Real-time assistance for people endangered by forest fires

MOBILE APPLICATION

Creative Technology bachelor thesis by
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Abstract

Wildfires have been having a great impact around the world and not only in countries such as Australia and the US but also here in Europe. Moreover, they are not projected to come down in frequency any time soon. This research project aims to develop a mobile app that helps people escape from a nearby forest fire. The app will make use of a fire prediction model that is being researched in parallel to this project. The state of the art is examined for similar apps and a literature review is conducted to assess the design elements required for such an app. Features discovered throughout these processes coupled with features generated during the ideation process formed the foundation for what the app should offer. Using these features a prototype mobile application was developed in Android Studio using HERE Maps for the maps and navigation. Subsequently the prototype was evaluated through user testing. Overall, it was well received however there is still much to implement and improve. This includes new features retrieved from the feedback of the user testing.

Acknowledgments

First and foremost, I would like to thank my supervisor Andreas Kamilaris for his guidance and feedback throughout this project. Not only did his feedback help greatly while writing this report, but also during the development of the prototype. His thoughts and ideas about the whole system helped take it to where it is now. I would also like to thank all the participants of the survey for their time and opinions. Their point of view and insight is critical in guiding this project into its next phase. And lastly, I would like to thank my friends and family for their support, their listening ear and feedback.

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Chapter 1 – Introduction

Over the past couple of decades the amount of wildfires and acres of land burned in the US have steadily been increasing [1] [2]. However, it is not just the US that is experiencing this increase in fires. Australia has been hit especially hard this past year having been struck by some of the worst wildfires in decades [3]. These wildfires can also be found in Europe, for example in Spain [4] and Greece [5]. Moreover, the frequency of these fires is projected to increase by 27% due to climate change [6]. Therefore, there is a high chance that more people will be faced and endangered by forest fires in the coming years. Luckily, our world also becomes increasingly connected with internet access and smartphone usage rising globally [7]. This might provide a solution to the question of how to effectively evacuate people endangered by these wildfires in the form of a mobile application. As of the start of the project, there do not seem to be any available solutions. That is why this bachelor thesis will aim at developing a prototype mobile application that, using a model predicting the fire's progression, will be able to provide its users with a safe route away from the fire. This thesis will focus on the creation of the mobile prototype, while the model of the fire's propagation will be developed in a separate bachelor thesis [8].

Research questions

The following research question and sub questions will be answered in this graduation project:

"How to design a mobile application to help evacuate people endangered by a forest fire?"

This question spawned the following two sub-questions:

"What tools are required to create such a mobile app?"
and
"What does a functional user interface for a forest fire escape app look like?"

Chapter 2 - State of the art

In this chapter the current state of the art will be discussed. This will consist of two main parts. In the first part similar products or products concerning the general topic that are already available or are currently being developed will be examined. In the second part a literature review will be conducted that will try to answer the second sub research question through the following three questions: how to efficiently point the user in the right direction they need to flee to; Which factors need to be taken into consideration to make the interface easy to use for older adults; And how people behave when evacuating from a natural disaster such as a wildfire. This chapter will conclude with a list of all the features observed in the examined products and features gathered through the literature reviews.

Existing mobile applications

Wildfire safety evaluator (WiSE) [9]

WiSE is an app being designed to help firefighters calculate safety zones and prevent burn injuries. This app will also be updated to include a model of how fast people are able to navigate certain terrain [10] [11]. The corresponding article can be found here [12]. This app is still in development but will be released to android, iOS, and Windows. It is already available as a webpage; however, an account is required to access it.

The app is described on their webpage as follows:

"*WiSE is a tool designed to provide safe separation distance calculations to wildland firefighters. This new tool gives firefighters the crucial ability to identify suitable safety zones while in the field. With inputs based on direct observations in the field, wildland firefighters now have the ability to quickly calculate the distance needed to provide themselves and others, safety from burn injury. wildland firefighters can enter on-scene observed data via parameters such as Wind, Slope, Fuel Height and Resource Information.*

Using these inputs, the individual can quickly calculate their Safe Separation Distance (SSD) and view the results on a map. As conditions change, wildland firefighters can quickly update observed conditions to view updated results, all without having to leave the mapping screen.

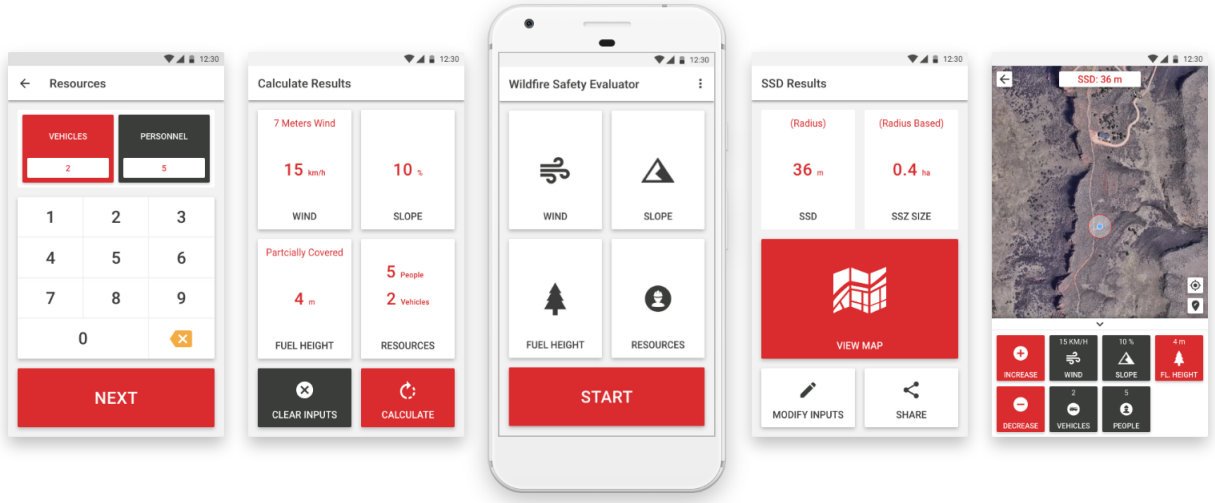


Figure 1: The WiSE app [9]

WiSE is unique in that it does not require an active data connection to calculate these safety zones."

Notable feature of the app are: a Fat-finger interface, which is an interface build using large buttons for fast use in the field; an Interactive map, allowing the user to edit data in real time while watching their fire zone on the map; and finally the app offers offline calculations.

Navicuate [13]

Navicuate is a prototyped developed in the Netherlands to warn its users of floods or other calamities. It is described as a crisis information and evacuation system that uses a smartphone application to inform and instruct users. The app provides clear location-dependent evacuation information in case of floods. The users can be informed proactively about upcoming floods in the area they live in. And, when necessary, given clear evacuation instructions. This includes escape routes and advice on when to start evacuating. However, there is currently no version available to download.

Figure 2: Navicuate app [13]

Gaia GPS [14]

This app is not necessarily meant for use during forest fires; however, it has been used by firefighters to plan escape routes, mark fire lines, and track a fire's progression. Since a new update, users are now also able to create polygons on the map and measure its area and perimeter. So, while it is not an app specifically made for fighting wildfires, it has some features that have been useful in the fight against wildfires.

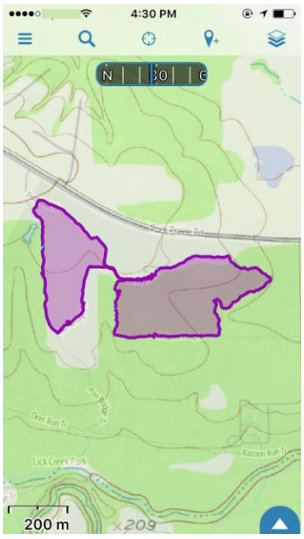


Figure 3: Screenshot of the polygon function

WFA Pocket [15][1]

WFA pocket is, as described on their own website, "a *mobile app that embodies the latest wildland fire behavior science into a robust tool for the firefighter and Fire Behavior Analyst. Leveraging the science developed by the US Forest Service Missoula Fire Sciences Lab, this app enhances calculations with a 3D interactive map interface, real-time weather integration, and seamless fuels data assimilation.*

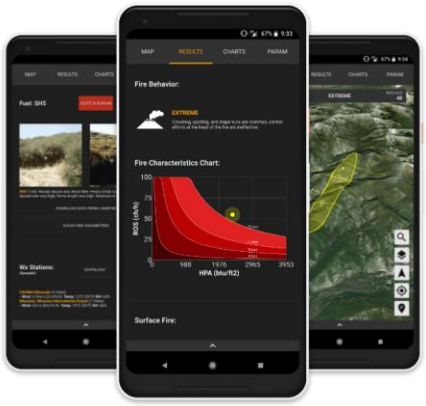


Figure 4: the WFA pocket tool [34]

WFA Pocket provides the wildland fire community with a powerful analytical tool that is designed to be used in the field. The app works either connected or disconnected, providing outputs and results in a form that is readily understood and usable."

It can provide a model for the fire's behaviour based on the user's input, such as the fuel types present, and other data such as real-time weather data. This app is already available and can be downloaded for android iOS, windows, mac, and Linux.

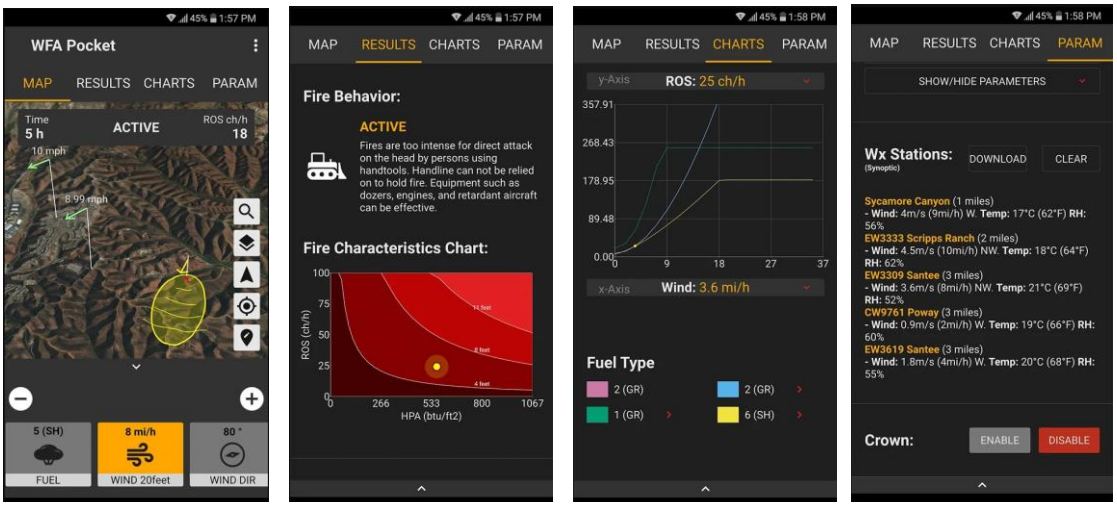


Figure 5: Screenshots of the WFA app

[1] https://play.google.com/store/apps/details?id=com.technosylva.PocketWFAv3&hl=en_US

Emergency – American Red Cross[2]

The google play store description says the following about Emergency: "*Help keep your family safe in severe weather, man-made/natural hazards with Emergency by the American Red Cross. Monitor conditions in your area or area of loved ones, prepare your family and your home, check to see if loved ones are safe and let them know you're safe. A must have for anyone who live in areas prone to severe weather or have loved ones that do.*"

The conditions mentioned by the description include, but are not limited to, severe weather, tsunamis, and wildfires. The app comes with the following features:

- Available in English and Spanish
- Real-time local alerts for severe weather and hazards.
- Customizable alerts and notifications
- Interactive quizzes
- A toolkit with flashlight, strobe light and audible alarm.
- Map with open Red Cross shelters and other weather-related layers.
- Step by step directions on how to make a family emergency plan.
- Support for Android Wearables 2.6 and above.

This app can be downloaded already; however, it seems to only be available in the united states.

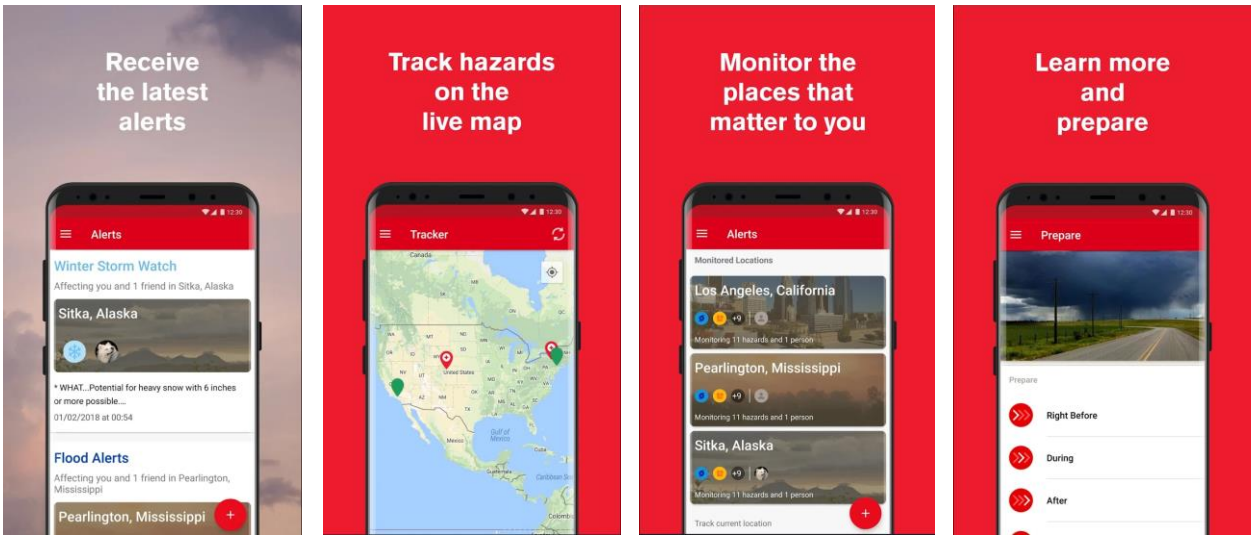


Figure 6: Screenshots of the Emergency app retrieved from the google play store

[2] https://play.google.com/store/apps/details?id=com.cube.arc.hzd

Disaster Alert[3]

The disaster alert app is based on PDC's DisasterAWARE platform and provides the user with near real-time information about 18 different types of active hazards. This includes, but is not limited to, Hurricanes, earthquakes, volcanos, and wildfires. For certain regions, additional hazard updates can be provided, for example in Hawaii's case the user can also select to be updated about flash floods. The user is also able to customize early warning alerts, view situational analysis reports and access modelled hazard impacts. This can be done is an easy-to-use map interface. All the data in the app is automatically derived from scientifically verified sources. The app can be downloaded from the google play store.

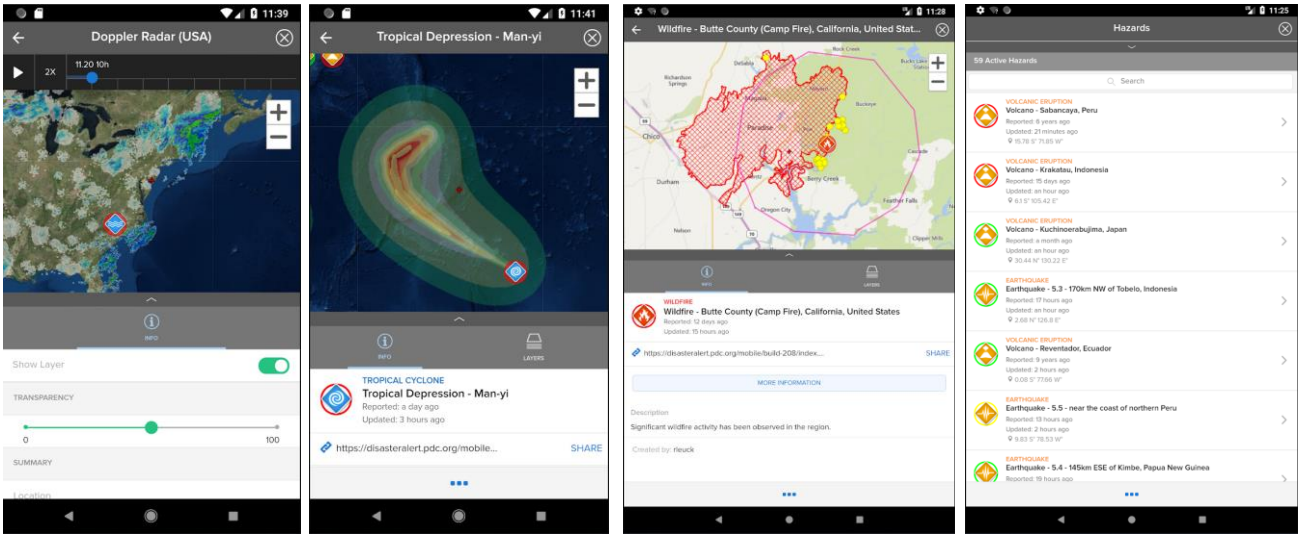


Figure 7: Screenshots of the Disaster Alert app retrieved from the google play store

[3] https://play.google.com/store/apps/details?id=disasterAlert.PDC&hl=en

FEMA App[4]

The FEMA app is available to anyone in the United States and provides the user with real-time alerts from the national weather service for up to five locations, allows the user to share real-time notifications and locate open emergency shelters and disaster recovery centres. It also contains some safety tips, emergency checklist, family plan and reminders. Finally, it enables the user to register for disaster assistance online.

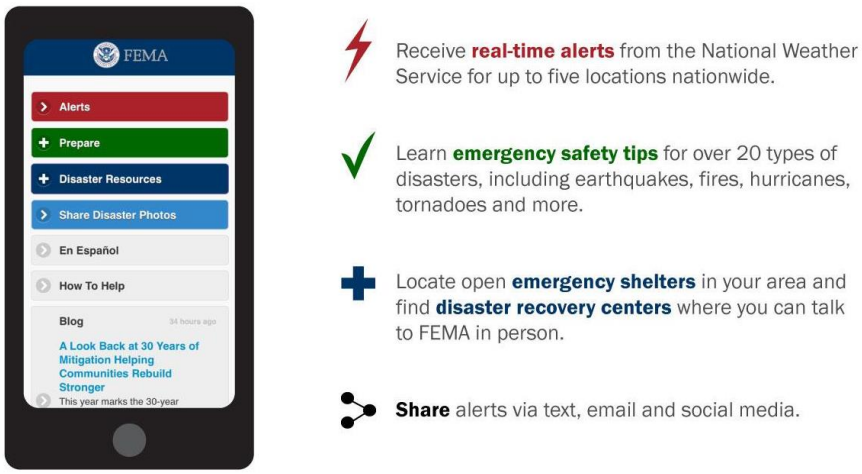


Figure 8: Promotion graphic for the FEMA App

[4] https://www.fema.gov/mobile-app

Hazards[5]

The hazards app is developed by the Global Disaster Preparedness Center and is mostly concerned with informing the user. It does this by providing the user with the information they need to prepare for and respond to any hazard. It comes with an alert system that can deliver official watches and warnings from alerting agencies. It currently supports the following Red Cross and Red Crescent regions: Argentina, Belize, Caribbean, Indonesia, Iraq, Italy, Kazakhstan, Myanmar, Philippines, and Vietnam.

On google play store page the following features are listed:

- Receive geo-targeted notifications for a range of hazards, including hurricane, earthquake, flood, winter weather, tsunami, and tornado.
- Monitor your current location and 5 others, including location of friends and family.
- Practical and useful preparedness information for a range of hazards.
- Preloaded content means you have instant access to all safety information at any time, even without cellular or Wi-Fi connection.
- Interactive quizzes allow you to earn badges that you can share with your friends and colleagues.
- Toolkit with additional features e.g. flashlight, strobe, and alarm.

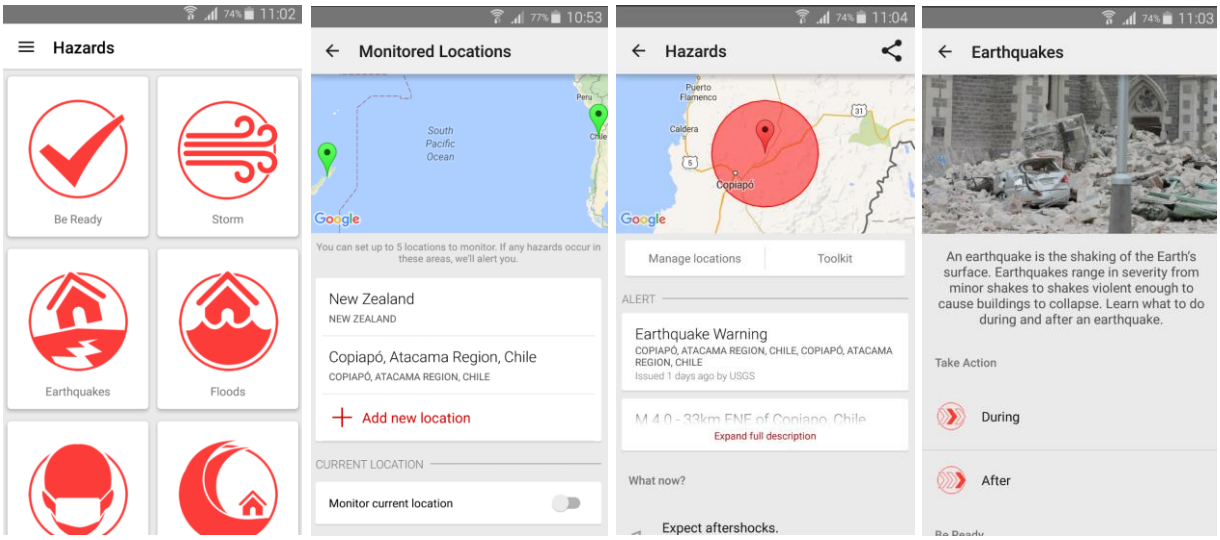


Figure 9: screenshots of the Hazards app retrieved from the google play store

[5] https://play.google.com/store/apps/details?id=com.cube.gdpc.hzd&hl=en_US

AEGIS App [16]

The AEGIS app was developed for the windows phone, as at that time there was no other app available for that platform. This also means that it is not available anymore, as windows phone has been discontinued. The mobile app was developed to work with the web-based platform of AEGIS. The app could provide the user with fire management data, such as the locations of water tanks, pumping stations, fire hydrants; weather data, such as the air temperature, humidity and windspeed; and the option to calculate the shortest route between the user's location and a location specified by the user. The platform was also integrated with the voice assistant of the windows phone, Cortana. Through this voice assistant the user could use phrases such as "AEGIS Open water tanks" to open the visualization of the nearby water tanks.

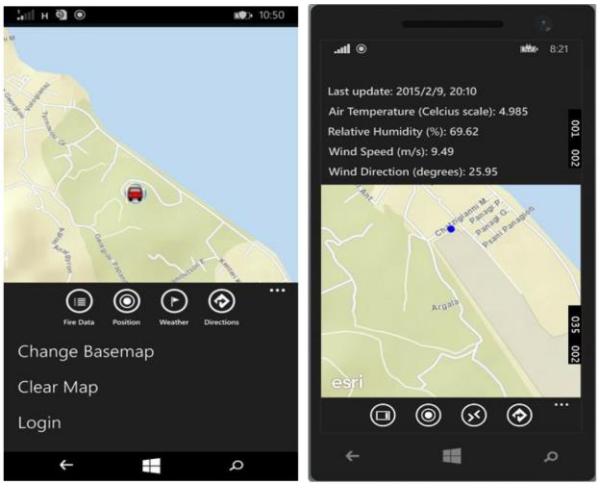


Figure 10: AEGIS App, screenshots obtained from [16]

Literature review

It is unclear how best to design such a tool for a mobile device, such as a smartphone, to be effective for a wide range of users. This is especially the case for users that have less affinity with technology such as elderly people. Thus, the main objective of this literature review will be to get insight into the design features with regards to the GUI (graphical user interface) necessary to create such a tool. This will be done by answering the following three questions. First, how to efficiently point the user in the right direction they need to flee to. Second, which factors need to be taken into consideration to make the interface easy to use for older adults. Since the app will be used in case of an emergency, it could prove useful to know how people will act in such a scenario. Therefore, the last question will be how people behave when evacuating from a natural disaster such as a wildfire. This literature review will start by looking into how to navigate people, then discuss the UI consideration with regards to older adults and finally examine how people will behave when evacuating from a wildfire.

Directing the user

As of 2018 google maps has by far the biggest market share when it comes to navigation apps, with nearly 70% of people saying they use the app. While the nearest competitors, Waze, and Apple Maps, sit only at 12% and 11% respectively [17]. However, these navigation apps all have something in common; their wayfinding instructions come from a driver's perspective, not a pedestrian's. Whereas a car navigation system might tell you to "turn left in 200 meters", a pedestrian navigation system should take a different approach. This is because it will be hard for people on foot to estimate long distances. It would work much better if they are able to recognize their surroundings [18]. Yet, it will also depend on the specific user what would work best. If a user has a good SoD (sense of direction), a map depicting a route (like the one provided by google maps) would work well. However, if a user has a bad SoD, the exact opposite would work better. This would consist merely of their location on a map and the direction in which they would have to walk to reach their destination [19].

Another important thing to keep in mind is that, even though most navigation systems today use TbT (turn by turn) instructions, human-generated wayfinding instructions also use a lot of landmarks [20]. It has been found that when utilizing these landmarks, for example in the form of landmark visibility indicators (indicators that show which landmarks should be visible from where the user is standing), it is easier for the user to create a link between the mobile map, reality and their mental map [21]. Having this link can greatly decrease the disorientation the user might feel when accidentally taking a wrong turn. Depending on the kind of instructions

given to the user, a different type of landmark might need to be used. Research suggests that to maintain orientation map material should refer to global landmarks while textual instructions should use local landmarks [22].

To summarize, depending on the user's sense of direction, two types of interfaces might be employed. The first is a map that shows the route a user must take (much like Google maps) while the second only shows the user their current location and points them towards their destination. This could be greatly beneficial if people quickly needed to evacuate. However, for now, this seems to apply only to an urban setting. Whether this would work the same in a more rural environment or in nature is not clear. The same holds for the landmark-based wayfinding instructions versus turn-by-turn instruction. These landmark-based instructions rely on clear landmarks which are abundant in the city but might not be that prevalent out in the country. Moreover, these landmarks must be noted down first, which could be accomplished in the city but would pose a challenge in the country. Should the areas that need to be evacuated contain urban areas, these are important points to keep in mind. It should be noted, however, that human-generated wayfinding would only be an option if the landmarks have already been found and are available.

UI Considerations for elderly users

Another consideration of the design process will be the user base. Ideally, this application would be used by people from all walks of life, including the elder generations. Only a few years ago only about 10% of people aged 55-64 in the UK used a smartphone, while as of 2018 this number has reached over 70% [23]. Therefore, it is important to also investigate what their preferences are, especially since this concerns an emergency app where it is paramount that everyone can easily find their way through the menus.

The problems elderly people encounter when interacting with a smartphone can be split into three categories: Visual limitation, psychomotor limitation, and cognitive limitation. The visual limitations experienced by these users are caused by slower accommodation of their eyes between light and dark areas on the screen. Moreover, the eyes also have trouble with quickly changing focus or reacting to fast-changing brightness. These problems can be offset by allowing the use of larger font sizes and by using contrasting colours [24]. According to Google's Material Design guidelines, the contrast ratio for large text (14pt and up) should be 3:1 against the background and for smaller text 4.5:1 [25].

The problems caused due to the senior's psychomotor limitations have to do with the fine movements required to interact with the UI. In general, a senior user requires 50-100% more time to complete the same task as adults under 30. Therefore, it is recommended to reduce the number of interactions as much as possible and using a simple menu structure [24]. The material design guidelines recommend touch targets, parts of the screen that respond to a user's input, to be 48 x 48 dp (device-independent pixels, a measure of the size used by the android platform) [25].

And lastly, the cognitive limitations experienced by the senior users are caused by a combination of factors. One of these factors is the working memory of seniors, which decreases significantly with age. Another important factor is their prospective memory, deficiencies in this area cause them to forget to carry out an intended task. Couple this with complex text and navigations and people will often get confused. Therefore, it is recommended to keep the menu structures simple and flattened, easy-to-use menus are preferred. Whenever icons are used in navigation, their function should be easily identifiable. To help with this, icon animation should be avoided as moving images would interfere with the user's focus [24].

When looking at different types of navigations two main distinctions can be made, a menu-oriented navigation (Figure 11, Figure 12 and Figure 13) and a content-oriented navigation (Figure 14, Figure 15 and Figure 16). Overall, the senior adults were able to navigate a content-oriented navigation more easily than a menu-oriented navigation. This can be explained by them having a decreased working memory while having maintained or even improved upon their reading comprehension [26]. Because of this it is easier for them to understand a list for example as compared to a side-drawer, since with a list they have to remember less and can still comprehend the items well. Even though content-oriented navigation would be preferred, there might be instances where a menu-oriented navigation is required. For that reason, for both types of navigation some recommendations will be given.

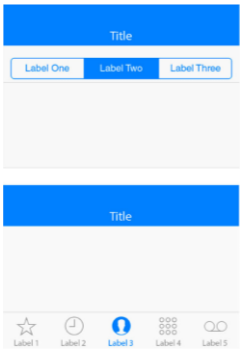


Figure 11: Tab Menu [26]

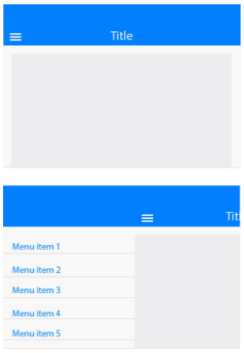


Figure 12: Side drawer [26]

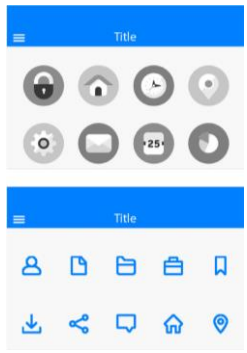


Figure 13: Springboard [26]

Whenever a horizontal scrolling navigation is chosen, a tab menu (Figure 11), top-tabbed menus are preferred [26]. An example of this can be seen at the top of Figure 11. This allows for

larger buttons and allows for text to be displayed in them. When using tab menus, scrollable tab menus should be avoided. However, if this cannot be done, they should be sufficient visual cues, for example, a visible scroll bar, to indicate that there are more options. And finally, minimize the space between the buttons to allow for larger buttons [26].

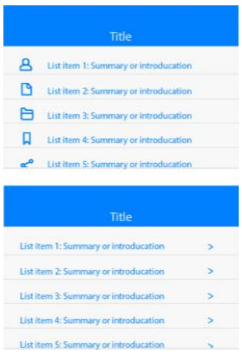


Figure 14: Lists [26]

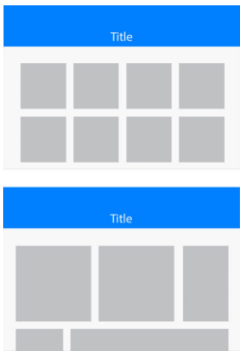


Figure 15: Gallery and Grids [26]

Figure 16: Cards [26]

While tab menus might have their use, it was found that senior user's preference went to vertical scrolling menus, such as the side drawer and springboard. For these to it holds that whenever scrolling is necessary, it should be indicated clearly. Moreover, there should be sufficient visual cues to indicate the direction in which the user is expected to navigate through the options. Something else to consider is the use of pictograms as opposed to text. In some cases, this can cause some difficulty as older adults can have significant difficulties with understanding what they mean and building the required mental model between the graphical item and its meaning [26].

Within the content-oriented layouts, lists and galleries were preferred by most older adults over cards. They allow for more information to be present on the screen at any time without the need to scroll. However, while lists were shown to outperform the other layouts, mistaken touches were found to occur whenever the list height was limited. Therefore, it is recommended to use larger list items to prevent these mistaken touches. Lists are great when showing broad and diverse categories, but when items start to become similar it will become more difficult to compare details. Thus, when comparing similar items, a gallery is recommended [26].

To summarize, it is recommended to reduce the number of interaction necessary for a given task as much as possible. This means that menu structure should be kept simple and shallow. Also, to help senior users keep their focus, contrasting colours should be used and there needs to be an option for setting a larger font size. Should icons or pictograms be used, their meaning should be obvious. However, whenever possible text would be preferred. When it comes to the different navigation layouts, content-oriented menus were more efficient than menu-oriented menus. Though this might not be an option for an application that incorporates a map interface. For such an application a tab menu or side drawer would be desirable as they cover less of the

screen when used. Should a tab menu be chosen, a top-tabbed implementation works best, especially when text is used instead of icons.

Behaviour during evacuation

Lastly, since this app will be used to help people evacuate in case of a wildfire, it would be beneficial to understand how people might behave in such a scenario. Perhaps more importantly would be why they behave the way they do in such a scenario as this could provide valuable insights for design of the app. When it comes to getting people to start evacuating the evacuees can be split in roughly two groups, those who do and those how do not comply with evacuation warnings. Sources do not agree upon the reason why some people refuse to stay. One explanation is that people who choose to stay behind are motivated by a desire to protect their property, for example their house or pets and livestock [27]. Another explanation says that there are two classes of individuals: those who believe evacuation to be an effective risk mitigation strategy and those with a higher tolerance for risk and the belief that they will be able to prepare their property for a wildfire. Something to note, however, is that there is a substantial part of each class that is not committed to their beliefs but are just waiting to see if they should stick to their specific desire [28].

It was also discovered that throughout the whole evacuation process, getting accurate information seemed to be a problem. This was a problem for the residents near a wildfire as they had to try to estimate the seriousness of the situation while also maintaining somewhat of a normal rhythm. However, as the situation got worse, the problem with regards to getting the right information also worsened as people had to try and interpret all the different clues and rumours received from various sources. Afterwards, the information residents would receive through the media was described as sensationalist, insensitive and even inaccurate when it came to place names and the conditions for specific regions [29]. This might be an area for the app to support the user since it would use a model of the fire's progression to determine a suitable escape route. It could therefore also keep the user up to date on the status of a nearby wildfire using the data of this model.

Finally, even though this is a little out of scope with regards to evacuating from a wildfire, something was found in support of but also with a warning for a mobile evacuation app. During times of stress a phenomenon called cognitive tunnelling, the narrowing of attention focus, can appear. When people were confronted with evacuation conditions, this was found to lead cognitive tunnelling and a strong attention focus on digital escape route signs [30]. It is worth mentioning that these evacuation conditions were in an indoor setting. And although this is not

necessarily the same scenario as a wildfire evacuation, it could be the case that, if the app were to be developed successfully, they might be seen as the escape route signs in the indoor evacuation setting. This could then suggest that the app would be relied upon by evacuees to determine where to go. However, it was emphasized that, since people would rely upon the escape route signs, it was paramount that the signs were up to date [30]. The same holds for the app. If the app were to be relied upon to the same degree as the escape route signs, it would necessitate a high confidence in its accuracy.

To summarize, when evacuating, there are two groups of people: those who leave and those who stay behind. It is not entirely clear why those who do not evacuate desire to stay, however a substantial part of those who are more inclined to stay might be persuaded to leave should they be given sufficient information about the fire's danger. Another point for consideration is that, throughout the whole evacuation process, people desire to have access to accurate and up to date information, which right now would sometimes still be lacking. Lastly, it is of utmost importance that the app will provide accurate data and a safe evacuation route. This is especially the case since there is a chance that people experience cognitive tunnelling during evacuation and fixate on the direction provided by the app.

Conclusion

To conclude, this literature review examined the design feature with regards to the graphical user interface necessary to create an effective wildfire evacuation app. This was done by looking at how to efficiently point the user in the direction the needed to flee to, by exploring which factors need to be taken into consideration when making the interface easy to use for elderly people and finally by getting insight into how people behave when evacuating from a natural disaster. When it comes to pointing the user in the right direction, two important points were uncovered. First, depending on the user's sense of direction it might be more beneficial to provide them only with their current location and the direction in which they should head to reach their destination as opposed to providing them with a route on a map. Moreover, it was found that, where navigation for pedestrians is concerned, a set of wayfinding instruction using landmarks is easier to use than turn-by-turn instructions. However, it is unclear if this holds true in rural areas as well.

To create a senior-friendly user interface, it is recommended to create a simple and flat menu structure and to reduce the number of interaction necessary for a given task. To help elderly users with focussing, contrasting colours should be used and there needs to be an option to increase the font size. Should icons be used for navigation, their meaning should be obvious as

they can often cause confusion for elderly users. For that reason, whenever possible text would be preferred over icons or pictograms. Should the app be designed to make use of a tab menu, a top-tabbed implementation is recommended, especially when text is used instead of icons.

And lastly, during an evacuation, there are two types of people: those who wish to stay and those who follow the evacuation warnings and leave. However, a substantial part of those who wish to stay behind might be persuaded to leave should they be given enough information about the fire's dangers. Another consideration is that during the whole evacuation process, people wish to stay up to date on the progress of the fire and the status of their home. Especially this last bit will often become distorted when reported by the media. Providing the user with information about their region would be a valuable feature to add to the app, since it will already have the data about the nearby fire to calculate the escape routes. Finally, it is extremely important that the app provides accurate data and a safe evacuation route, especially since people can experience cognitive tunnelling during an evacuation and might fixate on the directions provided by the app.

Overview

Here an overview can be found of all the features discovered throughout the state of the art and literature review. This list of features will only include those that are relevant to the context of this project. This means that for example features meant specifically for fire fighters (such as being able to enter the state of the fire and of the surroundings to be able to model the fire) will not be included in this list.

State of the art features

APP	Features
WiSE	Fat-finger interface
	Interactive Map
	Offline Calculations
Navicuate	Proactive information about risks and consequences
	Location-dependent evacuation information
	Escape routes
	Advice on time of departure
Gaia GPS	Track a fire's progression
	Use polygons on the map to display the fire
WFA Pocket	Cross-platform
Emergency	Available in English and Spanish
	Real-time local alerts for severe weather and hazards.
	Customizable alerts and notifications
	Interactive quizzes
	A toolkit with flashlight, strobe light and audible alarm.
	Map with open Red Cross shelters and other weather-related layers.
	Step by step directions on how to make a family emergency plan.
	Support for Android Wearables 2.6 and above.
Disaster Alert	Real-time information
	Scientifically verified sources
	Easy-to-use map interface
	Customize early warning alerts
FEMA	Real-time alerts from the national weather service
	Alerts for up to five locations
	Share real-time notifications
	Locate open emergency shelters and disaster recovery centres
	Contains safety tips, emergency checklist, family plan and reminders
Hazards	Receive geo-targeted notification for several hazards
	Monitor multiple locations
	Practical and preparedness information
	Preloaded content
	Interactive quizzes
	Toolkit with additional features (flashlight, strobe, and alarm)
AEGIS	Fire management data (location for water tank, pumping station, fire hydrants, on-duty fire vehicles, helipads, etc.)
	Route calculation
	Support for voice commands

Literature features

- Google maps like navigation is best for people with a good sense of direction, a location on the map with direction to the destination is best for people with a bad sense of direction.
- Wayfinding with landmarks easier for pedestrians
- Simple and flat menu structure
- Contrasting colours
- Option to increase font size (might already be provided on an OS level)
- Text preferred over icons
- Top-tabbed menu instead of bottom-tabbed if tabbed menu is used, side drawer would be preferable
- Give people information about the fire's progression.

Chapter 3 - Methods and Techniques

Creative Technology design process.

The process that is used in this project to develop the mobile app is based on the Creative Technology Design process [31], an illustration of which can be found in Figure 17. The processes consist of four phases, ideation, specification, realisation, and evaluation. During the ideation phase the product idea is brainstormed upon. Inspiration from already existing products might be taken in and a rough idea will be generated. This idea will be converted into features and requirements in the specification phase. This will be done using the MoSCoW method, which will be explained later. In the realisation phase the prototype will be built. Finally, in the evaluation phase the prototype will evaluated with user testing. The feedback gathered from the evaluation phase will be passed back to the previous stages to improve upon the idea and prototype, after which the cycle begins again.

MoSCoW method [32]

The MoSCoW method, invented by Dai Clegg, is a method to prioritize features during a products development. MoSCoW is an abbreviation of the four categories that make up the method, Must haves, Should haves, Could haves and Will not haves. Feature that are necessary for the product to function and that will be the main priority when developing the product are the *Must* features. Features that need to be there to make the product work well but are not critical for the product to function well are *Should* features. Features that are nice to haves in the product but are not essential to have a working product are *Could* features. These will only be implemented if there is time left. Finally, there are the *Will not* features. These are either out of scope for the product or not feasible to be implemented.

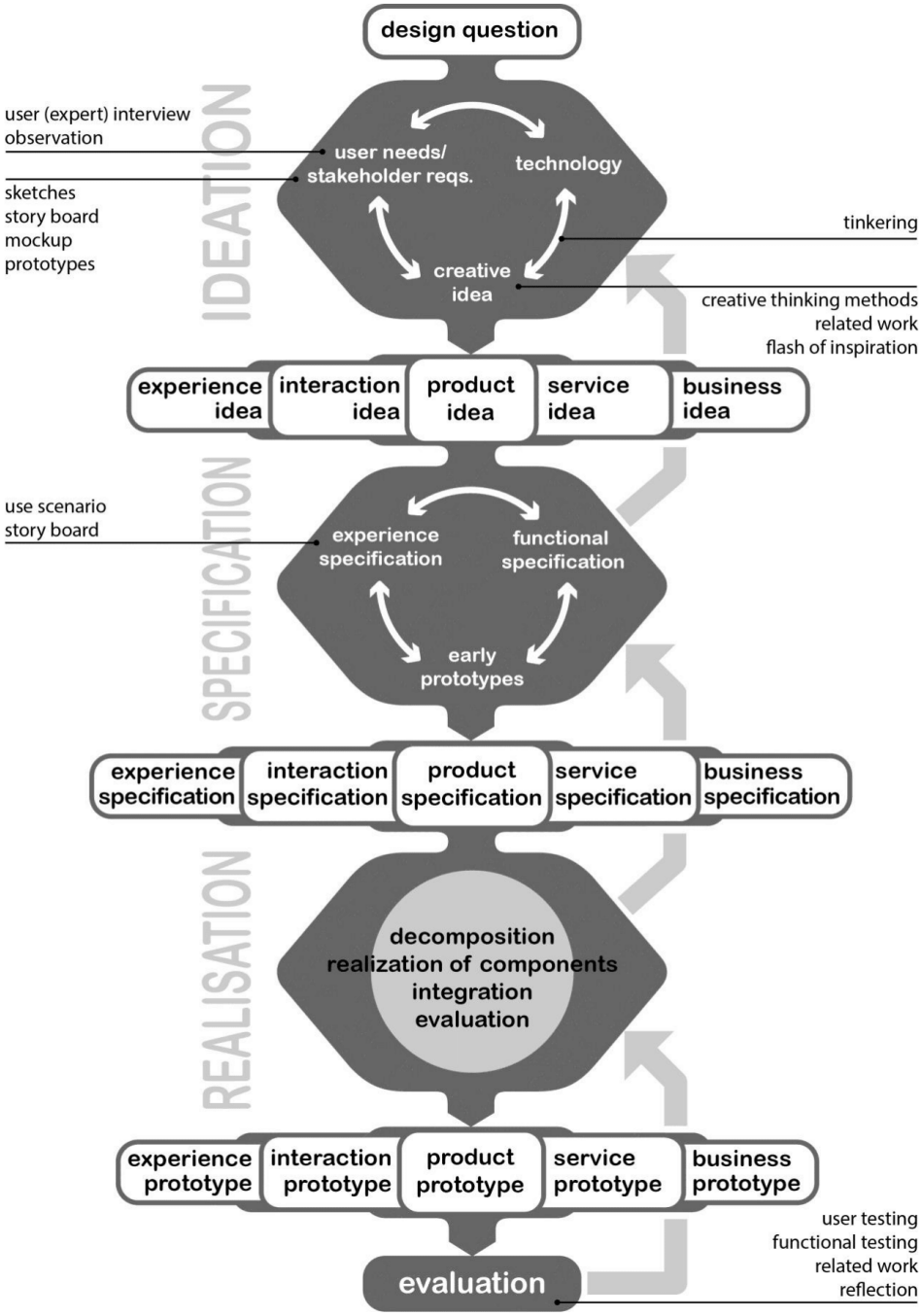


Figure 17: Creative Technology design cycle

Chapter 4 – Ideation

In this chapter a rough idea about the app's design will be explored through some sketches of the UI. For these sketches, inspiration was taken from existing applications found in the state of the art and other navigation apps (e.g. Google maps). At the end of this chapter a list can also be found of features discovered throughout this design process and through discussions about what the app should offer.

Sketches

The first couple things that needed to be designed with regards to the application's UI (user interface) were: the path that the user would need to take to get to the navigation view, the views used in this path, and the eventual navigation view. For the navigation view it was discovered in the start of the art that two types of navigation could be used: Turn-by-turn and direction based. The idea behind the design, throughout all the iterations of the navigation views, was to keep the information on the screen to a minimum. This would mean that

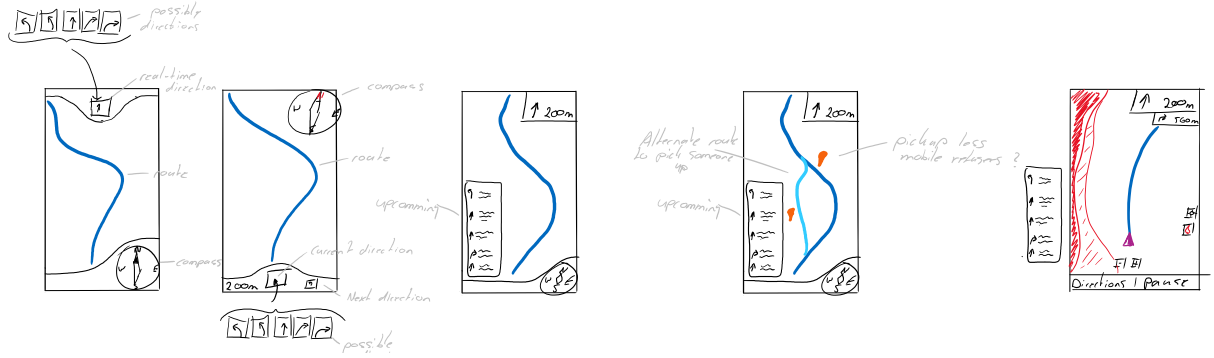


Figure 19: Turn-by-turn view

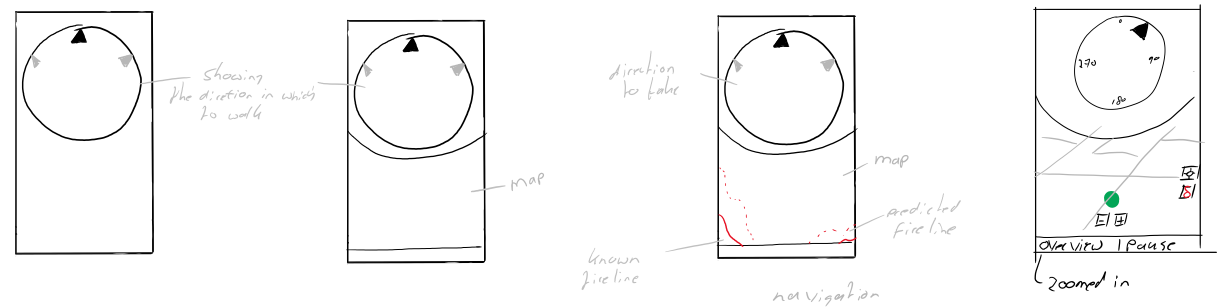


Figure 18: Direction based view

information that might be found in traditional navigation apps like the current speed or the speed limit will not be included. In Figure 19 the sketches for the turn-by-turn style of navigation can be found and in Figure 18 a couple of sketches can be found for the direction based navigation. In

both sketches the process evolved from left to right, with the view that has been implemented on the right-hand side.

The final design for the turn-by-turn view works as follows. In the top right corner, the next turn and the turn after the next turn are indicated along with the distance till each. Along the bottom the user has the option to open a complete list of directions, which is depicted next to the sketch but would look similar to how it is shown in the third and fourth sketch. This is a scrollable list with the type of turn and the distance till each. Next to the button to show the list of direction is a button to pause the navigation. This returns the user to an overview of the route. Above these buttons are also two zoom buttons. While these are not strictly necessary, as the interface has the option to pinch to zoom, they offer the option for fine zoom control. Along the right edge of the view are the two last buttons of the interface, a button to centre the screen to the user's current location and a button to centre the screen on the fire.

The sketches of the direction-based view vary less than those of the turn-by-turn view as the idea behind the direction-based view is a lot simpler. The idea is to have a map that displays your current location, your destination, and the direction you need to head in to reach your destination. To that end a compass like item can be found at the top of the view, which always points to the user's destination. The final design also includes a couple of buttons. The two on the right-hand side are the same as those found in the turn-by-turn style view, allowing the users to centre the map either on their location or the fire. At the bottom however the left button, which showed the list of directions in the turn-by-turn view, has been replaced with a button to show an overview of the situation, giving the user's context for their navigation. When the screen is in overview mode, this button will zoom them back in.

And finally, there are the path views. These can be found in Figure 20. The first idea was to have the users select their mode of transport after which would either lead them to a second menu to gather more info (such as if they are able to walk quickly or are in a wheelchair). After this they would get the option to either view the map (and the fire) or go to the navigation. The map view would also allow the users to continue to the navigation view. However, to make the whole process more straightforward and less confusing (which is one of the MoSCoW features), this whole process got shrunk down to a selection view and the map view. These two can be seen in the bottom left of the sketch in Figure 20.

The selection view offers the user the option to select their mode of transport (car, bicycle or on foot) and the style of navigation (turn-by-turn or directional) through two toggle menus. Below

the navigation toggle menu, a description of the type of navigation will be given to inform the users about their choice. These toggle menus show which option has been selected by making

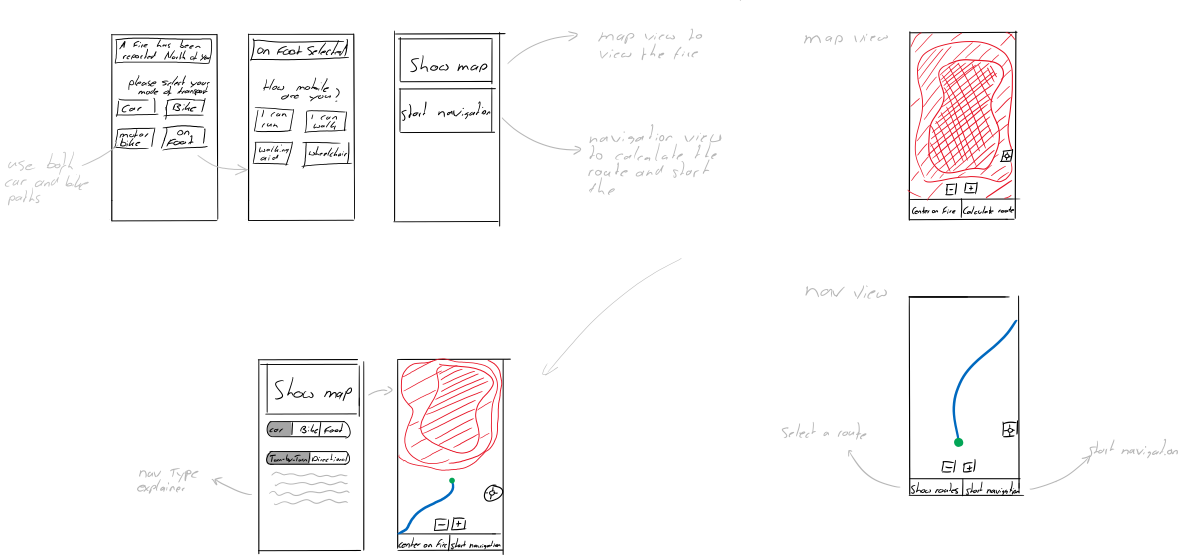


Figure 20: Path views

the selection slightly darker. The only other button in this view is the *Show map* button which lead the user to the map view. The map view is very similar to the map view in the original idea. It allows the user to centre the map on the fire, on their location or start the navigation.

Additional features

Throughout the process of envisioning the form of the app and through discussions about the app the following additional features were thought off:

- GPS compass vs build-in compass. Make sure that the internal compass is calibrated correctly and disregarding it when it is not (making use of a GPS based compass instead).
- Companion system for the government to pro-actively get people to evacuate (if they have not thought about doing so themselves)
- Picking up less-mobile evacuees through suggesting alternate evacuation routes.
- Available in Dutch
- Give instructions based on the user's situation (e.g. mode of transport)
- Traffic/evacuation aware navigation

Chapter 5 – Specification

In this chapter the features collected from the state of the art and ideation will be prioritized using the MoSCoW method. After having prioritized all the features, they will be explained in more detail.

MoSCoW

The features that are put into the MoSCoW method will be split up into those features derived from the state of the art, the literature review and finally the features gathered through discussions and brainstorm sessions of the ideation phase. The features will be prioritized based on how close they are to the core functionality of the app (to help people evacuate from a wildfire) and on how feasible they seem within the time constraints of this project.

Derived from state of the art

Must	Should	Could	Will not
Escape routes/route calculation	Polygons on the map to indicate the fire	Track a fire's progression (locally)	Cross-platform
Location-dependent evacuation information	Customizable alerts and notifications	Monitor multiple locations	Available in Spanish
Interactive map	Advise on time of departure	Map with different layers (shelters, lakes, etc.)	Step by step directions on how to make a family emergency plan.
Fat-finger interface		Voice command support	Proactive information about risks and consequences
		Fire management data	
		Toolkit with additional features	

Derived from literature

Simple and flat menu structure	Map interface + direction interface	Give information about the fire's progression	Wayfinding using landmarks
Contrasting colours	Option to increase font size		

Additional features

Situation aware instructions	GPS compass vs build-in compass	Alternate route for picking up less mobile	
		Companion system for the government	
		Available in Dutch	
		Traffic/evacuation aware navigation	

Feature list

Must

Feature	*Description*
Escape routes/route calculation	Calculate a route to escape the wildfire based on the user's location and the fire's location.
Situation aware instructions	Give navigation instruction based on the user's situation (e.g. access to a car or on foot)
Location-dependent evacuation information	Give the user evacuation information based on their location.
Interactive map	Allow the user to interact with the user, move the map around and zoom in/out for example
Fat-finger interface	Make use of big buttons to allow for easy and quick interaction.
Simple and flat menu structure	A menu structure that does not require the user to go through multiple menus to reach the screen they need.
Contrasting colours	Use contrasting colours as described by the google material design guidelines to make the interface easy to read.

Should

Feature	*Description*
Polygons on the map to indicate the fire	Indicate where the fire is on the map by using polygons. This way the user can see, in real-time, where the fire is and understand the escape route.
Customizable alerts and notifications	Give the user the option to customize what kind of notifications they receive and how often. For example, how near the fire is and how often to tell them this.
Advise on time of departure	Notify the user when it would be time to start evacuating. Either based on the fire's progression, recommendations provided by the government or both.
Map interface + direction interface	Give the option to use an alternate navigation interface that points the user in the direction of their destination instead of showing them the route on a map (the traditional navigation interface used by for example google maps).
Option to increase font size	Allow the users to customize the font size used in the app to make the app better legible for people with visual impairments (e.g. short sightedness)
GPS compass vs build-in compass	Create a system that compares the inbuild compass with the GPS compass to determine if the build in compass is configured correctly and can be used.

Could

Feature	*Description*
Track a fire's progression (locally)	Include the fire progression model into the app instead next to running the model in an online service (in case the phone loses internet connection).
Traffic/evacuation aware navigation	To avoid congestion while evacuating people from a region the route calculation could take into account traffic and/or be aware of the ongoing evacuation and generate different routes.
Monitor multiple locations	Allow the user to receive information for more locations than their actual location, for example for locations of family members.
Map with different layers (shelters, lakes, etc.)	Enabling different layers on the map, for example a layer for the fire, a layer that shows where nearby shelters are, etc.
Voice command support	Integrate voice assistant support into the app, for example google assistant.
Fire management data	Show the locations of water tanks, pumping stations, fire hydrants and the like.
Toolkit with additional features	A toolbox with quick access to features such as the flashlight, SOS signal or to call 112 (or the regional equivalent)
Alternate route for picking up less mobile	Provide the users with an option of an alternative route to pick up people that are less mobile. For example, in a scenario the user is evacuating by car and there are people who are evacuating on foot and cannot escape the fire quick enough.
Companion system for the government	Integrate a companion system into the app that allows the government to send messages to and provide extra information to the users.
Available in Dutch	Also provide a Dutch version of the app.

Chapter 6 – Realisation

In this chapter the prototype that has been designed will be realized. First the tools that were used will be discussed after which an overview will be given of how the individual parts of the app are connected. Next the structure of the app will be shown and finally some screenshots of latest version (as of writing it) of the prototype will be provided.

Tools

Early on it was decided to build an android app, but there are various ways this can be done. This includes building the app in Android studio, React Native or Xamarin just to name a few. While none of these have been used in Creative Technology, Android studio would be the most familiar as it would allow apps to be programmed in Java, which has been taught in Creative Technology. However, Android studio also allows apps to be programmed in another language, namely Kotlin. Kotlin is a language similar to Java but with some advantages, moreover Google announced in 2019 that Android development would become Kotlin-first [33]. Therefore, it was decided to create the android app using Kotlin.

As the main features of this app will be the map and navigation, a map provider needed to be chosen. There were three main options, Google maps, OpenStreetMap and HERE maps. Google maps would have been relatively straightforward to implement, as it already partially included in Android studio, however it is not entirely free to use. OpenStreetMap on the other hand is free map but still needs an SDK (software development kit) to be implemented on android. It depends on the SDK which features will be offered and whether it is free or not. The SDKs for android that are free often did not offer as much features as HERE or Google maps. HERE maps sits in between Google Maps and OpenStreetMap, while it is a paid service it does offer a free plan with limited transactions (like requesting a route). HERE maps does offer something else that is essential for this project that neither Google maps nor any (free) OpenStreetMap SDK offer and that is the ability to add banned areas. Banned areas are, as the name suggests, areas that are banned, but more specifically areas that the route calculation cannot use. This is essential for this project as the routes that will be calculated should avoid the area of the forest fire. HERE maps also has the option to easily place shapes on the map allowing the app to easily show the fire on the map using some polygons.

The last thing that is needed to make the whole system work is an API that allows the app to talk to the model (that is being developed by another student). Once again HERE offers a solution, this time in the form of their real-time location data management service *HERE XYZ*. This platform can be used as a go-between between the app and the model. Moreover, it can

accept multiple data types including the ones that seemed to be provided by Flammap6 (the platform that was being used to model the fire as of writing this). Because of this HERE XYZ would also act as a kind of converter, converting the data type provided by the model to a GeoJSON file (which contains the data about the fire in the form of multiple polygons) that would be provided to the app through its API.

Overview

To give a quick overview of the tools that will be used to create the prototype, the app will be programmed in Kotlin using Android Studio. The map will be provided by the HERE Maps SDK and the connection between the app and the model will be facilitated by the HERE XYZ platform. A schematic of these connection can be found in Figure 21.

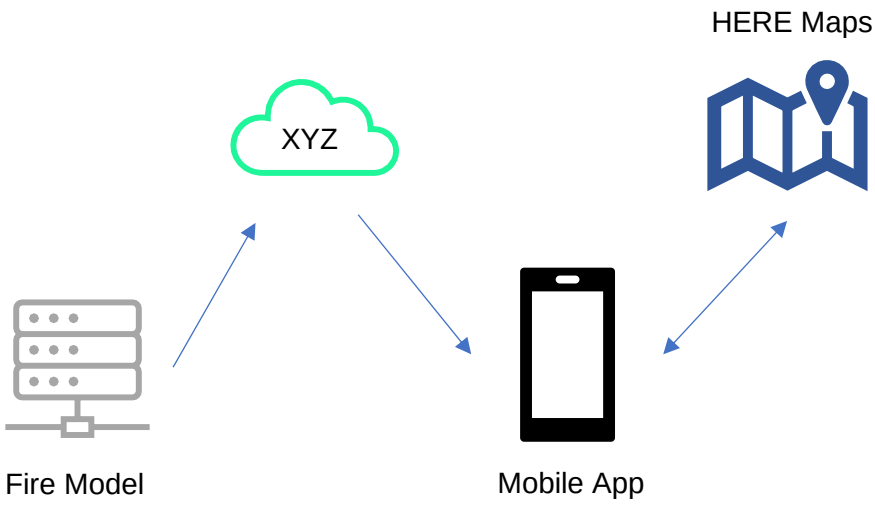


Figure 21: Schematic of back-end connections

App Structure

The app is divided into two views, the design of which will be discussed later. An activity is associated with each of these views. These activities are MainActivity (associated with activity_main, the home screen) and MapActivity (associated with map_view, which is used to display the map and navigation). These two activities contain most of the code of the app, however there are also some separate classes. The most important of these are the ApiHandler and the FireDataHandler.

MainActivity

MainActivity handles everything required to have the app function, such as checking permissions and setting up a cache path for the map, which is required for the map to function. It also attaches listeners to the buttons. These listeners are pieces of code that is run when their respective action has occurred. An onClickListener for example will run when a button has been clicked. Using these listeners, the actions being the buttons are set. The last thing that MainActivity is responsible for is starting the ApiHandler and having it run every 15 minutes.

ApiHandler

The ApiHandler is used to retrieve the data about the fire from the HERE XYZ web service through the associated REST API. It can request data from the webservice by calling a resource method of the API. In this case a get request is used to retrieve the data about the fire. The data about the fire's progression is stored in the form of polygons that describe the fire at its different stages (e.g. now, fifteen minutes into the future, thirty minutes into the future, etc). These polygons are returned by the REST API in the form of a GeoJSON file, which is shaped exactly like a JSON file however has predefined ways to store various different shapes (e.g. lines, polygons, etc.). The ApiHandler then uses the GSON library to convert the (Geo)JSON file to a FireData objects that can be easily used in code. This FireData object contains the polygons to describe the fire an all the coordinates to generate these polygons. Moreover, it contains most of the function needed to retrieve and interact with the fire data. These objects are then passed along to the FireDataHandler.

FireDataHandler

FireDataHandler is used to store the information about the fires retrieved from HERE XYZ and will act as a go between for the MapActivity and the data for the various fires. The FireData is added to the handler through the setFireData function, which is called by the ApiHandler. This function also tells the FireData object to generate the polygons (if the map has been initialized).

MapActivity

MapActivity is where the bulk of the code can be found. This activity is responsible for handling the map and navigation, which also includes generating the destination and route to get to this destination. The way the route is currently being calculated is done as follows. First the user's heading with regards to the fire is calculated. This heading is in degrees, like the degrees on a compass (see Figure 23). A heading for the fire itself is also calculated, to ascertain the direction in which the fire is moving. It is then made sure that the user's heading is adjusted such that the difference between it and the fire is at least 45 degrees. This heading together with a set distance is then used to calculate a destination. In the current prototype this distance has been set at 10km, however this was purely for testing purposes. The aim is to have this be set dynamically in the future. Before generating a route, it is also checked if the user is not already within one of the polygons describing the fire. If this is the case, the nearest coordinate outside if that polygon is obtained and set as the first waypoint in the route generation. Then the waypoint for the final destination is added.

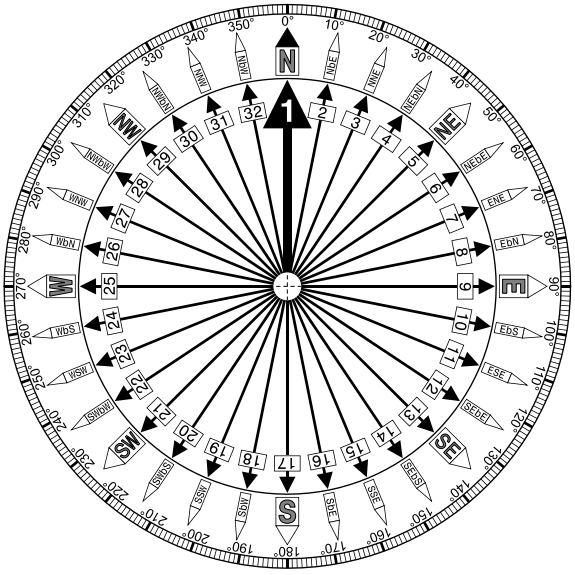


Figure 23: points of a compass [35]

Finally, the dynamic penalty is set. The dynamic penalty is what allows the route calculation to avoid a certain region or take into account the traffic when generating a route. At this moment only a banned area is set (the region the route calculation cannot use), however taking traffic into account is planned in future version. The banned area is set to all the polygons that describe the fire before the polygon in which the user is located. If the user is in the outermost polygon, for example, the inner polygons will be set as a banned area.

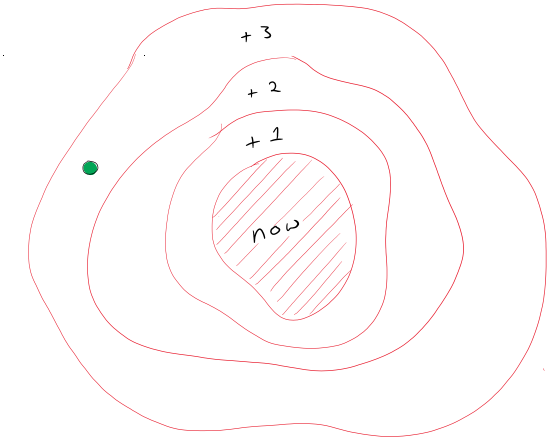


Figure 22: Illustration fire zones

An illustration of this can be seen in Figure 22. Here the centre of the inner most polygon (labelled now) is the fire as it is currently. The polygons around this labelled +1 through +3 are the polygons that describe the progression of the fire at different times. This is currently not yet

set, however each increment could for example be an extra 15 minutes into the future. This could mean that +1 is +15 minutes, +2 is +30 minutes, etc. The green dot indicates the user's location in this illustration. So, in this case the polygons labelled now, +1 and +2 will be set as a banned area since the user is in the area labelled +3.

App design

To design an interface for an app android studio offers a Layout Editor. This editor uses XML files to describe the layout of an app. There are a couple of ways to organize a layout in android, the latest of which is the Constraint Layout. This layout type links the individual objects together using constraints to keep them in place. To keep a button in the middle of the screen, for example, the button would have constrained from each of its sides to the sides of the screen. Each of these would be weighted the same essentially pulling the button from all sides keeping it centred. For a more detailed explanation please check the android documentation about the constraint layout[6].

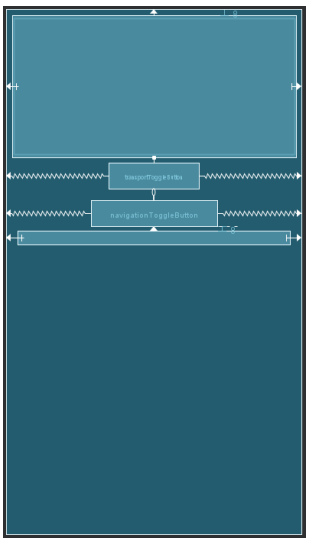


Figure 24: Blueprint of the home screen

Home screen

The home screen has a rather simple layout to avoid confusion as much as possible. The home screen contains two toggle buttons, one to select the mode of transport and one to select the type of navigation. It also contains an image view which gives a short explanation about the two different types of navigation. And finally, it contains the Show Map button, which lead the user to the map view. The blueprint and a screenshot of the home screen can be found in Figure 24 and Figure 25 respectively. The blueprint also shows the constraints between the different elements mentioned before. In this menu these are rather straightforward, however these can be a lot more intricate which can be seen in the blueprint of the map view (Figure 26)

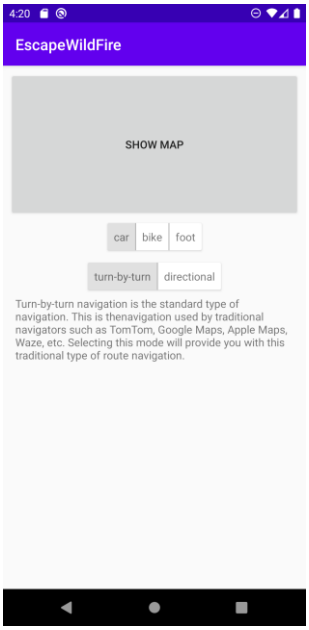


Figure 25: Screenshot of the home screen

[6] https://developer.android.com/reference/androidx/constraint layout/widget/Constraint layout

Map view

The map view is responsible for anything that involves the map, whether that is viewing the fire on the map or navigating. All these actions require the map fragment to work and since no way was found to have a single map fragment all these actions had to occur in the same layout. The reason for not having multiple map fragment is that each map fragment needs to be initialized and only once this is done can certain other listeners be started (e.g. the position listener which keeps track of the phone's location). To avoid having to initialize these each time the user switches between a map view and navigation view it was decided to combine the views.

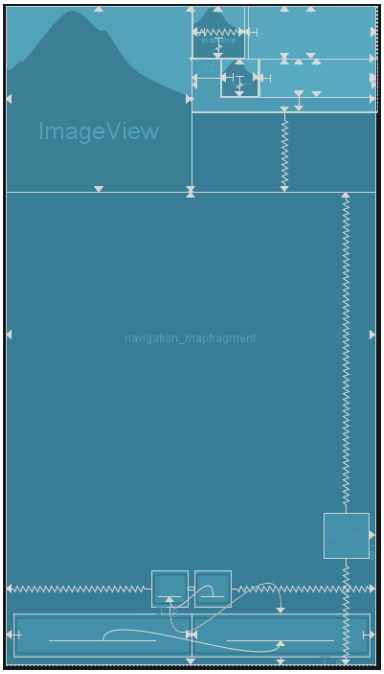


Figure 26: Blueprint of map view

To make sure that the navigation elements will not show up when not having started the navigation, the navigation elements are invisible whenever they rare not needed. These elements can be seen at the top of the map view blueprint, Figure 26. These are the square Image view on the left, the two smaller Image views on the right and the Image views next to the Image views. The top left corner is responsible for the directional navigation interface and the top right for the turn-by-turn navigation interface. Behind the top left Image view and the two sets of Image views and Image views are some Frame layouts which are responsible for the shape and colour of these areas. This is accomplished with an android canvas, which allows shapes to be drawn by giving a set of coordinates and the geometries that connect these coordinates. For example, a line from point x to point y. This canvas is then set as the view of the frame layout to give them their shape and colour.

To keep these elements in place and the right size the different elements are contained in a couple of nested constraint layouts (layouts within other layouts). All the elements are eventually contained in an encompassing constraint layout which is anchored to the top of the screen. This layout contains the two layouts for the turn-by-turn and directional views. There are some more constraint layouts within these to keep the image and text views and frame layouts in place correctly.

One final thing worth mentioning is the way the two bottom buttons are kept in place. The right button is kept in place vertically using normal constraints; however the left button is kept in place vertically using a baseline constraint. This constraint keeps an element on the same height as

the element it is connected to. They are both kept centred by constraints connecting them to each other and the sides of the screen. The result of the blueprint the elements within it can be seen in the screenshots in Figure 29, Figure 28 and Figure 27. For a complete set of screenshot of the app, please check Appendix 3 – Screenshots.

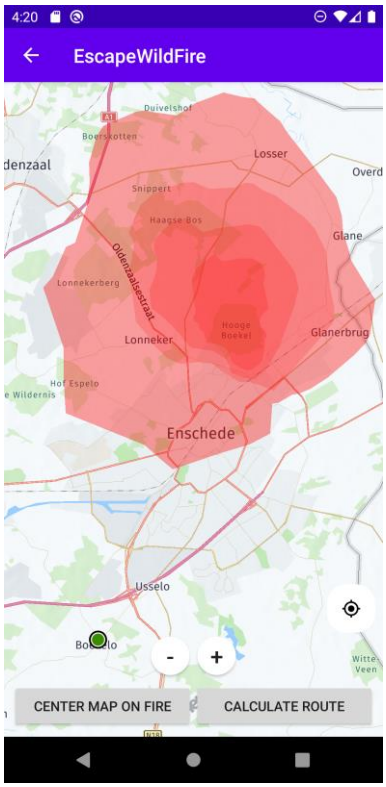


Figure 27: Screenshot of map view (no navigation)

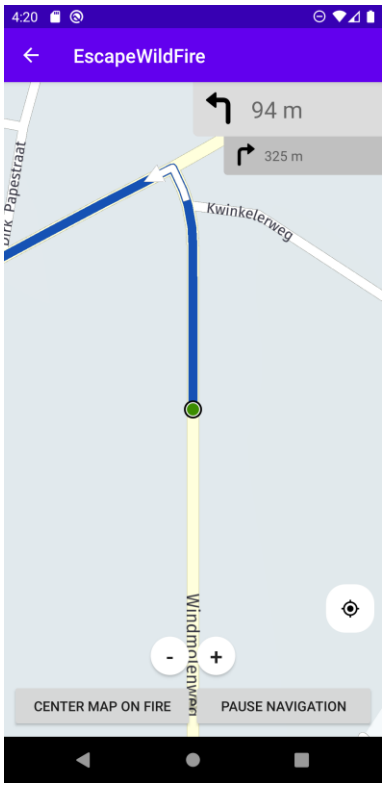


Figure 28: Screenshot of turn-by-turn navigation

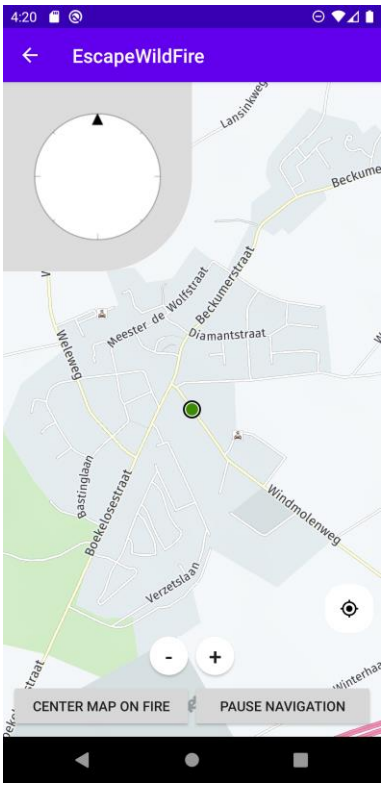


Figure 29: Screenshot of directional navigation

Chapter 7 – Evaluation

For the evaluation of the prototype two surveys were conducted. The first survey was an online only questionnaire while the second survey started off with a hands-on session with the prototype. Both full surveys can be found in Appendix 1 – Survey 1 and Appendix 2 – Survey 2. Since the questionnaire part of each survey was essentially the same, they will also be discussed together. However, first the hand-on part of survey 2 will be discussed.

Hands-on

During the hands-on part of the evaluation the participants were asked to complete 3 tasks, while handling the application for the first time. They were first asked to start the turn-by-turn navigation, then change the mode of transport for this navigation and finally to change over to the directional navigation. For each of these their number of interactions were recorded and the amount of time it took them to complete these actions. In total three participants completed this survey.

Results task 1

Of the three participants, two completed the first task in 4 interactions and in less than 30 seconds. This was almost the minimum amount of interaction, the minimum being 3. The only reason these participants both used one more interaction was because they chose to change their mode of transport. One of the three participants however had some more difficulty with this task. They needed 8 interactions and about 2 minutes to complete it. The reason for this was that they did not recognize the show map button as a button. They were looking down at the bottom right of the screen for a next button and when they did not find any, they tried tapping the other buttons again. Moreover, when starting the navigation, they also pressed the *centre on fire* button before the calculate route button instead of immediately pressing the calculate route button.

Results task 2

In general, the second task was completed the same for each of the participants. Two of them only taking about 10 seconds to change the mode of transport and accomplishing it in the minimum number of interactions of 5. One of the participants took slightly longer at 20 seconds and took one extra interaction to change the mode of transport. This is because they first paused the navigation before returning to the main screen.

Results task 3

The last task was once again similar for all the participants. They all managed to change to the directional type of navigation in around 15 seconds. Two out of three of the participants took the

minimum number of interactions of 5 to complete this task, while the other took 1 more interaction. However, this was because they also changed the mode of transport.

Questionnaire

Combined with the three participants from the hands-on survey, 32 people completed the questionnaire about the app.

App acceptance

The first question the participants were asked was, on a scale from 1 to 5, how likely they would be to use the app (assuming there would be a fire nearby). This was asked to assess the app's acceptance, whether people would be willing to use the app. The majority responded that they were likely to very likely to use the app. Only three responded that they would not use the app and three more responded with neither likely nor unlikely. However, the three participants that answered they were not likely to use the app all gave as a reason that there is either a very low chance or no chance of forest fires near them. One of the three did mention that they would consider using the app if forest fires were more frequent. Of the three people that answered neither likely nor unlikely, one responded that they were not sure if they would have the patience to download and use the app while in a panic because of the forest fire. Another one of these three answered along the same lines. They noted that since they are in an area with little forest fires, they would most likely not have the app on their phone and would probably not have the time to download it once they would need it. They did mention, however, that if they had the app that they would probably use it.

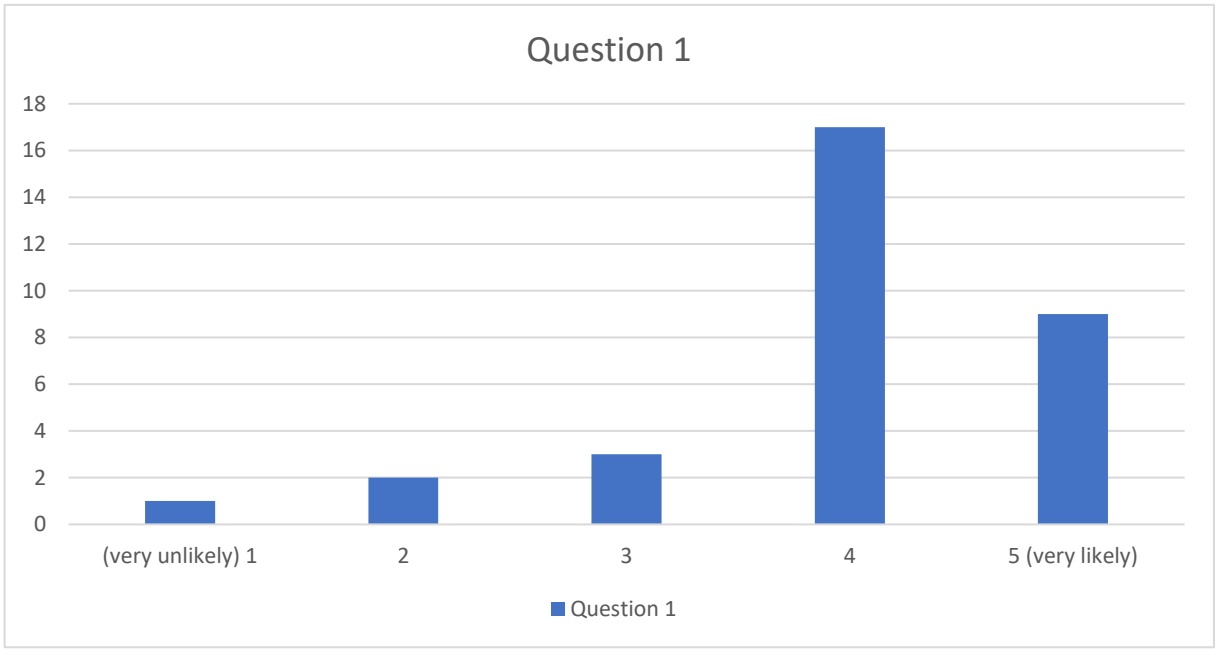


Figure 30: Results questionnaire app acceptance

Clarity of fire visualization

To determine the clarity of the fire's visualization the participants were asked two questions. These were essentially the same question, however the first question provided context for the second question. They were asked, twice, how clear it was that the different shades of red of the fire depicted the fire at different times (e.g. present, 15 min into the future, etc.). They were asked to rate its clarity on a scale from 1 to 10, with 1 being very unclear and 10 being very clear. The results can be seen in Figure 31. The question was asked twice to first assess how intuitive the visualization is and second to assess how clear the visualization is. Though the visualization is on the right track it is clearly not yet perfect. While most of the participants did recognize the different shades to be the different stages of the fire, they did not all recognize them convincingly and some not at all. When told what the shades of red represented, the score that was given only increased slightly.

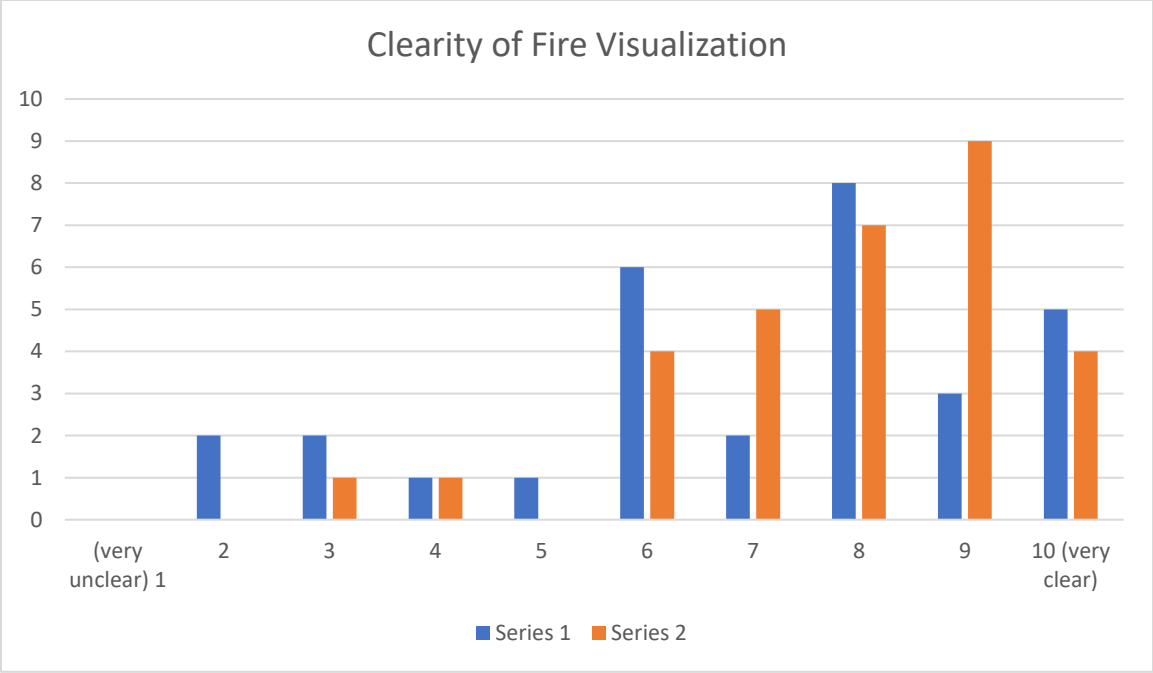


Figure 31: Results questionnaire clarity of fire visualization

Directional navigation

Next to the traditional type of navigation, turn-by-turn, the app also came with what has been coined throughout this project as directional navigation. Therefore, the next question was asked to evaluate if people would use this type of navigation and why they might or might not. To the question if they would see themselves use this alternative type of navigation, of which the result can be seen in Figure 32, the majority responded with no. When asked why, a common answer was that they would prefer a known type of navigation, especially in a stressful situation. Another reason that was given was that they expected the turn-by-turn navigation to give them shorter routes or that they themselves did not have good sense of direction so would rather rely on clear instructions. One participant also mentioned that they did not understand the concept.

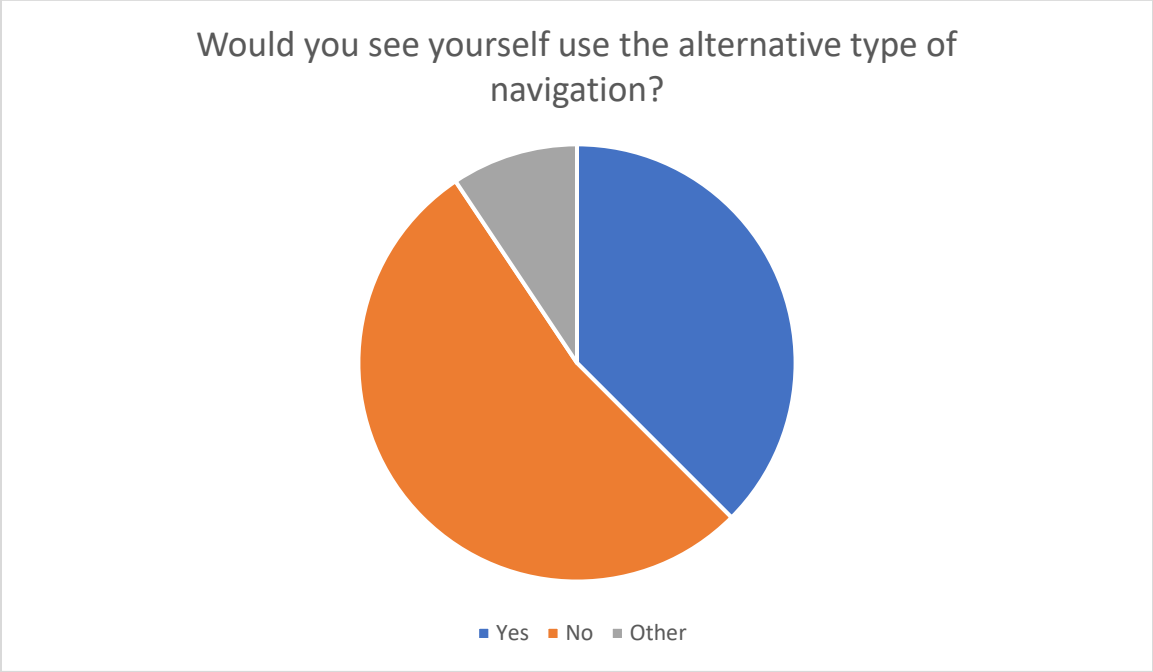


Figure 32: Results directional navigation question

Ease of use of UI

To examine what the participants thought of the ease of use of the app, they were asked to rate how usable it was on a scale of 1 to 10 with 1 being very unusable, confusing even, and 10 being very usable, straightforward. In this case the results from the hands-on questionnaire are examined separately as these participants got to use the app while the participants of the questionnaire only survey had to assess the UI through a screen recording. The results of both can be seen in Figure 33, with survey 2 being the hands-on survey. In general, the results are positive. None of the participants seemed to have found the UI confusing to use, with all but one giving it a 7 or higher. The remark made by the participant that gave the UI a 5 was that they did not understand was trying to tell them to do. Also, from their other answers they did not seem to have understood how the app is supposed to work. The response from those participants that got to use the app was also positive, with two giving a score of 10 and one a score of 7. Two of the participants did remark that it was not entirely clear that the *Show map* button would lead them to the map and, more importantly, eventually to the navigation. One of them suggested changing the text to something along the lines of *Start navigation* while the other suggested to have the app start on the map interface rather than the home screen. There were also a few remarks from those that had to evaluate the UI through the screen recording. Two of them remarked that the buttons could be made even bigger or more striking.

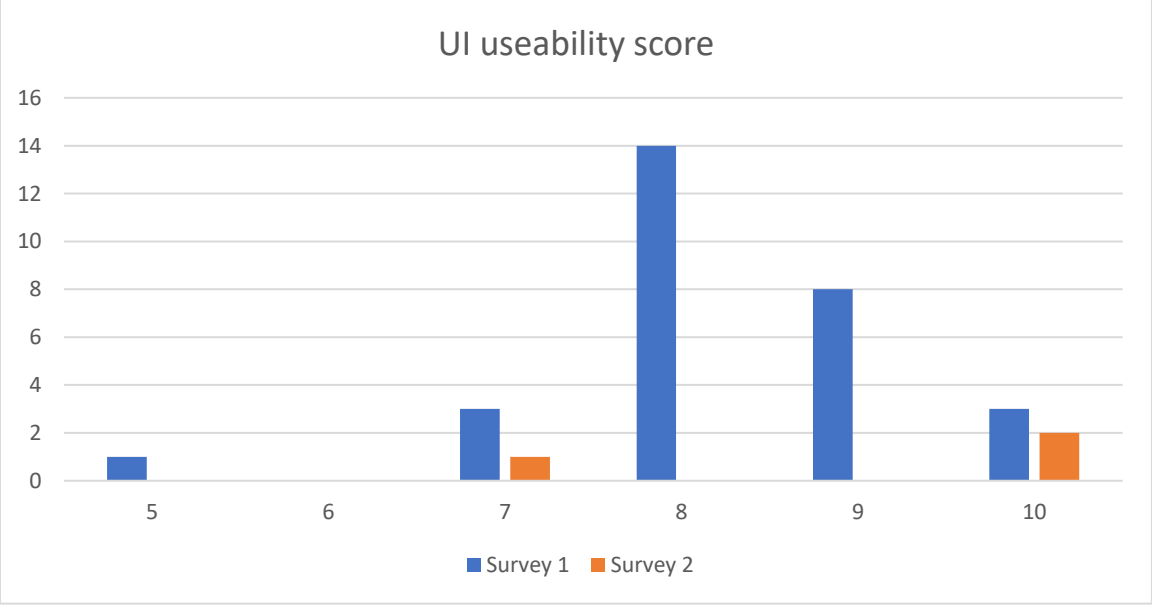


Figure 33: Results assessment ease of use UI

Feedback

The last two questions asked the participants for more general feedback. What they liked or dislike about the app. What they wished to see added, removed, or changed. This resulted in a lot of valuable feedback which has been boiled down to the list below. This list also includes feedback given in the previous open questions.

Improvements to the fire visualization

- Use shades of red with greater contrast or different colours altogether for the different time frames of the fire.
- Add a legend.
- Have the fire be animated, like *Buienradar* does with weather forecast (to show the fire expanding).
- Have time stamps right next to the fire.
- Have a heat gradient in the fire to show the severity of the fire.
- Something to show how dangerous the fire is, or the smoke generated by the fire.
- When zoomed in on the phone's location, where the fire is not visible, have an indicator that shows to which direction the fire is located.

Navigation improvements

- Allow use with other navigation apps (e.g. Google maps).
- Show traffic on the map.
- Have multiple routes to choose from.
- Have the app start on the map rather than a separate home screen (like how other navigation apps, like *Google maps* or *Waze* for example, start).

Other

- Include other hazardous situations (smoke, toxic air, etc).
- Provide an explanation of how the app works.
- Include an option for parents to keep track of where their kids are.
- Some general information/tips on the home screen.
- More modern GUI.
- Notifications for when the fire is nearby.
- Indication of how likely it is for the fire to reach my house.
- For people 40+ text could be bigger.
- Change the text of the *Show map* button (e.g. *Next*)

Overview

In general, the app was well received. Most participants would see themselves using the app, in case there was a fire nearby, and none of the participant found the user interface confusing. One area that could use some improvement is the way the fire is visualized in the app. Here not everyone agreed about how clear the visualization was. There were some great suggestions to improve this, however. These ranged from using different colours and a legend to having the fire be animated to show how it is spreading. The UI, though rated as being pretty straightforward, also had some suggestions for improvement. There were also some compliments found throughout the comments, from a simple "*Nice app"* or "*Good job"* to more elaborate comments. Overall, the evaluation provided lots of good and valuable feedback to consider in the next step of the app's development.

Chapter 8 – Conclusion

The goal of this graduation project was to develop a prototype mobile application to help people escape wildfires near them. This is especially important since the frequency of these wildfire is only projected to increase due to climate change [6]. When examining the state-of-the-art other mobile apps were found that provided information about hazardous situations nearby and even one that was being developed to help people in the Netherlands help evacuate in case of flooding. However, no existing apps were found that provided their users with information about a nearby wildfire and navigation to get them away from said wildfire. Throughout this project a prototype wildfire escape app has been built. This was accomplished using the following research question: “How to design a mobile application to help evacuate people endangered by a forest fire?” To help answer this question two sub questions were asked: “What tools are required to create such a mobile app?” and “What does a functional user interface for a forest fire escape app look like?”. The prototype that was developed using the answers to these questions, was evaluated and feedback was gathered for possible future versions. In the evaluation the app was well received and seen as easy to use. There were also enough points the participant pointed out that could use some improvement.

Chapter 9 – Future Work

During this bachelor project there was only time to implement a few of the many features that were envisioned. Moreover, during the evaluation even more features and improvements were uncovered. This alone would leave enough work to be done in further development of the app. However, not only the app has to be developed further also the integration with the model must be worked on. During the realization of the prototype, the model had not yet reached a state where it could be attempted to integrate it into a complete solution. Luckily, there seems to be progress on that front as well. Once improvements have been made the product has to of course be tested again. Wat is more, not just the interface will have to be tested, as it was in this project, but also the routes that the app generates will have to be thoroughly tested, in conjunction with the fire prediction model, before the system made available to the public.

Appendix 1 – Survey 1

Survey: Escape WildFire mobile app

by Wouter Couwenbergh (w.couwenbergh@student.utwente.nl)

* Required

About the survey

Over the past couple of decades the amount of wildfires has been steadily increasing. Not only in Australia and the US but also in Europe. Moreover, the frequency of these fires is projected to increase due to climate change. Therefore, there is a high chance that more people will be faced and endangered by forest fires in the coming years.

The aim of this graduation project is to develop a mobile application that helps people escape from wildfires. It does this by using a model of the fire (which is being developed in a separate graduation project) to predict how the fire will progress and based on the fire's progression the app will calculate an escape route away from the fire.

The hope is to gather valuable feedback on the prototype through this questionnaire . This feedback will be used to improve the app wherever possible in order to provide people with the most complete system to help them escape wildfires.

You can participate in this survey if you are at least 18 years old. Participation is entirely voluntary. You can indicate at any time, without giving any reason, that you no longer want to participate in the study. You can decide until at least 24 hours after participating in the study that you still want to have the data deleted.

Which data is collected?
All the data will be collected through the questionnaires. This will include some general information about yourself, such as age.

How is the data stored?
The data is processed as anonymously as possible (for example, any IP addresses are removed after the data collection phase) and stored securely according to AVG guidelines. Research data is stored for at least 10 years according to VSNU guidelines.

Who has access to the data?
The questionnaires and later interviews are accessible to people involved in this research. A list of names of people who have access to the material is available and can be requested from Wouter Couwenbergh.

How is the data used?
The data is analyzed for its use in the graduation project. This will include a thesis that will be submitted to the University of Twente and might be publicly available.

Will information about me be made public?
The materials will not be shown publicly or made available without permission. The material will not be used for promotional purposes unless explicit separate permission has been given for this.

Can I have my data deleted?
If you decide during or immediately after the activity that you do not want to participate (anymore), all data from that session will be deleted. This is in any case possible up to 24 hours after the activity. For this we need to know what time you participated, we kindly ask you to include this in the request for removal. When all sessions have been completed, the data (further anonymised) from that session will be permanently added to the research data and can no longer be deleted.

Informed Consent

As a participant of this research I hereby declare the following:

1. *

Check all that apply.

☐ I hereby declare that I am fully informed about the research. The purpose of the research and the methods have been explained to me, and I have had the space to ask questions.

2. *

Check all that apply.

☐ I understand that I can end my participation at any time, without giving any reason, without any consequences (including later in the school year). This can be done up to 24 hours after participating, please indicate the time of participation.

3. *

Check all that apply.

☐ I give permission for the collection and use of data with regards to the research. I understand that this data will be collected and processed in such a way that I remain anonymous.

4. *

Check all that apply.

☐ I allow to make the anonymous research materials collected when participating in the study publicly available

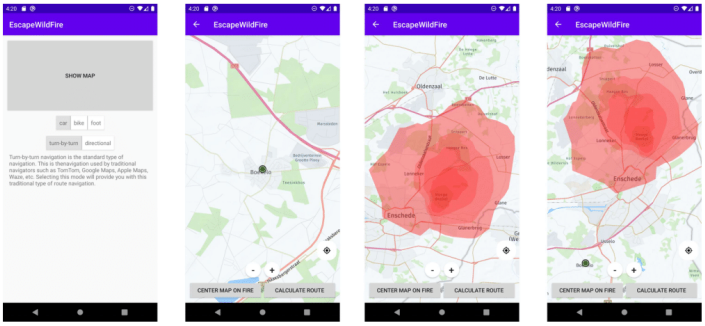
Survey: Escape WildFire mobile app

The app

About the app

The aim of the app is to help its users get away from a nearby wildfire safely and quickly. As mentioned before the app will accomplish this through the use of an online model of the fire that will predict the fire's progression. Using these predictions a safe escape route can be calculated. To make this evacuation as optimised as possible the app will allow its users to choose their mode of transport. The plan is to also offer an alternative way to navigate, other than the standard turn-by-turn navigation offered by for example Google maps (more on this later). Below you can find some screenshot of the current prototype to get a first impression of the app. These are screenshots of the home screen, the map and the fire that is being displayed on the map.

Home screen and map view



5. If this were a completed app, how likely would it be for you to use it (assuming there is a fire nearby)?

Mark only one oval.

	1	2	3	4	5	
Very unlikely	◯	◯	◯	◯	◯	very likely

6. Please explain why or why not you would use the app *

7. How clear was it to you that the different shades of the fire represented different versions of the fire, with dark being the fire right now and the lighter shades the fire further into the future? *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very unclear	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	very clear

8. Now that you know that the different shades of red represent the fire at different stages throughout time, how clear is the fires progression? *

Mark only one oval.

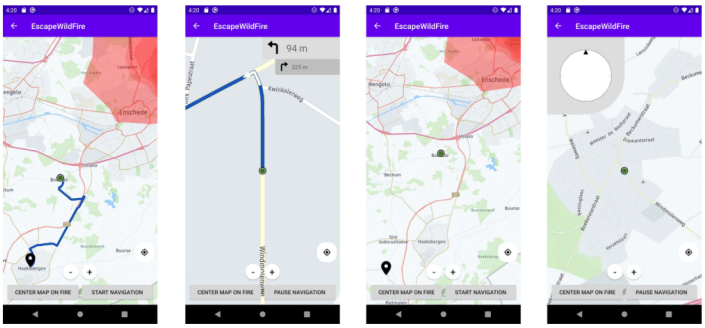
	1	2	3	4	5	6	7	8	9	10	
very unclear	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	very clear

Alternative way to navigate

In the explanation about the app another type of navigation was mentioned, this would be a directional type of navigation. Rather than show when to take which turn, also called turn-by-turn navigation, this type of navigation is rather simple. The idea is that the only things that will be provided are the phone's current location, the destination and a heading that points to the destination at all times.

Both of these types of navigation can be found in the screenshots of the prototype below. From left to right the screenshots are: an overview of the calculated route for the traditional turn-by-turn navigation, the view of the turn-by-turn navigation, a view of the destination calculated for the directional type of navigation, and the view of the directional type of navigation.

Turn-by-turn and directional navigation views



9. Would you see yourself using the alternative type of navigation? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____

10. Why or why would you not use the alternative type of navigation? *

_____

_____

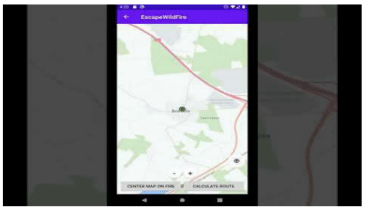
_____

_____

_____

App navigation

One of the aims of the app was to keep all the navigation of the app as straightforward as as possible. The video below shows some of the features of the map like centring the map on the phone's location or on the fire's location. It also shows the steps needed to get the navigation started, whether this is the turn-by-turn or directional type of navigation.



http://youtube.com/watch?v=llERSXr874g

11. From what you are able to see in the video, how would you classify user interface of the app (the layout of the buttons, the steps you need to take to start a certain action, etc)? *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very unusable, confusing	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	very usable, straightforward

12. Is there anything you wish to mention with regards to the user interface of the app? If not, you can leave this blank

13. As of right now the app is still very much in development and only the essential features have been implemented. What are your thoughts about the app so far? *

14. What would you like to see added/removed/changed?

Survey: Escape WildFire mobile app

General information

15. What is your gender *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Prefer not to say

16. What is your age *

Mark only one oval.

- 18 - 25
- 26 - 35
- 36 - 45
- 46 - 55
- 56 - 65
- 66 - 75
- 76 - 85
- 86 and older

Survey: Escape WildFire mobile app

Thank you for taking the time to fill out this survey! If you wish to stay in the loop of the app's development (e.g. for further testing or for when it is released), please leave your email address below

17. E-mail

Appendix 2 – Survey 2

Survey: Escape WildFire mobile app

by Wouter Couwenbergh (w.couwenbergh@student.utwente.nl)

* Required

About the survey

Over the past couple of decades the amount of wildfires has been steadily increasing. Not only in Australia and the US but also in Europe. Moreover, the frequency of these fires is projected to increase due to climate change. Therefore, there is a high chance that more people will be faced and endangered by forest fires in the coming years.

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Check all that apply.

☐ I hereby declare that I am fully informed about the research. The purpose of the research and the methods have been explained to me, and I have had the space to ask questions.

2. *

Check all that apply.

☐ I understand that I can end my participation at any time, without giving any reason, without any consequences (including later in the school year). This can be done up to 24 hours after participating, please indicate the time of participation.

3. *

Check all that apply.

☐ I give permission for the collection and use of data with regards to the research. I understand that this data will be collected and processed in such a way that I remain anonymous.

4. *

Check all that apply.

☐ I allow to make the anonymous research materials collected when participating in the study publicly available

Survey: Escape WildFire mobile app

For the researcher

About the app

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5. Number of interactions to reach the tbt navigation view *

6. Time to reach navigation view *

7. Remarks on reaching the tbt navigation view

8. Number of interactions to go back and change the mode of transport

9. Time to change mode of transport *

10. Remarks changing of mode of transport

11. Number of interactions to go back and change to directional navigation

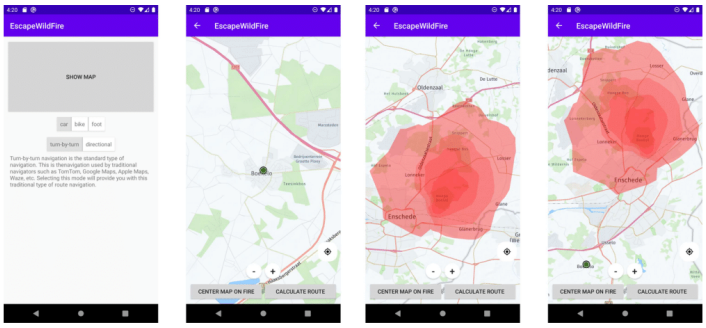
12. Time to change to directional navigation *

13. Remarks changing to directional navigation

Survey: Escape WildFire mobile app

The app

Home screen and map view



14. If this were a completed app, how likely would it be for you to use it (assuming there is a fire nearby)?

Mark only one oval.

	1	2	3	4	5	
Very unlikely	◯	◯	◯	◯	◯	very likely

15. Please explain why or why not you would use the app *

16. How clear was it to you that the different shades of the fire represented different versions of the fire, with dark being the fire right now and the lighter shades the fire further into the future? *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very unclear	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	very clear

17. Now that you know that the different shades of red represent the fire at different stages throughout time, how clear is the fires progression? *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
very unclear	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	very clear

Alternative way to navigate

In the explanation about the app another type of navigation was mentioned, this would be a directional type of navigation. Rather than show when to take which turn, also called turn-by-turn navigation, this type of navigation is rather simple. The idea is that the only things that will be provided are the phone's current location, the destination and a heading that points to the destination at all times.

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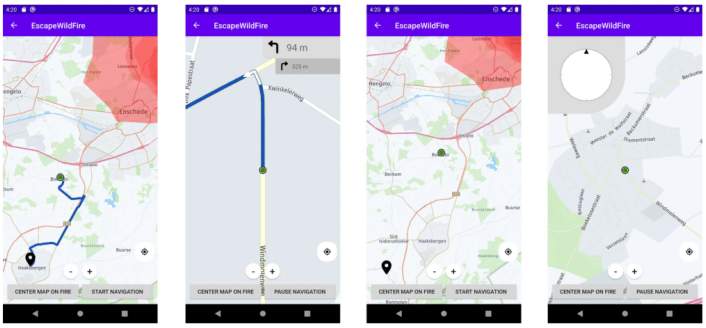
Turn-by-turn and directional navigation views



18. Would you see yourself using the alternative type of navigation? *

Mark only one oval.

- Yes
- No
- Other: _____

19. Why or why would you not use the alternative type of navigation? *

_____

_____

_____

_____

_____

20. From your experience of using the app, how would you classify its user interface (the layout of the buttons, the steps you need to take to start a certain action, etc)? *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very unusable, confusing	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	very usable, straightforward

21. Is there anything you wish to mention with regards to the user interface of the app? If not, you can leave this blank

_____

_____

_____

_____

_____

22. As of right now the app is still very much in development and only the essential features have been implemented. What are your thoughts about the app so far? *

_____

_____

_____

_____

_____

23. What would you like to see added/removed/changed?

Survey: Escape WildFire mobile app

General information

24. What is your gender *

Mark only one oval.

- Male
- Female
- Prefer not to say

25. What is your age *

Mark only one oval.

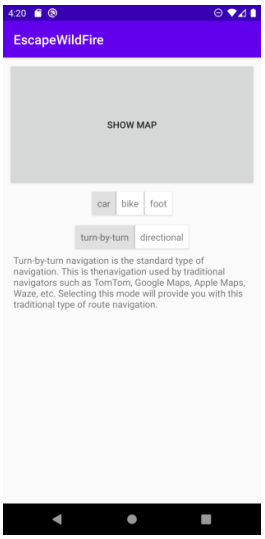
- 18 - 25
- 26 - 35
- 36 - 45
- 46 - 55
- 56 - 65
- 66 - 75
- 76 - 85
- 86 and older

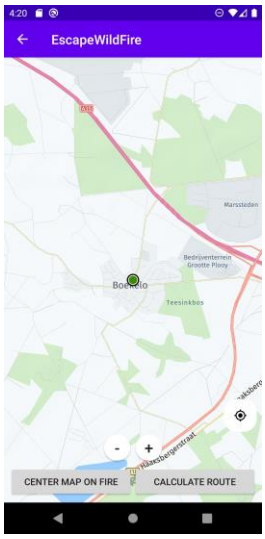
Survey: Escape WildFire mobile app

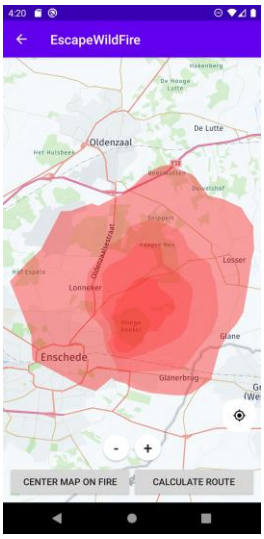
Thank you for taking the time to fill out this survey! If you wish to stay in the loop of the app's development (e.g. for further testing or for when it is released), please leave your email address below

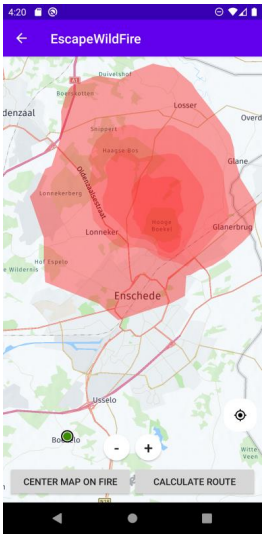
26. E-mail

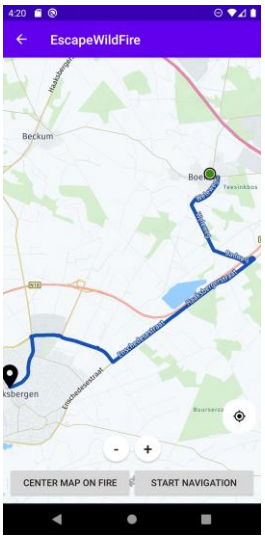
Appendix 3 – Screenshots

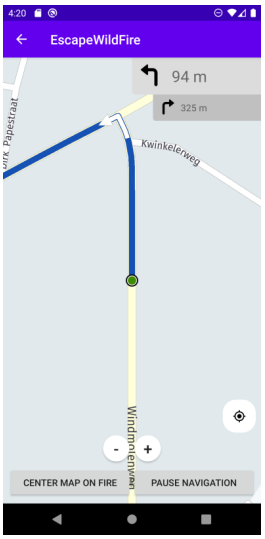


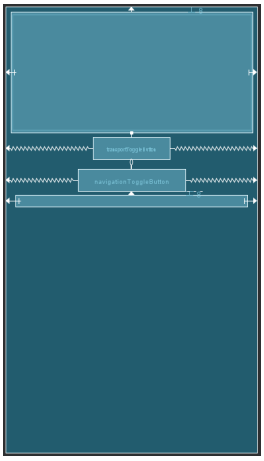


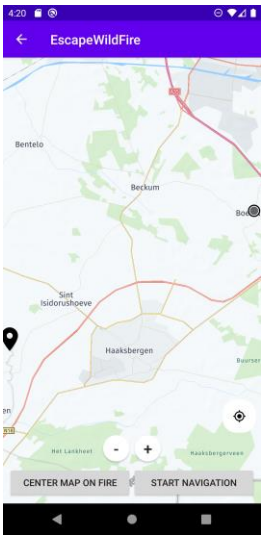


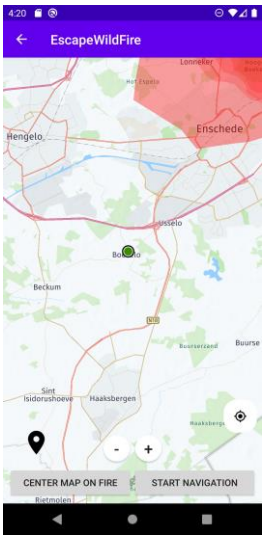


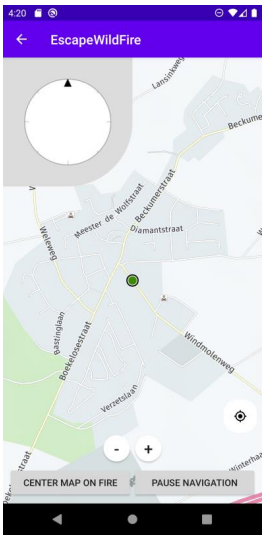


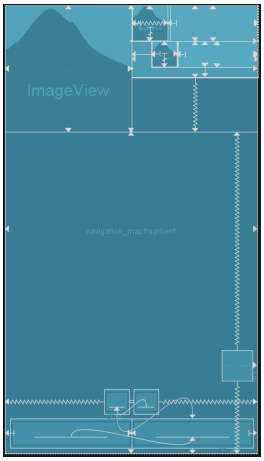












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