have to interface with our backend and mobile application. That task has been deferred to next semester when we are able to continue with our hardware development.

5.2. Hardware and software

Software

We will decide to choose the best testing hardware and software once we have some part done. Flutter test library is a package used in flutter to make test cases; It can be used to make unit tests. It can be used for many functionalities on a mobile application. Mockito is a testing framework. The framework allows us to mock dependencies rather than fetching them from a database.

Database

We also use Postman to test the database by getting and posting data to it. This will allow us to make sure our database is working well before the front end is accessing it.

Web Application and Hardware

For testing or angular web application, we will be using the Jasmine testing framework. This will allow us to continuously test functionality and appearance as we add more to the web application. For hardware testing the NVIDIA Jetson TX-2 we have nothing currently planned for testing but will research more into it once we have access to the device again.

5.3. Functional Testing

We are going to test all the functionalities for our mobile and web application.

We will test our mobile application with unit testing in flutter. We will do some automation testing.

We are building our web application using the Angular framework. The framework divides web application components into “modules” with interconnected functionality. We have functional unit tests for each module that has been implemented. Through the Angular CLI we are able to frequently run our unit tests using the built in Karma test runner.

We are using SQL and python to create our backend. To test this, we have installed a framework called python virtual environment. This lets us deploy the database to a local port. From here, we can run various commands through an API testing app, such as Postman, and ensure the database is read from and populated correctly. We followed the iterative design approach outlined in [6].

5.4. Non-Functional Testing

Security - We are having a login page, which requires a username and password for the user to login. The passwords will be encrypted. It will also be able to connect with Facebook accounts.
Performance - We’ve launched our mobile application in Android and iOS environments. Currently, they run smoothly and it is doing what we are expecting.
Usability - Users are able to use it like a normal mobile application, which prioritizes user experience while not skipping out on functionality.
Compatibility- We designed the mobile application to work on Android and iOS. We have tested it with a few android and iOS emulators.

For the web application there are many non-functional tests that we are considering as well. First off is the performance of the application. To do this we will attempt to create load tests to create high demand on the application and test its response times. Another test we must consider is usability. To test this we will have usability test sessions where we can express our concerns with the user experience To test for compatibility we will make sure that the web application looks and navigates the same on multiple web browsers/environments. Finally, to make sure our web application is secure we will require two factor authentication.

5.5. Process

Mobile App

We will be testing the Mobile Application with Flutter’s built in unit testing library, named the Flutter Test Library. This allows us to test the functional requirements of the app. To test aspects that require us to use data from our database, we will use Mockito to mock dependencies over fetching real data from our database, making testing quicker.

Flutter has a built in Hot Reload feature that allows for real time compilation of code into functionality at the press of a button. This speeds up our testing workflow greatly and allows the team to develop features quicker and debug quicker, especially for functional testing.

Web App

We will be testing the Web Application with the Jasmine testing framework. Jasmine has the Karma testing interactive interface built in for more seamless testing procedures. We have yet to begin

testing the web application, as it is not yet complete. When we do begin testing, we will focus on the search result speed, aiming for below 2 seconds of time. Additionally, we want to test the Web App with upwards of 1000 videos to ensure that the accompanying features still work properly. Finally, we want to implement multi user testing, confirming that 100 users can load the application and watch a clip at the same time.

Database

For the database, we have begun initial testing of the API by opening it publically such that the mobile app can access it. This will ensure the API can go out to the database and make requests accordingly. From here, we moved to initial stress testing of the database by making several calls to the database every hour. From here, we will redo this process once the Webapp is ready to receive information through the api. We plan on expanding this so that the api can send and receive video information.

Hardware

As mentioned in an earlier section, we will be testing hardware by ensuring that OpenALPR is installed and configured correctly on the NVIDIA Jetson TX2 and that it is recording driving sessions in 1080p. We will also test to make sure that the database is configured to receive these videos from the hardware.

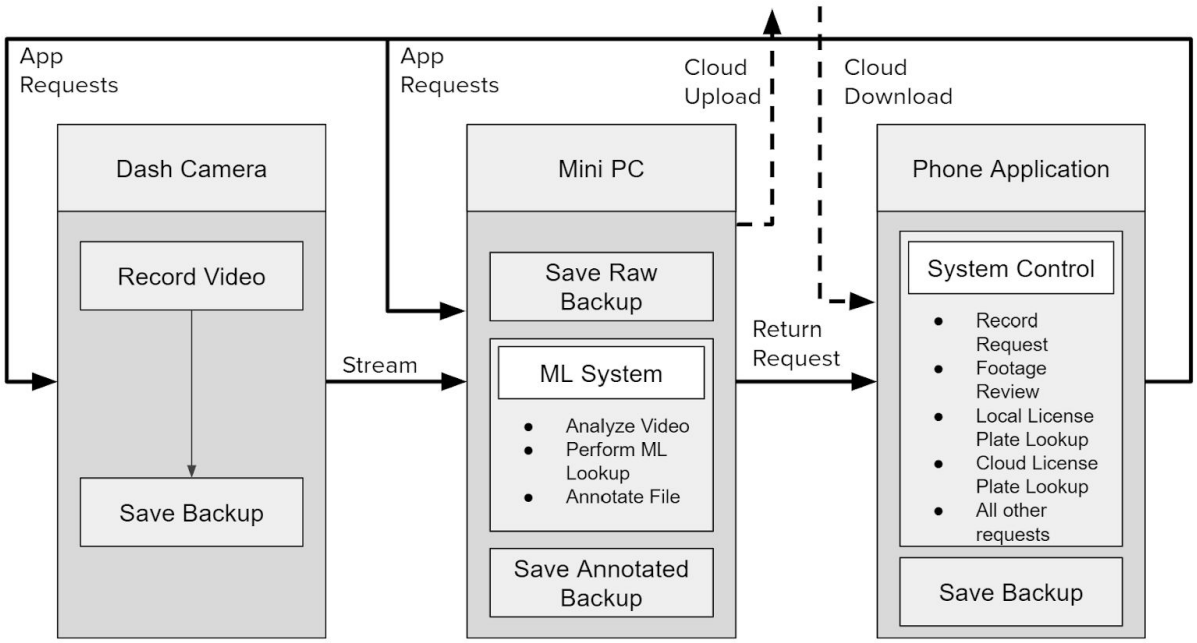

Figure 5.1: Process Flowchart

5.6. Results

Given the structure of our development, our results will be obtained during our 492 semester. At this time, we are only able to discuss how we will collect and display the results that we do end up achieving, and speculate upon the efficacy of our development.

Failures

- Facebook login page in Flutter is failing to run on iOS.

Successes

- Facebook login page is working when we run it on an Android device.

What we learned, and how we plan to change it

- For the software team, we have learned how to work on flutter by using .dart language. We might add a sign in with google button, or we might remove facebook login button if we are not able to resolve the issues that it is failing to run on IOS.

Modeling and Simulation

- We will add modeling and simulation information next semester once it has been completed.

Issues and challenges

- Our team has no experience in flutter and dart.
- We are not being to meet by person to discuss about the project due to the virus

The hardware team is in a similar position to the software team in that the majority of our results will be obtained during the 492 semester.

Failures

- Inability to configure the built-in camera on the NVIDIA Jetson TX-2

Successes

- Over the course of the semester, we have been able to set up the virtual machine with a Postgres database to store information.
- We've created a basic api that allows different subteams to begin integration to the project as a whole.

- Screenshots of test data being sent and received from the database

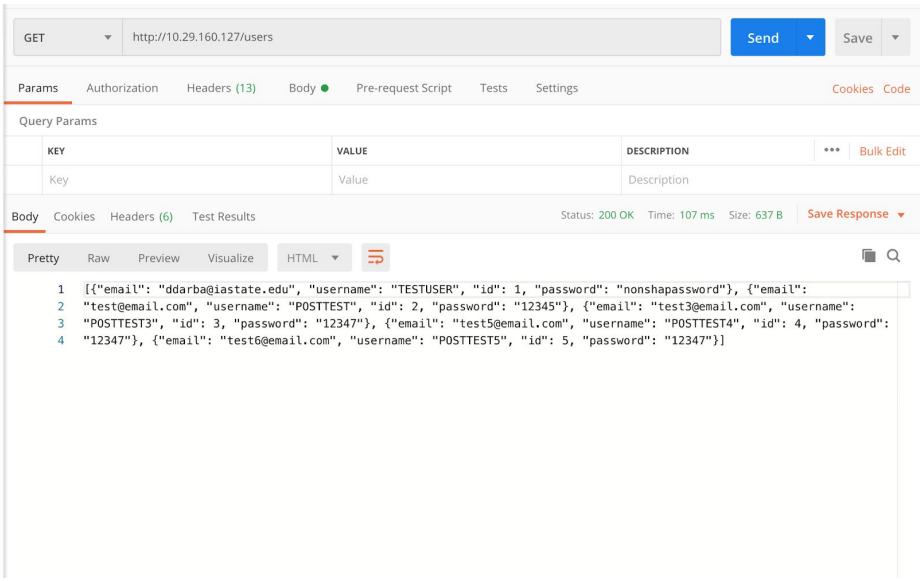

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Figure 5.2: Screen capture from Postman pulling user data.

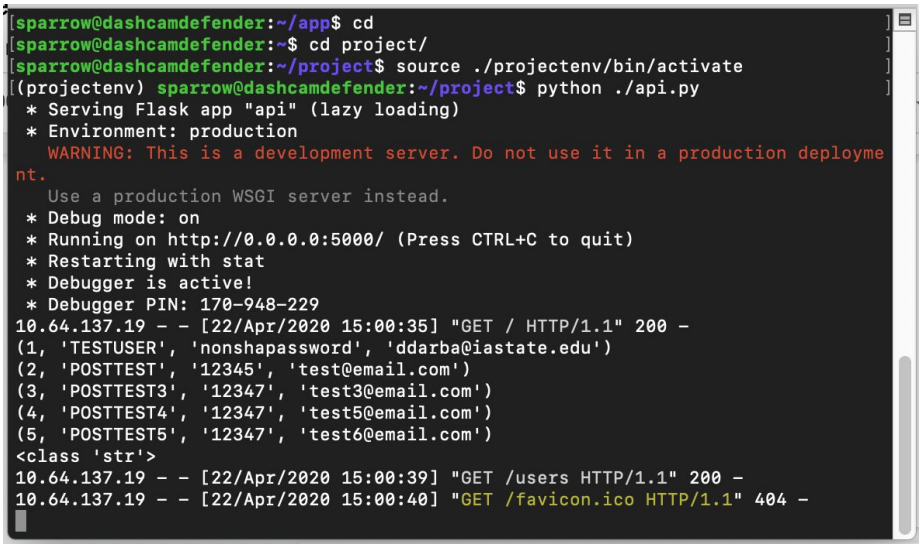

Figure 5.3: Screen capture of the virtual machine reporting each API call.

Information Learned

- We are beginning to learn Angular to develop our web application and have had success setting up the database.

Issues and Challenges

- Inability to meet in person to test and configure the NVIDIA Jetson TX2
- Inexperience with developing in Angular

6. Closing Material

6.1. Conclusion

In order to help drivers on the road, we need a better way to hold reckless drivers accountable. With our app and dash cam, we can do this. Furthermore, we can help insurance companies and the police get a better idea of people on the road. By meeting our specifications through the milestones we've set, we will be able to finish this project in a timely fashion.

6.3. References

*Everyone on the team add one reference IEEE style
Follow this guide:
https://ieee-dataport.org/sites/default/files/analysis/27/IEEE%20Citation%20Guidelines.pdf

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6.5. Appendices

Any additional information that would be helpful to the evaluation of your design document. If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc. PCB testing issues etc. Software bugs etc.

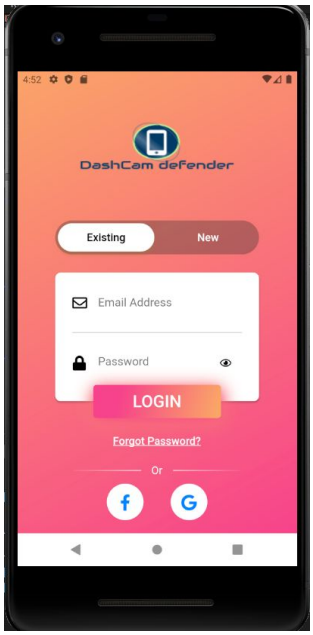

Figure 6.1: Login page

Figure 6.2: Car selection page

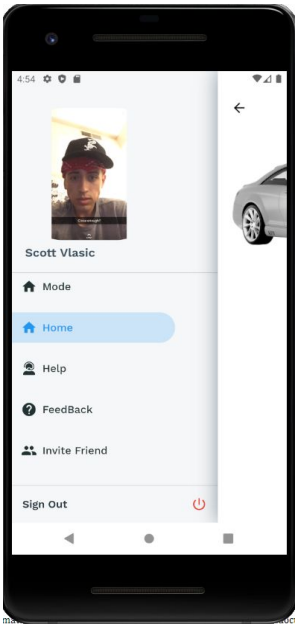

Figure 6.3: Sidebar

Figure 6.4: Mode Selection Page

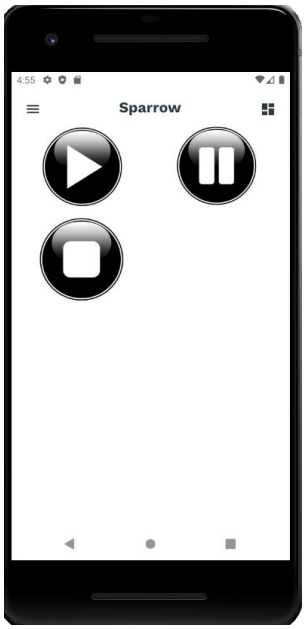

Figure 6.5: Driver Mode page

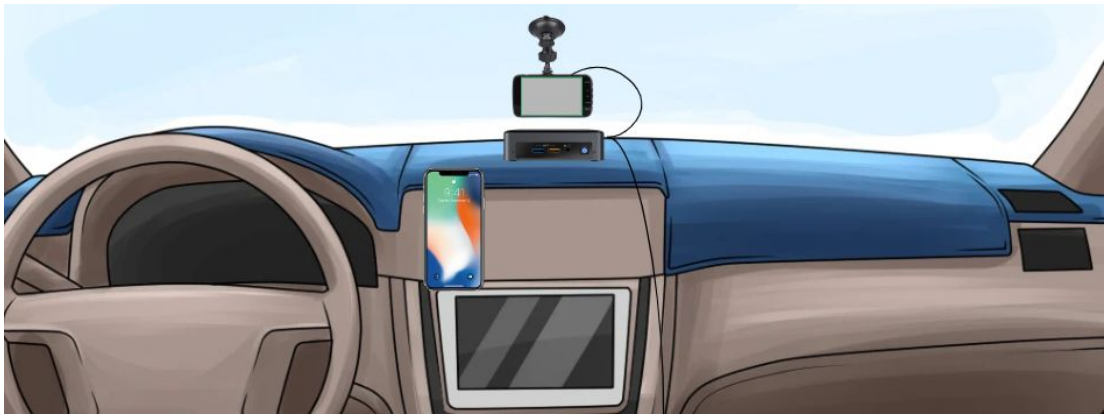

Figure 6.6: Concept image of full system in a vehicle

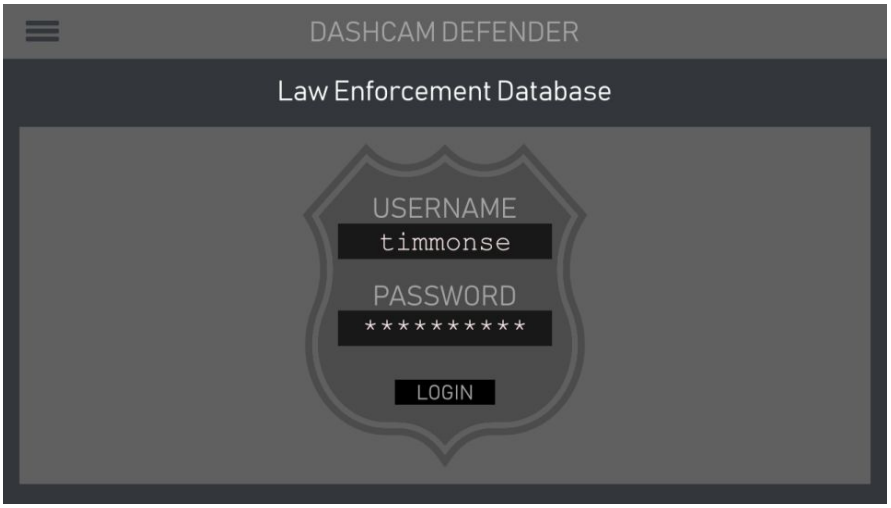

Figure 6.7: Prototype law enforcement database login

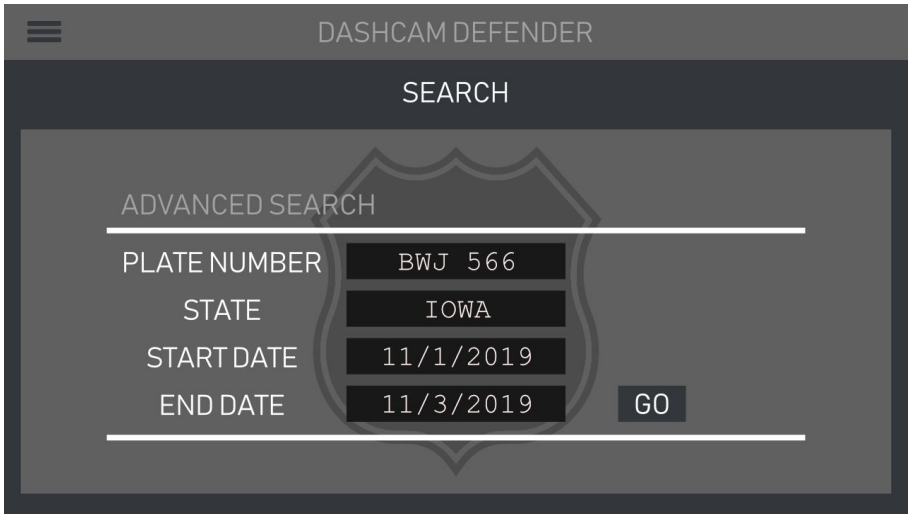

Figure 6.8: Prototype law enforcement license plate search

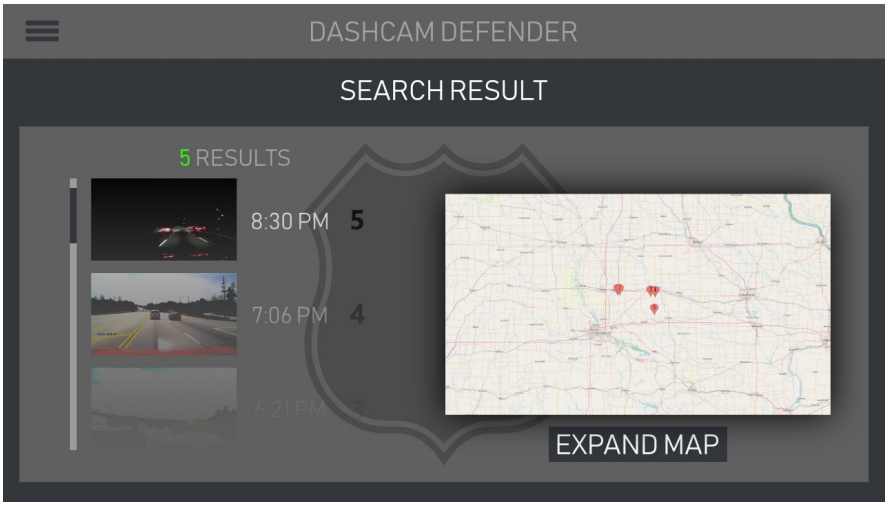

Figure 6.9: Prototype law plate search results

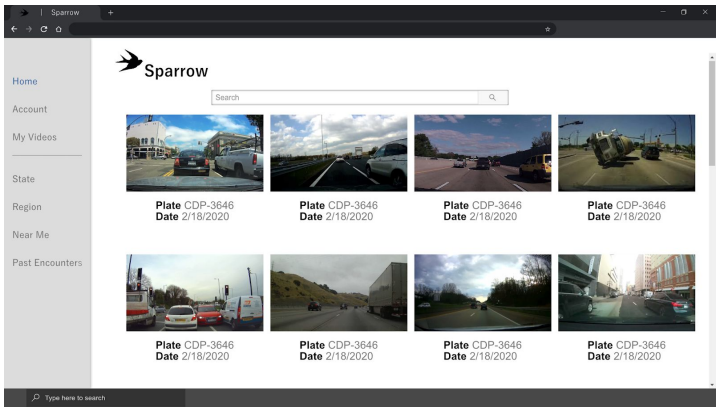

Figure 6.10: Prototype WebApp

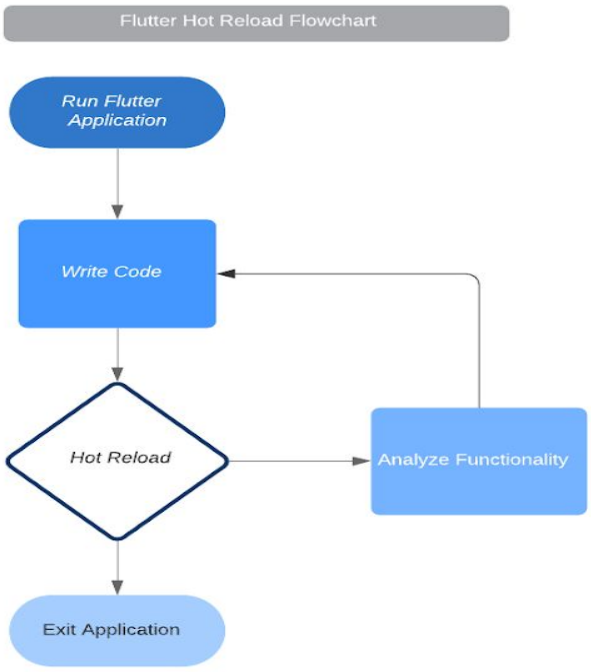

Figure 6.11: Hot Reload Flowchart

Software bugs- Mobile applications are working as normal in android phones, but having issues while launching the mobile application for IOS.

List of Figures

Only figures used so far, made by Evan Timmons. Used in section 2.4 “Conceptual Sketch” Additional figures will be cited here when used