Department of Electrical and Computer Engineering
Howard University

Senior Design Proposal:

EyeView Navigation System

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1. PROJECT DESCRIPTION

The purpose of this project is to propose an advanced GPS navigation system that will eliminate the gap between current navigation interfaces and the real world driving experience, utilizing a live stream of the driver's eye view by displaying an overlay of his route. This system will improve safety while driving with GPS navigation. The system will employ a camera as the source of the live stream that will be displayed on an LCD Display. The camera is connected directly to the DE5i (Intel Atom + Altera FPGA) Board, which allows ultra-fast image processing to overlay the route of the driver. The route data is received from a mobile device, via the EyeView app (we will create). Subsequently, the DE5i Board parses and interprets the data received from the mobile device and overlays the resulting route images (generated from the data) on the video frames and displays the result on the LCD screen. This advanced navigation system also includes an additional safety feature specifically for traffic light detection and recognition to alert the driver while approaching a traffic light. In essence, we hope our device will evolve the future of GPS navigation system technology.

2. CHALLENGE DEFINITION

2.1 Problem Formulation

Globally, many drivers depend on GPS navigation devices for everyday travel pursuits. Some lucky ones have mastered the art of GPS navigation systems and make it to their destination with no problems; however, this is not always the case. For this reason, there has been continuous advancement in technology centered on ensuring that users seamlessly move from Point A to Point B. Initially, there was a transition from Map View to Satellite View, which was deemed revolutionary in all ramifications. Even better, there was tireless work on advancing the navigational experience with the transition to Street View – the ultimate milestone. So we pose the question—why the continuous advancement in technology? Very simple. A driver cannot get from Point A to Point B seamlessly without making the navigation interface as close as possible to the real world driving experience. Today, most GPS navigation systems provide a combination of the aforementioned navigation view interfaces, but still fail to provide directional justice for most drivers.

In terms of safety, the National Highway Traffic Safety Administration estimates that driver distraction plays a role in 25 to 30 percent of the roughly 1.2 million car crashes in the United States each year, as one can tend to run red lights and cause havoc, or even directly bump into other cars due to distractions. GPS Navigation Devices contribute to the previously stated figures to a reasonable extent. While driving, looking at anything besides the road for more than a second is potentially dangerous. There has been one major approach to solving this problem: audio turn-by-turn navigation. This approach has had some level of success, but we would agree that there is always the innate need for visual context while driving.

2.2 Problem Definition

We wish to develop a navigation device that takes a driver from Point A to Point B with a navigation interface displaying a live stream of the driver's eye view with his route overlaid on the video stream. The navigation device will also have an option to alert the driver when he or she is approaching a traffic light that is on red.

2.3 Design Requirements

	Design Requirements
Objective	The system must overlay navigation data onto a video feed of the driver's eye view in real time, and notify the driver when he/she approaches a red light
Tasks	System must be able to: • Stream video from external camera on the vehicle • Communicate with smartphone app (we will create) that acts as an input for user location data and destination data. • Determine a route from the driver's current location to their destination • Successfully scale the external camera feed with that of the navigation data • Overlay navigation data onto the external camera feed • Display overlaid camera feed on LCD for user consumption • Reroute the driver in the event that they derail from the provided path • Detect and alert the driver of a stop light at least 15-20yards from the car with an audible tone • Allow drivers to enable or disable stop light safety feature via the smartphone app
Cost	• Capable Smart Phone: $199 – 900 • 5 – 7" LCD screen: $50 – 200 • USB Phone Cable: $1 – 10 • External Cameras: $50 - 500
Compliance	• Federal Communications Commission's (FCC) Part 15 rules with respect to GPS systems • FCC regulations on Specific Absorption Rate (SAR) of electronic devices (Electromagnetic Radiation from the DE2i Board) • V C Section 26708 Material Obstructing or Reducing Drivers View
Noise Level	• Audible red light warning message shouldn't exceed 20-30db
Weight	• Maximum of 10lbs for easy installation
Power	• System must be able to run on the battery power if the vehicle it is installed in.
Interface	• 5 – 7" LCD screen • User's smartphone • External Camera
Environment	• System must be used in a car
Setup	• Maximum of 10 minutes to set up

Table 1: Design Requirements

3. <u>CURRENT STATUS OF ART</u>

There is currently no device on the market that serves the same purpose as our proposed project. Granted, the Street View Navigation feature on Google Maps is parallel to what we envision, but still largely different from our project goal.

3.1 <u>Description</u>

The Street View Navigation incorporates the generic mapping interface navigation with an added spice. It includes the display of a previously taken street view photo (with the driver's route overlaid on it) only when the driver is about to make a turn or exit, so as to provide him with an exact picture of the turn or exit they are about to take. Google leverages their database of street view photos as an attempt to bridge the gap between mapping navigation interfaces and the real world driving experience at specific targeted events during the driver's trip, for example, when the user is making a turn or exiting.

Google Street View Navigation is currently only available on Android devices, and is rumored to be available on Google Maps iOS soon.

3.2 <u>Drawbacks</u>

The added feature of the street view photo to aid turns or exits while driving fails to address one of our major concerns: distracted driving. Taking one's eye from the road, while driving at any time, puts the driver, passengers and others on the road at risk, hence our justification for using live feed of the driver's eye view. Unfortunately, the generic mapping interface with the street view photos fail to add value in this regard.

Nevertheless, the addition of the street view photo makes a good attempt at solving one navigational problem: making the correct turns and exits. Considering this, the majority will agree that a street view photo is viable if it is a replica (or comparable to a replica) of the current view of the driver. In addition, everyone will also agree that construction sites can change the entire look of a geographical area, hence possibly making a number of street view photos inaccurate. This tremendous flaw is well addressed by the EyeView Navigation System. Our system retrieves up-to-date navigational data based on current roads, and overlays the route on the video feed for the driver's convenience.

4. <u>PROPOSED SOLUTION</u>

Our solution involves the use of a mobile app to query a GPS navigation data provider for route or directional data (in XML or JSON format) and send the information to the DE2i Board to parse the information and generate a route that will be mapped on the video feed received from the camera mounted behind the rear view mirror. There are a few devices/technologies that come into play in this solution which include a mobile phone (equipped with the EyeView Mobile App), the DE2i Board, Camera and LCD Screen.

To further our ideology in a more detailed manner, we have divided our approach into four primary phases (Note: Other cases will be discussed in 4.1).

PHASE I: Two-way Handshake

A connection has to be established between the mobile phone and the DE2i board. This connection is made with a USB cable. The cable should be connected before the mobile app is launched. Once the app starts running, it will trigger a response from the Atom board, which

then will return a satisfactory message to the mobile device to complete the two-way handshake. The LCD screen will display a friendly welcome message once it is connected to the mobile device.
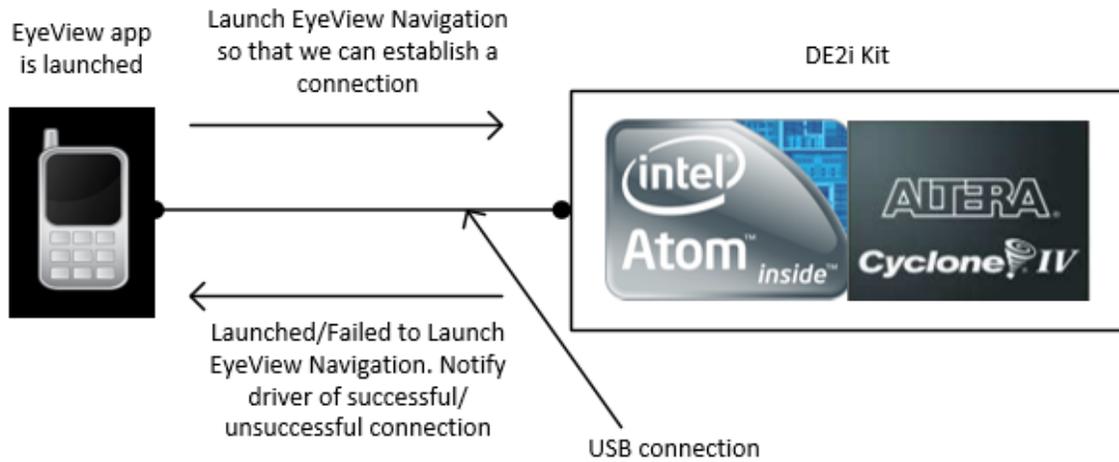

Fig. 1: Two-way Handshake

PHASE II: Data Acquisition and Transmission

Since there is an established connection between the processor and the mobile phone, we can now begin the back-and-forth transfer of data. The EyeView app provides a few functionalities, one of which is to allow the driver to input his or her destination address. A number of API calls are made to a GPS navigation data provider to retrieve the route data of the driver. The format received is usually XML or JSON depending on which is preferred for parsing. Afterwards, the file is automatically transmitted to the processor for processing.
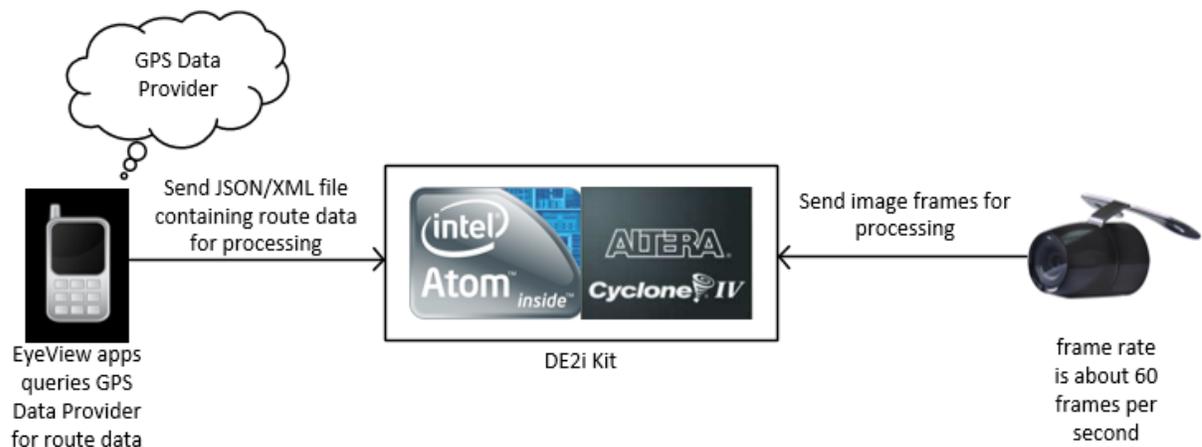

Fig. 2: Data Acquisition and Transmission

On the other hand, the camera retrieves about 30 to 60 image frames per second, and these frames are sent the processor either USB or wireless connection.

PHASE III: Data Processing and EyeView Navigation Display

At this point, the processor has all the data needed from external sources to produce a route overlay on the live video stream, and also to determine when a user approaches a red traffic light. The processor receives the XML/JSON file from the mobile phone, and parses the data to retrieve relevant directional meaning. Simultaneously, each frame received from the camera is tested for the presence of a red traffic light (Traffic Light Detection). After the test phase, an algorithm will be used to overlay the navigational route on each frame. This algorithm will involve road recognition, among others, so that the route is properly placed on the road. The resulting modified image is displayed on the LCD display.
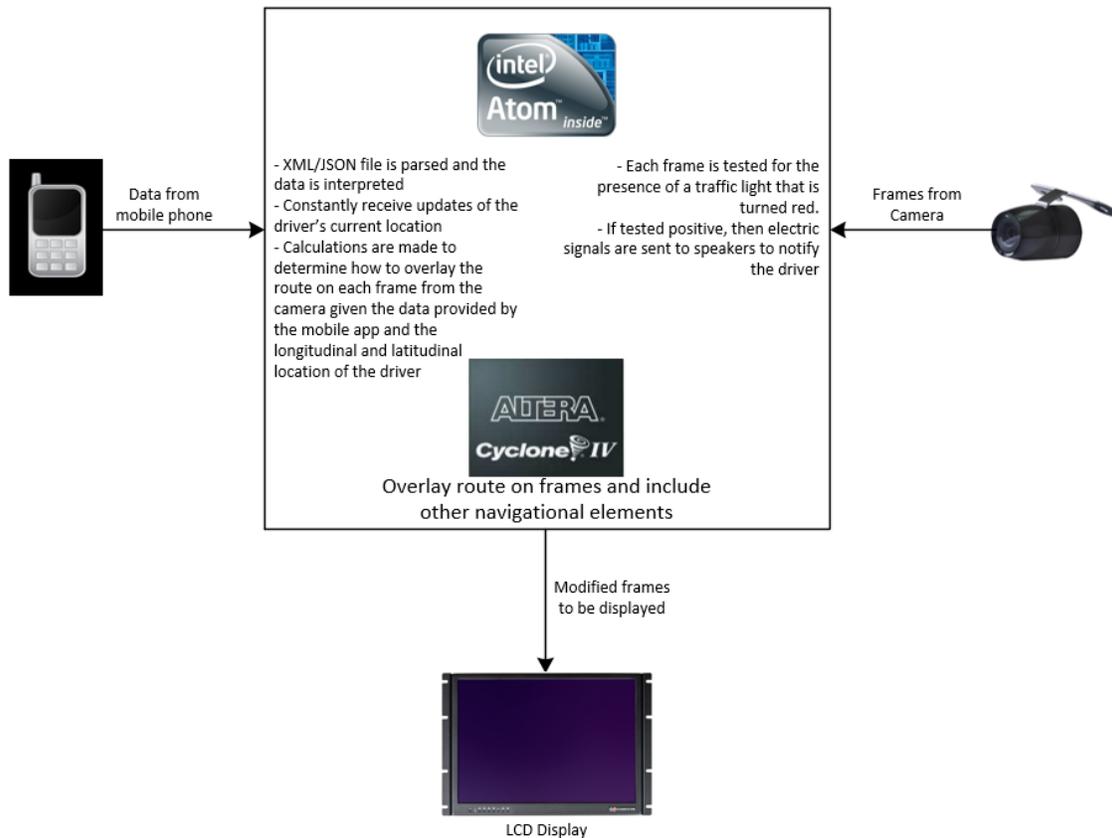

Fig. 3: Data Processing and EyeView Navigation Display

4.1 Other Scenario Considerations
- **Rerouting scenarios**

This is a very popular scenario in the world of navigation. Drivers make the wrong turns, and have to get back on track in order to arrive at their destination. In our approach, we are expecting the rerouting rate (unintentional) to decrease significantly, regardless, we will still account for it. Our approach to rerouting is very simple. Notice that we always use the GPS position of the driver to make sure that he remains on track with the initial route data that was received from the mobile phone courtesy of the EyeView app. Therefore, if the driver leaves the assigned route, the GPS location of the driver will be an indicator, so the DE2i Board sends a request to the mobile device to get updated route data using the current GPS location. Subsequently, Phase II and Phase III processes are repeated.

NOTE: The user has an option of ending the navigation or starting a new one if this was an intentional reroute.

- **No-Road scenarios**

What happens when you make the connection between your mobile phone and the EyeView device (DE2i Board (Intel Atom + Altera FPGA) + LCD Screen), and you enter the destination address, while your car is still parked in the garage? What gets displayed on the screen? Is the route overlaid on the wall in the garage? This is one of the very common scenarios in our day-to-day life that we must account for. Our solution for this type of problem involves road recognition. We will check if the driver is on a road on his lane, before we commence navigation. If these conditions are not met, we will display a friendly message urging the driver to get on the road.

4.2 Testing/Verification Plan

There will be a series of happy-path testing to ensure that we always get the results we expect from different functionalities, and also a chain of brutal-testing to see how our systems responds to edge-case scenarios. In the development phase, incremental testing will be done as well.

The table shows a list of some functional tests that we will perform on the navigation system.

Function	Test
Get route data	Ensure the retrieved data is valid and correct
Send route data	Ensure the content of the route data received by the mobile phone is the same as that received by the processor
Parse data	Ensure that all useful data is retrieved without fail. In case of corrupt data, request for another route data
Request for GPS info	Ensure that there is no broken chain in communication as the processor continually demands for the GPS location of the drive from the EyeView app
Overlay route on frame	Ensure the route is perfectly aligned on the road, with smooth transition from one frame to another
Existence of Red Traffic Light	Ensure the passing rate of the traffic light detection algorithm is as close to a 100% as possible

Table 2: Functional Tests

4.3 Demonstration at Intel-Cornell Cup

Due to the nature of the project, a live working demo will not be present at the Cornell Cup Expo. However, we will have a well-documented video of the EyeView Navigation System in operation, covering all end-to-end scenario. Nevertheless, we will be present with all the

components of the navigation system. Therefore, if an opportunity presents itself for us to do a demo, we will be ready.

5. PERFORMANCE MEASURES

The EyeView System must be able to live stream the driver's forward facing environment into the DE2i Board using its external cameras. It must be capable of collecting GPS and location data from the user's smartphone and sending the data to the DE2i Board. Then the systems must be able to interpret and represent the navigation data of the user and output a live feed of the driver's real time environment with the navigation data overlaid onto it. As an added safety feature, the system must be able to recognize a traffic light that is on red.

6. TASKS AND DELIVERABLES

Every team member of EyeView's Five is responsible for every part of the project lifecycle. However, for efficiency of project delivery given our time and resource constraints we divided roles and responsibilities and assigned leads to the three most critical parts of the project as follows:

Software Development:
This aspect of the project will cover:
- Develop device application
- Write code to program the DE2i Board for the specified results
- Test, refine and implement software for the device

Lead: **Emmanuel Ademuwagun**

Software Test:
This aspect of the project will cover:
- Develop integration techniques for the software and hardware components
- Develop simulation and test protocols for project
- Implement test strategies for project

Leads: **Zachary Spence** and **Jordan Wren**

Program Management:
This aspect of the project will cover:
- Research, decide on and acquire parts and software to be used for the project
- Verify that relevant standards are met
- Test, refine and give feedback on prototype implementation

Leads: **Patrick Buah** and **Yusuf Siyanbola**

We expect to have a working prototype for our navigation system by ECE Day (Mid-April 2014). A user will be able to successfully use the EyeView navigation system to go from point A to point B without any glitches through the efficiency of incorporating live stream with a route overlay navigation platform.

7. PROJECT MANAGEMENT

This section outlines how the team intends to implement our solution strategy. It includes milestones, deliverables and dates to complete them.

Milestones and Deliverables	Duration	Completion Date
Team Creation	15 Days	September 2014
- Team Selection		
- Project Selection		
Project Proposal Development	30 Days	October 2014
- Problem Formulation		
- Proposal Write up		
- Proposal Submission and Presentation		
Mid-term Review		November 2014
Prototype Design	30 Days	December 2014
- Develop algorithms for solution approaches		
- Choose best approach for implementation		
- Get parts and software needed for implementation		
Prototype Development	45 Days	February 2014
- Write software		
- Assemble hardware components		
- Incorporate software and hardware components		
Mid-term Review		February 2014
Prototype Testing and Iteration	45 Days	March 2014
- Test integrated components		
- Debug and fix glitches		
Final Proposal Development	10 Days	April 2014
- Final Proposal Write up		
- Final Proposal Submission		
Project Presentation		
- ECE Day Presentation	1 day	April 2014
- Cornell Cup Presentation	1 day	May 2014

Table 3: Milestones and Deliverables

8. FEASIBILITY AND RESOURCES AVAILABLE

To ensure that our solution will be feasible, we performed extensive research on compatibility, integration and usefulness of our proposed system and found that it will be possible and effective. We also enacted a survey and received feedback on how critical our project will be in breaching the current gap between navigation interfaces and real-world driving experiences.

Consequently, every member of EyeView's Five has had tangible industry experiences that will be crucial to the completion of this prototype. At Microsoft, Emmanuel Ademuwagun worked on the Windows Phone team developing a Cinemagraph-like feature for the Photos/Camera team (which involved image processing) to be released on the next big Windows Phone roll out. Patrick Buah was a part of the GEAR UP team that went to Turkey this previous summer where he worked computer vision applications that involved the use of Lab View and other software. Zach Spence interned for the US Navy where he tested existing software for numerous applications and built software for monitoring classified materials. Jordan Wren has also interned in the Department of Energy in the past serving as an IT support technician. Yusuf

Siyanbola has also had experience with software testing, database creation and project management for Goldman Sachs. All of these experiences will contribute in ensuring the efficiency and completion of the EyeView Navigation system. Overall, every team member has a proven track record of being accountable, resourceful and a team player. With the time we have, we will produce a working prototype that meets our expectations for the visionary navigation system.

9. CONCLUSION

The EyeView Navigation system seeks to deliver a solution to navigation and interface issues present in modern GPS systems. The goal of the team is create a system that will successfully present the user with a live feed of their external forward environment along with an overlay of their necessary navigation elements. This solution will eliminate many of the common aspects of modern GPS navigation systems that lead to confusion and failure to reach the specified destination, or even accidents from driving distractions. The system will rely heavily on the use of the DE2i Board (Intel Atom + Altera FPGA) in order to interpret the necessary navigation data and create the overlay for the video feed. The team will utilize the aforementioned project guidelines and timeline in order to create and intensively test the system in time for ECE Day and the Cornell Cup competition.

10. REFERENCES

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11. APPLICATION PLEDGE

Application Pledge:
To be submitted with the team's application (scanned copies of the signatures are acceptable)

We, the student team, agree if accepted as finalists to the competition, to complete the project we have proposed in this application to the best of our ability and to fully participate in the final Intel-Cornell Cup competition event which includes completion and submission of all elements of the final report, travelling to and participating in the competition's demonstration expo, and the submission and delivering of a final presentation to the judge committee. We also agree to conduct at least 2 formal design reviews as required by the competition and will record their completion and results with the Intel-Cornell Cup.

Team Member Signatures

Print name: _Emmanuel Ademuwagun_ Sign name: . ___ Date: 18/15/2013

Print name: _YUSUF SIYANBOLA_ Sign name: . ___ Date: 10/15/2013

Print name: _Jordan Wren_ Sign name: . ___ Date: 10/15/2013

Print name: _Zachary Spence_ Sign name: . ___ Date: 10/15/2013

Print name: _Patrick Buah_ Sign name: . ___ Date: 10/15/13

As the academic advisor(s), although I may plan to meet with the student team regularly, I agree to conduct at least 2 major reviews throughout the academic year. Should the team be accepted as a finalist, I also agree that at least 1 academic advisor will be in attendance for the final event at Walt Disney World and I will review their submitted written materials as well as their final presentation and final competition expo display. I will also be responsible for receiving and managing any resources awarded to the team.

Team Advisor Signature(s):

Print name: __Charles Kim_____ Sign name: . ___ Date: 10/15/2013

Print name: _____ Sign name: _____ Date:_____

Print name: _____ Sign name: _____ Date:_____

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