Theia: Navigation for the Blind

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Project Summary

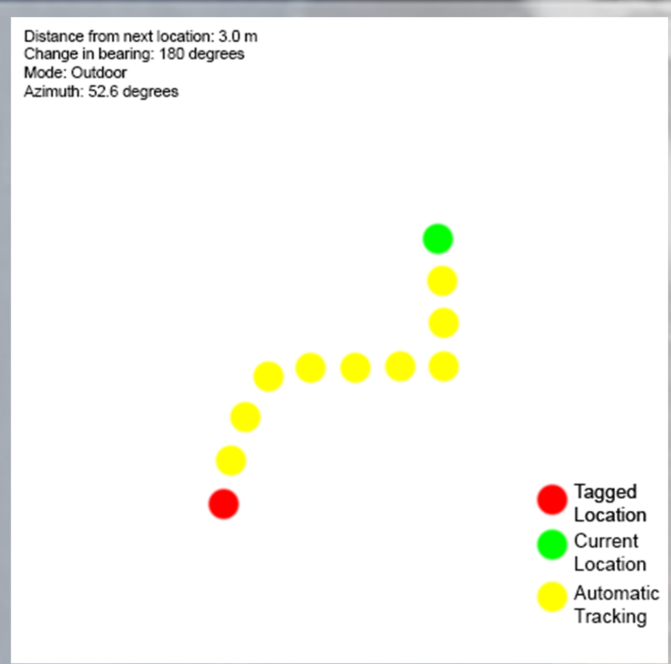
A general sense of direction and orientation is something that many people take for granted every day, but this is not the case for those with sensory impairments, specifically a visual impairment. When you have a visual impairment, day-to-day tasks like going to the beach, park or going to the shops can be a daunting activity. Theia: Navigation for the Blind is a project which is focused on designing and creating an Android mobile application that can be utilised by the visually impaired to make their day-to-day life easier and boost their confidence at the same time.

The application is developed in Java, using Android Studio with the help of the Google location API and voice API. Voice control and haptic feedback are primarily utilised by the user to communicate with the application. Features of the application include constant path tracking by geolocation, step detection, storing points of interest, navigation assistance toward different points of interest, voice control and an indoor or outdoor mode option. The application aims to provide user location accuracy up to 2 meters with a return to point accuracy of 3 meters on average. Future improvements include creating a partnered smart watch application and gesture detection.

2.0 Objective

The aim of the application at the most basic level is to tag a location that is a point of interest and then continuously track the user's movement every three meters. Once the user wants to return to the tagged location, they simply speak "return" to the voice controller and the application will guide them back.

This is done by the the application guiding the user to the nearest tracked location walked previously. This is represented by the the green dot being the current location and the yellow dot the next location to be moved towards. This process will continue until the user is back at the red dot which represents the tagged location.



The above image is a debugging system designed in order to make sure that the guidance instructions, sensors and location data was correct to what was physicaly happening while walking. It also allowed us to have a visual representation of the journey to the tagged location and effectively analyse it.

3.0 System Overview

3.1 Hardware

The hardware of the system is the Android mobile device that the application is installed on. It is essential as it provides many important sensors and features such as accelerometer, step counter and GPS which is required for the software to process the user's movements.

3.2 Software

The software of the system comes in to play when the location data comes in from the hardware, it then processes the tagged location, the user's current location and constant storing of movement from the tagged location to the current location in an array list. This is done in Java with the use of Android Studio. Some algorithms implemented include Kalman Filter, as well as different modes for indoor and outdoor use.

3.2.1 Kalman Filter

The Kalman Filter implemented in the system is used to predict an estimate of the next location and evaluate the accuracy of the location read in by the device. This is useful as it checks how trustworthy the resulting location is.

3.2.2 Indoor Mode

Indoor mode is executed by using the step detector to count steps and estimate how far the user moves and in which direction as the information is processed and stored.

3.2.3 Outdoor Mode

Outdoor mode uses location data from the device to track and store the user's movements and store points of interest as geolocation, ie. latitude and longitude.

4.0 Results

Location Accuracy	Paid API (20 test average)	Google API (20 test average)	Step Counter (20 test average)
Indoor Accuracy	15 meter radius	18 meter radius	4 meter radius
Outdoor Accuracy	5 meter radius	3 meter radius	4 meter radius

GoogleAPI	Location Accuracy	Battery Usage
20 ms / High Accuracy	Medium	Low
50 ms / High Accuracy	Medium	Low
100 ms / High Accuracy	Very High	Medium
200 ms / High Accuracy	Very High	High
20 ms / Low Accuracy	Very Low	Very Low
50 ms / Low Accuracy	Low	Very Low
100 ms / Low Accuracy	Medium	Medium
200 ms / Low Accuracy	Medium	Medium
Our Optimal Settings	Very High	Medium

PaidAPI	Location Accuracy	Battery Usage
20 ms / High Accuracy	Medium	Medium
50 ms / High Accuracy	Medium	High
100 ms / High Accuracy	High	Very High
200 ms / High Accuracy	High	Very High
20 ms / Low Accuracy	Very Low	Medium
50 ms / Low Accuracy	Low	Medium
100 ms / Low Accuracy	Low	High
200 ms / Low Accuracy	Medium	High

The above tables of results show different methods of gathering location data and compares them against eachother. Tests were run based different levels of accuracy and update frequency to determine which balance of the two would be best suited for optimal experience as well as optimal battery usage.

The results were analysed and it is seen that the Google API would be used for outdoor movements and tracking while the step counter would be used for indoor movements and tracking.

5.0 Conclusion and Future Work

Theia: Navigation for the Blind is a project that will change many vision impaired user's lives for the better. It will allow it's user to navigate around with confidence while getting day-to-day activities done.

The designed system provides a high returned location accuracy rate while tracking a user's current location accurate to a 2 meter radius. Battery usage is also optimal at a 0.1% per hour usage. The system is succesful in both indoor and outdoor settings but performs best in an open area as location data is most accurate with less interference. The step counter in indoor mode is also quite accurate after customizing the size of the user's step in meters.

Future work will include creating a smart watch partner application which will allow users to navigate and tag locations remotely and more comfortably from their smart watch. Another feature we hope to add is wrist gestures to trigger features in the application. For example, flip your wrist upside down to trigger a tag.

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