Designing the User Interface of an Autonomous Vehicle Design Stage - Group Report

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ABSTRACT

This report will demonstrate the development of our "smart car" interface system, mainly focusing on the functionalities of the tablets which also acts as the main control centre of the car. We used methods such as cooperative evaluation, storyboarding and thinking aloud to assist our idea creation, and identify the necessary functionalities. We also followed Fits Law and conducted an experiment to determine a preferred layout. In our final result, we produced a drawn screen flow, wireframe and multiple prototypes including PowerPoint prototype, Invision prototype and AdobeXD prototype.

Keywords

Self-driving car, interaction design, futuristic technology, interface, design

INTRODUCTION

In Report one, the interior and user interface design of a "smart car" was proposed. The findings of report one concluded in the ultimate goal of convenience, accessibility and functionality. Accessibility is one of the major recurring points in the design objectives, in order to appeal for all types of generation and demography, it was chosen to use tablets as the interactive medium. This is because of their convenience and popularity, and are becoming widely acceptable and relatively easier to understand as a medium of technology.

The tablet being the main control centre of the car will provide functionalities from self-driving and route management to basic entertainment and environment adjustment. It is the core of the design and will be crucially important as a channel that connects the user with the system invention.

Similar to report one, we also assume the limitless possibilities of technology, meaning that the seemingly futuristic ideologies are still considered and that the financial obstacles are not considered. This project aims to develop and solidify the design of the user interface, with the tablet interface being the main priority. This report aims to explain and illustrate the interaction between users and the car and demonstrate how this design is able to meet the goal being convenience, accessibility and functionality.

BACKGROUND WORK

In the car industry, a human to vehicle interface is often called an Infotainment system. This is the combination of the words "information" and "entertainment". Nowadays, a car maker's infotainment systems may be a make or break factor for potential customers. To align with current market demands, the system developed throughout this report will aim to develop a system that is both recreational and informative.

Advantages of Current User Interfaces and Vehicle Infotainment Systems

Majority of consumers base their reviews and assessments of a vehicles user interface and infotainment system based on the organisation, design, content and controls of the system, moreover also consider the system's ability to meet the standard with other consumer electronics like tablets and smartphone interfaces. From our research, an acceptable infotainment system will have call functions, mapping and navigation, music and audio control, vehicle cameras, drive modes and even seat customization controls (Kwan, 2017). Since our vehicle is autonomous, we are able to create designs of a user interface that include more aspects of "entertainment" without the fear of putting passengers at risk.

Market Leaders

Current market leaders such as BMW, Jaguar, Audi and Mercedes have all continued to develop their user interfaces on their infotainment systems. Taking large steps into the future, technologies such as BMW's gestures control completely eliminates the need for the driver or passenger to physically touch the interface. BMW had developed sensors in their cabin to recognise "hand movements and gestures" (Cars guide, 2017), (see Figure 1).

Figure 1. ***BMW's Gesture Control in the 7 Series.*** **[Digital image]. (Copyright 2019 carsguide.com.au). Retrieved from www.carsguide.com.au/car-advice/what-makes-a-good-car-**

Figure 2. *CarPlay*. [Digital image]. (Copyright 2019 Apple) Retrieved from: https://www.apple.com/au/ios/carplay/

The system developed in this report aims exceed the current market standard of vehicle interfaces, and to further develop the Human-Machine interaction. A point of difference the proposed design could possibly integrate of functions and controls that mirror that of their mobile devices or tablet devices. This provides a familiar interface for users, therefore there is a seamless transition between the existing and new interface.

Apple CarPlay (see Figure 2) and Google's Android Auto are current models with a seamless transition between drivers and infotainment system. These two are crucial for many drivers as it allows for smooth audio calls, text notification and music playing functions. However, a drawback of the two systems is that users are only able to connect their devices if they belong to their respective operating systems. This means that Apple IOS users can only connect their device to their vehicle that support Apple CarPlay and likewise with Android users with Google's Android Auto.

Typefaces

Determining an appropriate typeface to use is an unmissable factor in the systems design. Choosing the correct type enables clarity for users to read and thus able interact with the system in an appropriate way. Clarity of text is the most important factor in selecting the suitable type for our system. Letterform refers to the overall shape in which a letter is presented in, and the clarity of the letterform is what designers should focus on. The simpler the letter form is, the clearer it becomes. The bolder the type is, therefore will also result in a clearer reading experience as the letterform is more pronounced (Typography for User Interfaces, 2016).

However, on the computer When designing for a website or a mobile app "a font can easily be the most subtle, and yet powerful differentiator for the next UI"(Muzli, 2018). The following three fonts are examples of typefaces optimised for the web:

1. Open Sans (See Figure 3)

This font is optimised for prolonged use. This font has excellent legibility and its "easy on the eyes" (Muzli, 2018) and could be a potential choice for the proposed interface. Passengers may using our system could potentially be using

Figure 3. *Open Sans*. [Digital image]. (Copyright 2016 Medium) Retrieved from: https://medium.muz.li/top-5-ui-fonts-for-website-mobile-apps-d78829e58f7e

it for long periods of time and this font could facilitate regular consumption.

2. Montserrat (See Figure 4)

The geometric design of this font is both playful and legible at the same time, however it does not look the most professional. This font is best suited for for headings, even in caps, rather than in slabs of text. This design would suit "minimal and modern Websites & Mobile Apps" (Muzli, 2018).

Figure 4. *Montserrat*. [Digital image]. (Copyright 2016 Medium) Retrieved from: https://medium.muz.li/top-5-ui-fonts-for-website-mobile-apps-d78829e58f7e

3. Playfair Display (See Figure 5)

This font is an ideal stylised, elegant and sophisticated Websites & Mobile Apps (Muzli, 2018). This stylistic font is best used in agency, portfolio websites, travel and fashion blogs. The lack of modernity in this font may not be the most suitable choice for the proposed system.

Figure 5. *Playfair Display*. [Digital image]. (Copyright 2016 Medium) Retrieved from: https://medium.muz.li/top-5-ui-fonts-for-website-mobile-apps-d78829e58f7e

METHODS

Persona and Scenario Requirements

The driverless vehicle designed in report one is targeted towards passengers with busy schedules and their priority is to get places as soon as possible. The findings of report one are illustrated below:

1. Including a tablet like device on each chair for the passenger
2. Accessibility of a map, including where passengers currently are and the estimated time of arrival of desired destination
3. Logins for each passenger
4. Personalisation and customisation of each individual's account after login

Screen Flow

Based on prior background work and the findings of the report one, the group created a quick and low-cost low-fidelity prototype. A screen flow was developed to graphically depict the main screens of the tablet like interface. This allowed group members to understand the overall progression of the interface. The screen flow was quickly and effectively hand drawn using paper and pen.

https://www.apple.com/au/ios/carplay/

Fitts's Law

Fits Law was used in order to guide the initial design of the first prototype.

> *"Fitts' law states that the amount of time required for a person to move a pointer (e.g., mouse cursor) to a target area is a function of the distance to the target divided by the size of the target. Thus, the longer the distance and the smaller the target's size, the longer it takes"* - *Interaction Design Foundation: Fitts's Law, 2019*

This helped guide the initial design of the interactive buttons in the system. The most important buttons, for example the access button to the map, are the largest and towards the side of the screen. While less important buttons, for example the settings button for the screen brightness is smaller and is in the top left corner. Placing a small button in the corner reduces the error rates of accidently clicking on it, however when it is near the corner essentially the width becomes infinite. This means when it is needed to be clicked it is much easier.

Wireframe

A second low-fidelity was created which was a hand drawn wireframe. This was created using paper and pen. This allowed for group members to visually understand the contents of the screen flow. A wireframe allowed to diagrammatically convey the size of buttons and layout of screen.

PowerPoint Prototype

The first sketch prototype created was created using PowerPoint based on our wireframes. It was of Medium fidelity as it had most of the working buttons, general layout of each page, size of fonts and colours. This method is a more similar medium to the final output.

Evaluations and Observations

Cooperative evaluation

To evaluate the first prototype, a cooperative evaluation was used. This method was the most appropriate as the prototype was in the first stages. This method allowed us to talk to the participants about what they were doing, and they were able to give the interviewer real time results about their issues and thoughts on the system. There were three people needed to conduct this evaluation method:

1. The interviewer
2. The data recorder
3. The interviewee

We recorded the data using a pen and pencil. This was the most convenient and least intrusive method to record our data. 5 participants were asked the following questions to guide them through our prototype:

1. Please lower the brightness to your required level
2. Please register a new account
3. Please login to the system
4. Please expand the map
5. Please open an app

Scenario Storyboard

At this stage of the design a story-board scenario was created in relation to the scenario created in the first report (See Figure 6). The scenario in the first report outlined is outlined below:

> *"Kyla (persona from report one) has suddenly falls ill and needs to be taken to a restroom along the road. Kyla's father who initially entered their destination on his tablet interface, places his fingerprint to unlock his tablet and heads into the map application. He types in 'nearest restroom' and tablet shows possible locations, he can then select one which will revise the route. In case of a software malfunction, there will be a physical emergency button that will immediately stop the car and automatically contact the nearest emergency roadside assistance" - retrieved from report one*

Through sketching we diagrammatically mapped out how this scenario would unfold when using the PowerPoint prototype.

Think aloud

After results from the scenario storyboard and the cooperative evaluation were taken into consideration, some updates were made to the PowerPoint. Then a think aloud secondary evaluation was done on the system. This evaluation worked the same as the cooperative evaluation, however the interviewer was not able to speak and the interviewee verbally conveyed each step through the interface.

Invision Prototype

A medium-high fidelity prototype was constructed using invasion. Although this program took much more time to create, the output was closer to the final product.

Evaluations and Observations - Laboratory/Field study

After the Invasion prototype was created, interviewees were gathered in a lecture theatre with fold out tables. An iPad was attached to the fold out table. Interviewees were asked to behave as if they were in the driverless car. A screen recording of the Interviewees tasks was recorded alongside notes on pen and paper. This method aimed to mimic a field study to gain insight into how the system would work as a whole.

Questionnaire

Interviewees were asked to participate in a post-task interview in the form of a questionnaire (See appendix 1 for questionnaire document). The questionnaire used was the User Interaction Satisfaction (QUIS). The aim of this questionnaire was to assess the user "subjective satisfaction". This questionnaire measures specific interface factors such as screen visibility, terminology and system information, learning factors, and system capabilities (University of Maryland: Questionnaire for User Interface Satisfaction, 1986-1998). The questionnaire consisted of 14 questions and participants were asked to record their satisfaction on a 9-point scale. Each group member scouted five people each. In total 25 questionnaires were done.

AdobeXD Prototype

A final high-fidelity prototype was created using Adobe XD. This prototype took all of the results from the Laboratory/Field study and the questionnaire into consideration.

RESULTS

Screen Flow

The screen flow (See Figure 6) resulted in system starting with a welcome screen, from there the user will log in an then access the main part of the interface.

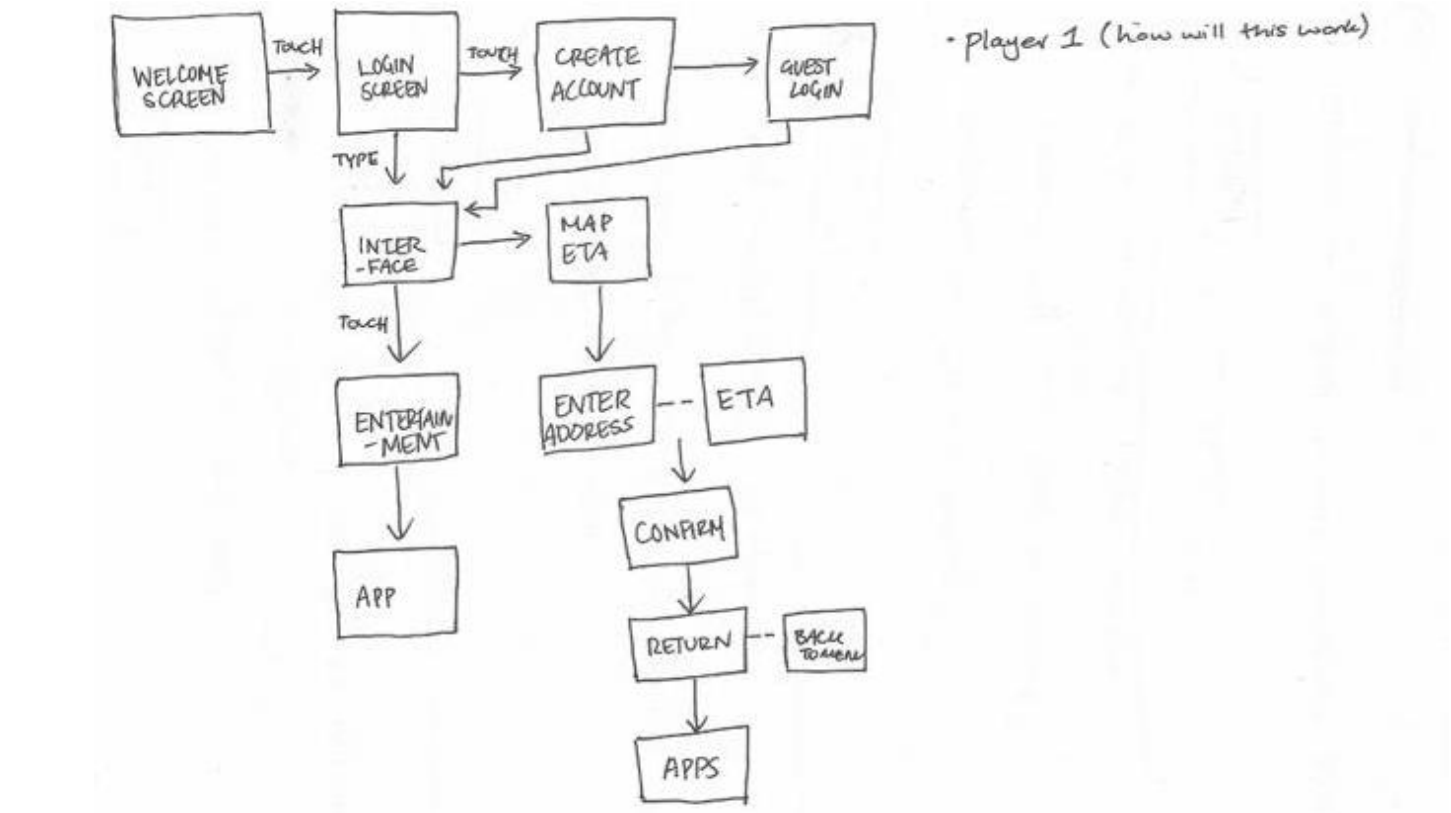

Figure 6. Screen Flow

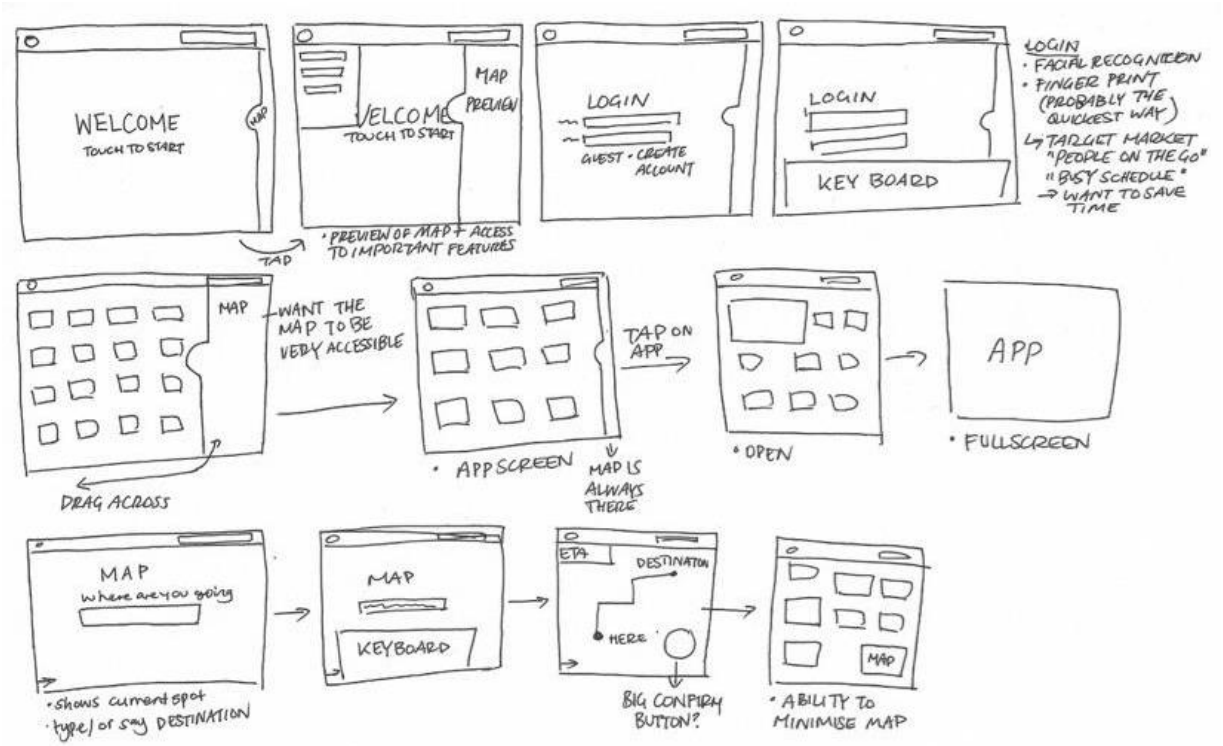

Figure 7. Wire Frame

Wire Frames

The wireframes aimed to depict what each page of the design would contain. Following the same design as the screen flow but contained more information.

PowerPoint

The PowerPoint prototype (see Figure 8, next page) resulted in the settings bar located in the top left corner to make it locatable in the corner, but also not easy to accidently click as Fitt's Law explains. In addition the map is located on the right side and so it is the most accessible feature which aligns with our target markets needs of quick transport.

Cooperative Analysis Feedback and Analysis

Through analysing the data collected (see Table 1), it was concluded that the register account button was too small and the font colour was too similar to the background making it difficult for users to locate. In addition, there was multiple issues surrounding the 'register account' feature in the login page. As evaluators, we decided it would be useful to add other options like facial recognition or fingerprint registering systems. It was also found that it was unclear how to adjust the brightness of the screen, to resolve this reoccurring issue the following prototype was labelled along with a diagrammatic icon.

User	Feedback and Observations
1	- Unable to find register account button - Cannot locate brightness
2	- Unsure how to close the brightness window pop-up - Issues expanding map - Register account difficult
3	- Unable to locate brightness adjustment - Unclear how to 'drag' or 'click' map
4	- Register account, clicked in wrong spot - Keep clicking background when unsure what to do (prototype incapability)

Table 1. Results of Cooperative Evaluation

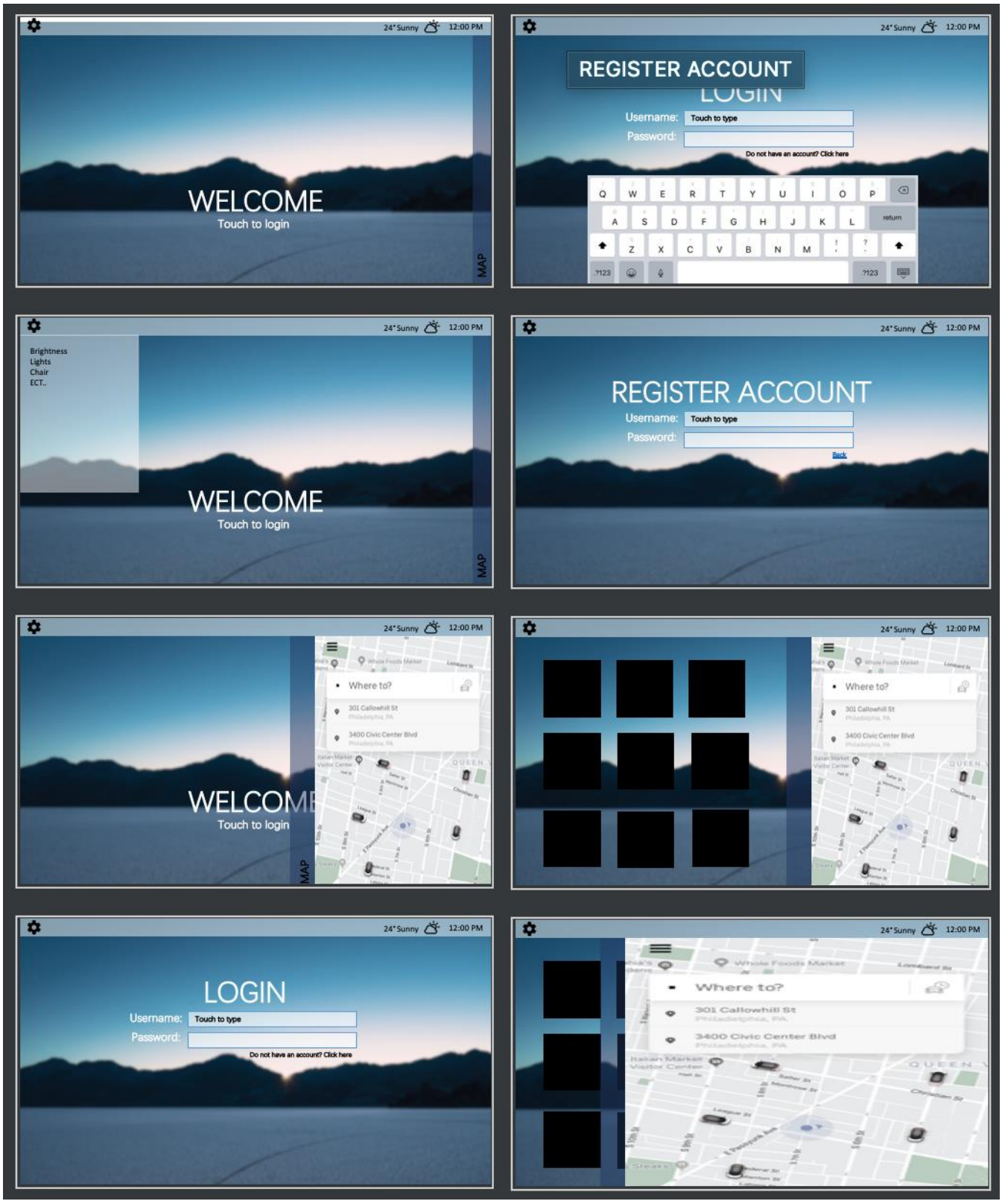

Figure 8. PowerPoint Prototype

Think Aloud Results and Analysis

An iteration of the PowerPoint prototype was made in accordance to the cooperative evaluation feedback.

- Bigger settings button labelled and icon
- Arrow to drag map
- Change of font colours

This evaluation method was not as successful for the following reasons.

- Users constantly clicking the screen and changing the slides
- Unsure what to do

Our group concluded that these issues were mainly caused by the limitations in the medium of the prototype. Therefore it was decided to make a new prototype using Invision.

Scenario Storyboard

Though an analysis of the scenario storyboard (see Figure 9), it was discovered that a pause or stop button would be required in these types of situations in order to re-route the vehicle. The process of creating the scenario storyboard also made it obvious there was lack of an emergency button in the prototype. This button could be used when the car malfunctions.

Invision Prototype

The Invision Protoype (see Figure 10) changed dramatically from the PowerPoint. The main changes involved :

1. Background colour
2. Map accessibility
3. App layout
4. Orientation
5. Addition of help messages
6. Car controls
7. Highlighted colour

An interactive version of the prototype is available in Appendix 1.

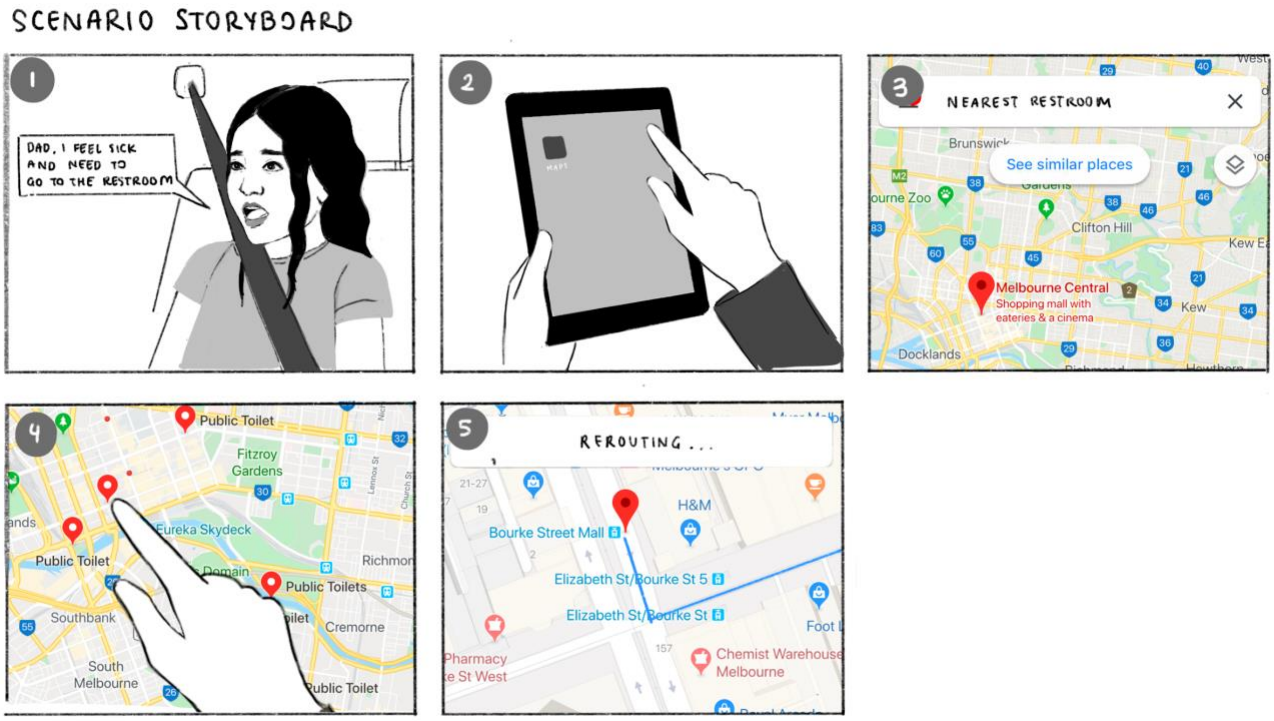

Figure 9. Scenario Storyboard

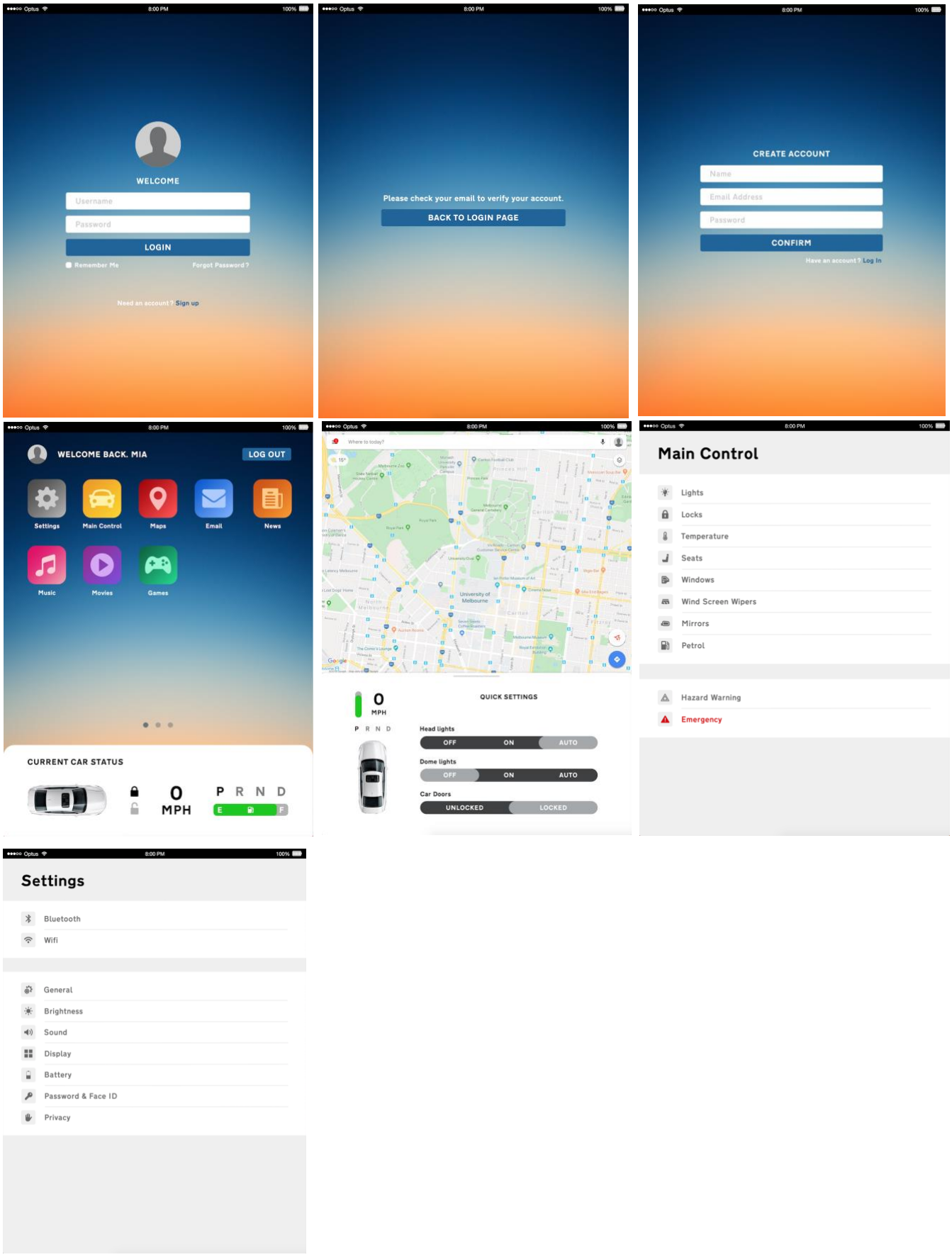

Figure 10. Invision Prototype

Issue	Feedback
1	- Make the main control panels bigger so it would be easier to tap on in case of emergency > should make the settings panel bigger as well to keep consistency.
2	- Add Face ID option on log in page. - Add 'Guest Log In' button on log in page.
3	- Add 'drive to destination' and 'pause/stop' button on maps. - Execute the map app in more detail > Describe how users will search up their destination / change route (to reflect scenario) - make maps more prominent
4	- Change the rounded corners of the headlights / dome lights / car doors and petrol metre under 'quick settings' into rounded rectangles to keep the design consistent.

Table 2. Laboratory Study

Laboratory Study

The results of the laboratory study concluded in four main aspects in need of improvement.

These improvements revolved around the following topics:

1. Usability of control panel
2. Login system
3. Emergency or reroute method
4. Lights
5. Lack of estimated time of arrival (ETA)

Questionnaire

The average results for each question can be found in Appendix 3.

The findings of the questionnaire found that overall our system was well received by evaluators. Most answers received an average of seven or eight out of nine. The main areas for improvement were related to the sequence of screens, how to get back to the main screen. The best aspects of the system is the colour scheme, web optimized fonts and the easy to learn and operate.

AdobeXD

This was the final prototype produced which was changed in accordance to the evaluation and observations of prototype 2 (see Figure 11). The main focus was improving the map functionality and moving the icon the front to emphisise it.

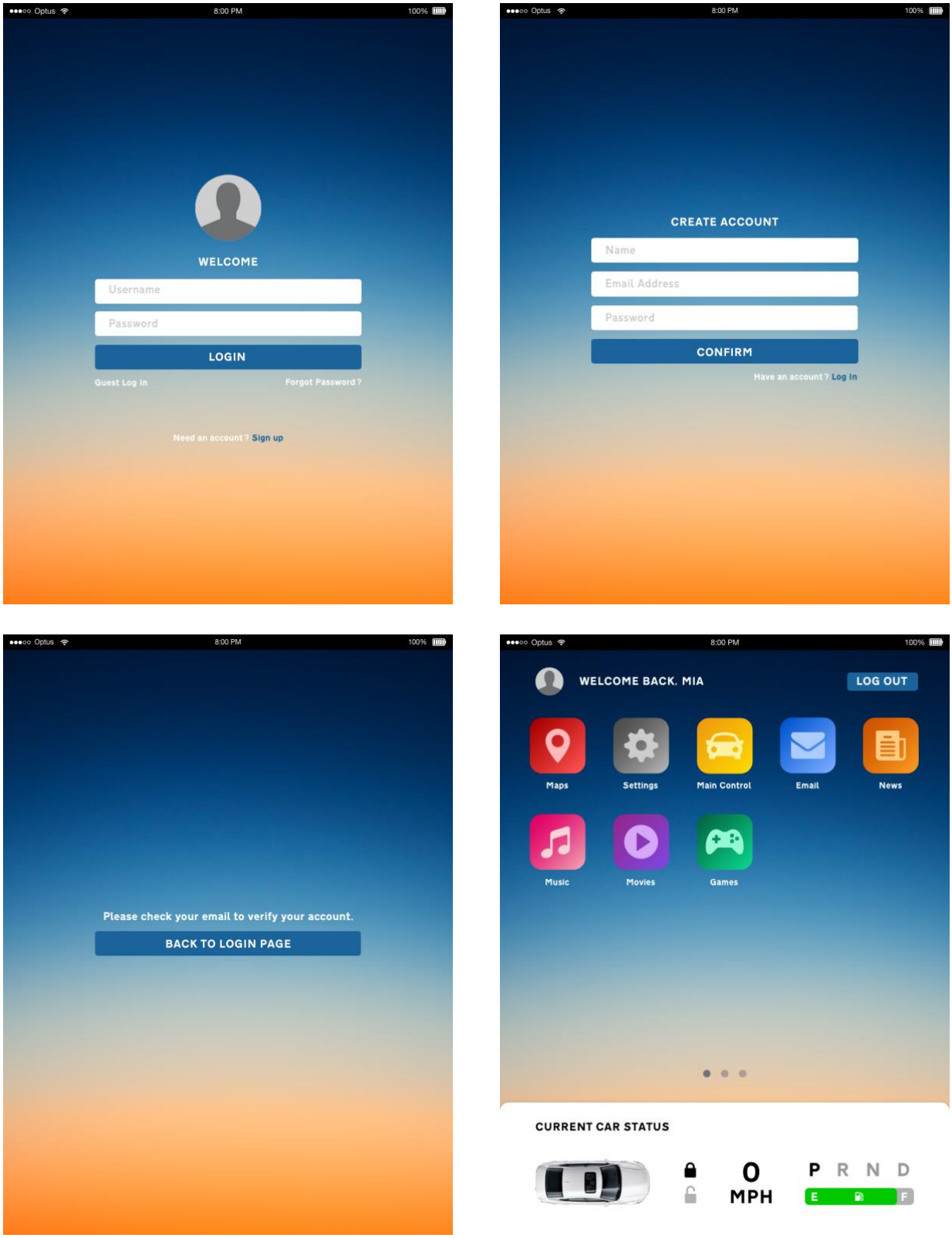

Figure 11. AdobeXD Prototype

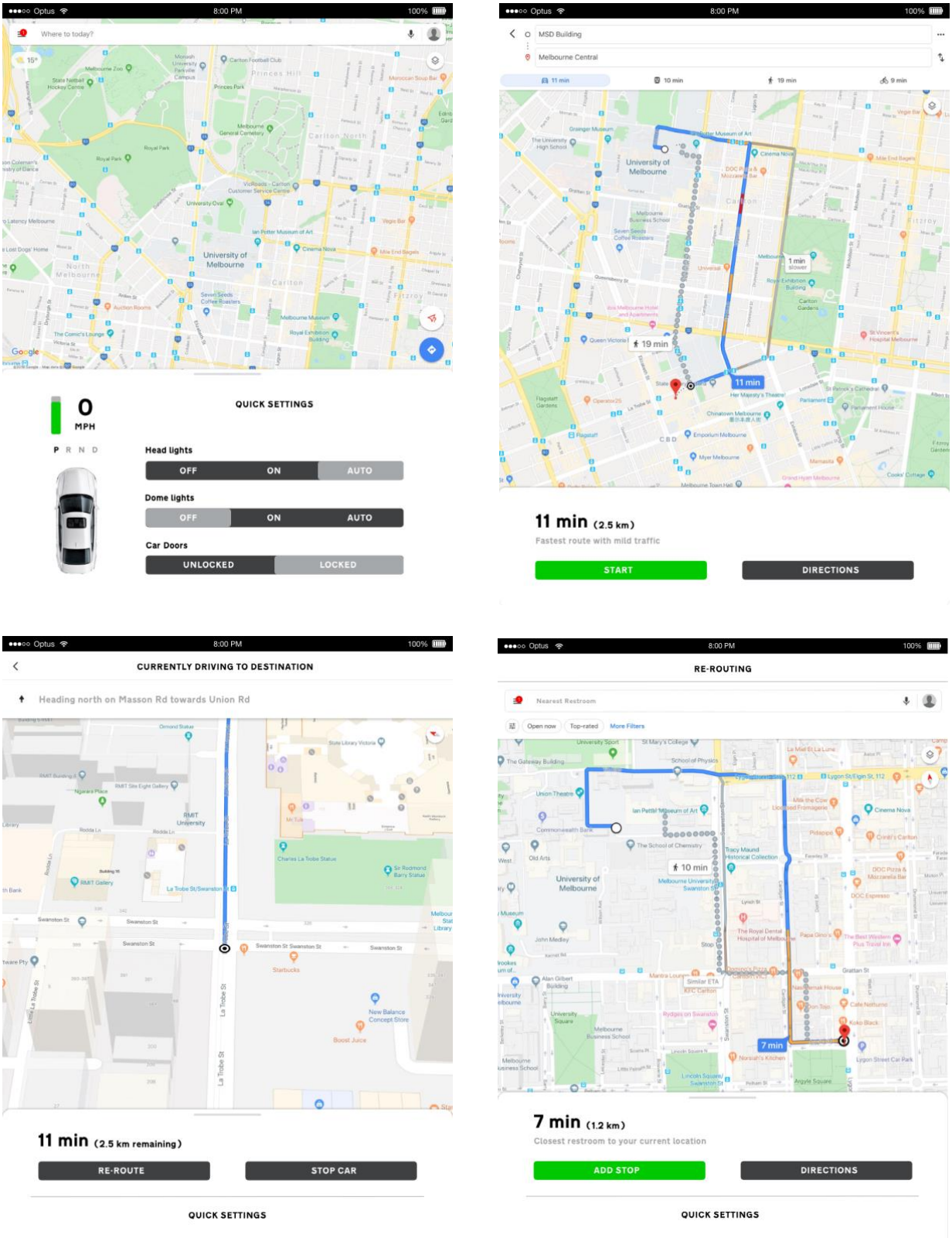

Figure 11. AdobeXD Prototype

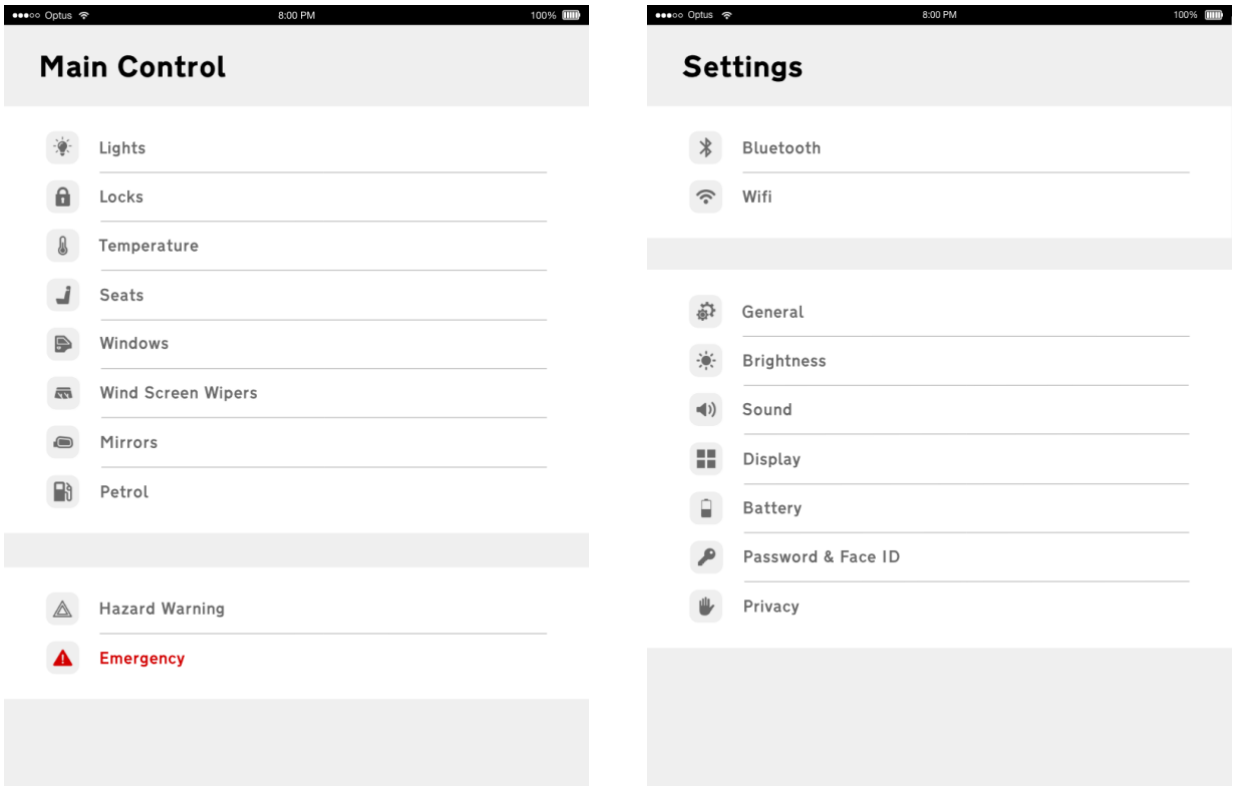

Figure 11. AdobeXD Prototype

DISCUSSION

As the group became more confident with the design through evaluation, the fidelity of the also prototypes increased. The aim was to spend more time and energy on effective and useable designs.

After the initial screen flows and wireframes were designed based on the personas Mia, Kyla and Kevin's needs, the first prototype was created through PowerPoint. This was a medium-fidelity prototype that had some working buttons and a similar layout to the final output. The evaluation and observation techniques chosen were appropriate for the medium-fidelity prototype. The first method used was a cooperative evaluation which allowed the interviewer and interviewee to communicate throughout the evaluation process. Since it was our first prototype, it was still a rough draft that has not been refined. This method enabled the interviewer to clarify possible confusions that the users may have while performing the given tasks, while also giving power to the users to criticise the system. The users observed were classmates, they were able to give strong advice and helpful critiques on how to improve the design. After the group updated the PowerPoint prototype in accordance to this evaluation, a think aloud observation was performed. As evaluators, we did not help or guide the users at any time, so that we could better identify any difficulties that the user may still have and observe the instincts of users when using the system. With this method, we obtained results that were significant to single out specific problems. Overall, the evaluation of the first prototype gave indicated the improvements to make. One of the main problems encountered was the users observed were classmates, university students between the ages of 18-22. To improve, people of different backgrounds and ages should test our prototype. For this reason we also created a persona storyboard which helped us to understand how our target audience would respond to the system.

The invision prototype sketch was of higher fidelity and more coherent than previous. A field study was mimicked by placing a tablet on a lecture seat. For this evaluation, we recorded data using screen recording. This is a method that is accurate and realistic but not obtrusive, since the users were unaware the screen was being recorded. This method provided helpful information for the third AdobeXD prototype. Even though the study tried to mimic the inside of the car, the conditions are still very different. One of the main limitations of our prototype evaluation is that we cannot have an actual driverless car to test our results. The QUIS questionnaire allowed the group obtain numerical data that could be analysed to indicate the strongest and weakest parts of the design. This method could be improved by allowing a wider time frame to obtain results.

Although the group resolved a final design solution for the driverless car's tablet system, this final prototype is still not

perfect. Once the system is implemented into the car it must continuously be updated to provide the changing needs of the user.

ACKNOWLEDGEMENTS

Thank you to classmates (Bob, Coco, Cara and Christina) and other participants of cooperative evaluation, think aloud and

Thank you to all 23 participants who responded to our questionnaire.

Group work

Introduction – Mike (20%)

Background Work – Clovis (20%)

Methods – Nicola (20%)

Results – Michelle (20%)

Discussion – Sofia (20%)

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LIST OF FIGURES

APPENDIX

Appendix 1: Invision prototype

(Best viewed on tablets)

https://interactiondesign.invisionapp.com/public/share/YNWTWRFXP

BOB

1. Cant read register account text

~~[illegible]~~

2. Brightness → clicked anywhere to minimize drop box

Coco

1. Brightness - how to close
2. Another page after "register account" → change register page, add email etc. or finger access or Audio
3. "map already there?" (expand)

Cara

1. Brightness → "is it in settings?"
2. Expand map → drag to expand?

~~*~~ Click anywhere → closes window

Charisma → ADOBE XD

1. Register → clicked to next powerpoint slide
2. ~~Login account~~ →
3. Kept clicking background which went to next slide → therefore use a better software to create apps
4.

User Evaluation of an Interactive Computer System
(For each of the following questions, fill in 0-9 or leave blank if question is not applicable)

OVERALL REACTIONS TO THE SOFTWARE

terrible — wonderful
0 1 2 3 4 5 6 7 8 9

difficult — easy
0 1 2 3 4 5 6 7 8 9

frustrating — satisfying
0 1 2 3 4 5 6 7 8 9

inadequate power — adequate power
0 1 2 3 4 5 6 7 8 9

dull — stimulating
0 1 2 3 4 5 6 7 8 9

rigid — flexible
0 1 2 3 4 5 6 7 8 9

SCREEN

Characters on the computer screen

hard to read — easy to read
0 1 2 3 4 5 6 7 8 9

Highlighting on the screen simplifies task

not at all — very much
0 1 2 3 4 5 6 7 8 9

Organization of information on screen

confusing — very clear
0 1 2 3 4 5 6 7 8 9

Sequence of screens

confusing — very clear
0 1 2 3 4 5 6 7 8 9

TERMINOLOGY AND SYSTEM INFORMATION

Use of terms throughout system

inconsistent — consistent
0 1 2 3 4 5 6 7 8 9

Computer terminology is related to the task you are doing

never — always
0 1 2 3 4 5 6 7 8 9

Position of messages on screen

inconsistent — consistent
0 1 2 3 4 5 6 7 8 9

Messages on screen which prompt user for input

confusing — clear
0 1 2 3 4 5 6 7 8 9

LEARNING

Learning to operate the system

difficult — easy
0 1 2 3 4 5 6 7 8 9

Tasks can be performed in a straight-forward manner

never — always
0 1 2 3 4 5 6 7 8 9

Help messages on the screen

unhelpful — helpful
0 1 2 3 4 5 6 7 8 9

SYSTEM CAPABILITIES

Experienced and inexperienced users' needs are taken into consideration

never — always
0 1 2 3 4 5 6 7 8 9

USABILITY AND UI

Use of colors and sounds

poor — good
0 1 2 3 4 5 6 7 8 9