**INTRODUCTION**

So PlugMap is a route planning android application designed for EV owners to try and reduce range anxiety, which is the fear of running out of charge before getting to a destination.

**BACKGROUND INFORMATION ABOUT ELECTRIC VEHICLES**

Electric vehicles are still somewhat new, and it’s only been in recent years that they have grown in popularity. This is due to several things like battery improvements which will increase trip distance, fast charging technology that allows Evs to be quickly charged. And the overall need for government to reduce their fossil fuel emissions. For example, the UK aims to have zero emissions by 2030. As you can see in figure one battery electric vehicles have drastically gone up since 2019 due to the global shift towards more sustainable transport. However, there are still gaps within the market and lots of improvements that still need to be made like the charging infrastructure. Infrastructure takes a long time to develop and a lot of funding. There is still a scarcity of charging stations especially in rural environments that don’t have lots of funding. The UK government are putting lots of money into developing infrastructure and creating rules and incentives to adding charging sockets to your homes. For example, every new home in the UK now must have an EV charging point. However, this still takes time to implement. This is why it is important to have an effective route planning algorithm that can navigate a user to their destination with a charging station on route. This will combat the infrastructure issues. An algorithm that is specifically designed to reduce range anxiety would be beneficial for the whole EV market as it would increase people’s opinions about electric vehicles.

**THE PROBLEM STATEMENT**

The problem statement that is being addressed in this project can be split into 5 different categories, each shedding light on various aspects of the challenge at hand. Firstly, we have range anxiety. This is the fear an individual experiences when they worry about their electric vehicle’s battery running out before reaching their intended destination. Studies indicate that a driver will start to face range anxiety when the vehicle hits the 30% battery threshold. Secondly, we encounter the current gaps in EV route planning. Despite the availability of navigation system for electric vehicles, there’s a notable absence of route planning algorithms designed specifically to alleviate range anxiety. Thirdly, we must address the infrastructure gaps in the electric vehicle charging network. Limited charging stations and lengthy wait times contribute to the overall unease drivers feel about relying solely on electric powered vehicles. The fourth category revolves around consumer hesitation. Range anxiety acts as a significant deterrent for potential electric vehicle buyers, complicating the transition to electric vehicles despite their numerous benefits. Lastly, we cannot overlook the environmental impacts associated with range anxiety and the transition to electric vehicles. Embracing electric vehicles is essential for reducing carbon emissions and addressing the urgent need to mitigate climate change. As you can see within figure 2 it shows that combustion engine cars double the range of electric vehicles it is important to note that this was created in 2021 and battery technology has greatly increased since then. By understanding and addressing each of these categories, we can take steps towards overcoming range anxiety and accelerating the transition to a cleaner, more sustainable transportation future.

**PROJECT AIM & PLAN**

The aim of the project was to develop an android mobile application to reduce range anxiety using routing algorithms & real-time charging infrastructure data. The user interface needed to be clean and minimal which could be used by a variety of different age groups. At the start of the project, I created a simple Gantt chart that can be seen in figure 3. This Gantt chart allowed me to get an understanding of how the project would unfold although the Gantt chart was not followed to the T it still gave me a good understanding of the milestones ahead.

**INNOVATION (ALGORITHMS USED)**

There were 2 algorithms that were implemented into the final product. The first algorithm was the midpoint algorithm which was the main decision maker in the product. It started out by finding the midpoint between the start location and the destination and draws a large radius around this point. It then filters through all the chargers within this area until it finds one that is compatible with the user’s vehicle and is open for use. Once it has filtered out all the chargers that the algorithm deems not necessary. It shall then find the closets charger to the start point within the midpoint radius that is on route to the destination removing unnecessary travel time and diversions from the planned route. Within figure 4 you can see a simple diagram of the algorithm at work. The algorithm would then work out if the trip was feasible by calculating the total distance and how far the car can travel. This is done by multiplying the cars total battery capacity by the current battery percent then multiplying that sum by the efficiency of the vehicle which would be miles per kWh. If the trip is not possible it shall notify the user before driving has begun to waste less time. It is important to note that when a car hits a charging station the battery shall be updated to 100% again as the car should now be charged. The second algorithm is used for emergency cases if the car battery is super low. Instead of finding the midpoint it shall divert the driver to the closets possible charging station that is compatible with the vehicle you can see this in the figure 5 diagram.

**INNOVATION (REAL-TIME INFORMATION & USER INTERFACE)**

Two different APIs were used to collect real-time data. The google direction API was used to find the fastest routes from A to B. And the Open Charge Maps API was used to collect real-time data of chargers like there compatibility their availability and their status. Using these 2 APIs played a significant role in the development of the application as it was the main way that data was collected and pass through the algorithms to get a route. The user interface that was implemented was successful in being simple to navigate. The following UI features were implemented:

1. Pill information boxes that show the user what their charge will be at the arrival destination, how many miles to the destination & the time it will take to get to the destination excluding time to charge.
2. A blue polyline that displays over the map to navigate the user to the destination.
3. Destination and charging markets displayed on the map.
4. Search functionality that allows the user to search for an address.
5. And finally, a settings page where you can select the cars socket type, change its current charge percentage, and modify the cars efficiency in miles per Kwh.

**APPLICATION DEMO**

Begin application demo.

**EVALUATION OF THE PRODUCT**

The product and the current algorithms that were implemented work correctly and successfully reduces range anxiety. However, the algorithm could be improved on as there are a few flaws. For example, currently we do not check real-time traffic data which could impact battery life as the car could be idling for longer than usual. Information about gradients is also not available which could be important as the car motors will use more energy going up hills and less going down. During the development phase of the midpoint algorithm, I came up with a better way of finding a charger. However, because I was already halfway through the development phase I would have had to delete lots of work and might have not been able to complete the project on time. So, I decided not to implement it. However, this algorithm was much more suitable as it uses two radiuses that would be drawn around the start location and the selected chargers. The outer radius would be the max distance the car could travel, and the inner radius would be 20% less that the outer radius within this zone would be the most optimal chargers. The closer the charger to the inner radius and the destination the more optimal it would be for range anxiety. As studies have shown that range anxiety starts to occur when the battery hits roughly 20%. Once a charger is selected it would then do the same for the next charger on the on route until the destination has been reached making sure that it is impossible to run out of charge. If a charger could not be found within the 2 radiuses the algorithm will increase the zone by 10% until it finds a suitable charger. You can see a diagram of the algorithm in figure 6. The UI was also successful in being simple and easy to use. However, there was a few hiccups in the settings page as I thought when designing the application that there were only 3 different socket types. When there is over 50+ this made selecting a socket type a little more complex than I would have wanted it to be. Every other UI element was successfully implemented though. Apart from the following 3 that were considered too complex and could not be done due to time constraints.

1. Voice Navigation.
2. Different turning signal prompts with signs & speed limits.
3. Full tracking the car to the destination.

Overall, the current product does solve the problem statement, but it could be improved on with the following things I have said above.

**CONCLUSION**

In conclusion the implemented algorithms an UI element works as intended. Although there are some flaws that could be improved on. The application demonstrates reliability and proves that the concept of a route planning algorithm to alleviate range anxiety does in fact work. The original wireframes do differ slightly from the product, but the general idea was still brought across with a simple and non-distracting UI for drivers. I think that the product does fit the product specification well.

**QUESTIONS**

Any questions?