MS1: Ideation and Planning Report

NPS2001B: Eryn Lim En Yi (A0265301R), Hamamoto Sayuri (A0265893L), Ho Kai Liang Austin (A0251821M), Pandrangi Tamrita (A0257397L), Tang Ser Jen, Tiffany (A0255729R)

1. Problem

The real-world problem of accessibility in navigation is prevalent in our daily lives, and is felt most keenly by those with limited mobility. These can range from wheelchair users to people on crutches, or those with other mobility needs. In the NUS Faculty of Arts and Social Sciences (FASS) building cluster, individuals face difficulty in navigating buildings as they are connected mainly by stairs, and facilities like elevators and ramps are uncommon or inaccessible due to their obscurity.

Figure 1.1

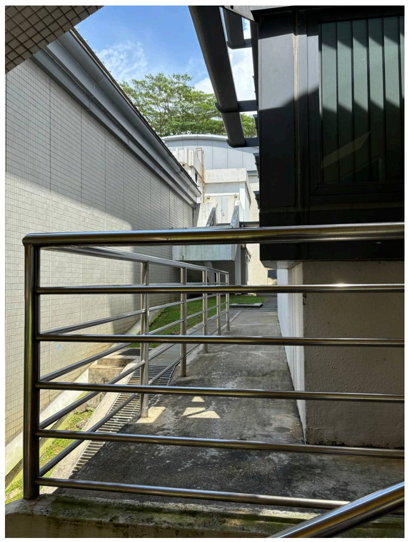

Figure 1.2

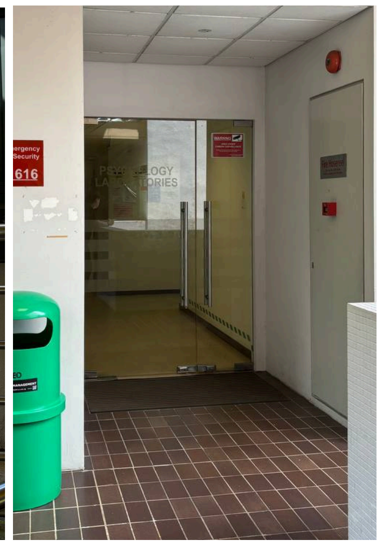

Figure 1.3

For example, Figure 1.1 shows a wheelchair-accessible ramp that leads to a parking area with a rocky path, which is not feasible for wheelchair-bound students and may be difficult for those with crutches to navigate. Figure 1.2 shows a path that allows students to cut across two buildings without using stairs, but it is too narrow to accommodate wheelchair users. Figure 1.3 shows the entry to a lesser-known path which allows one to skip stairs by cutting through the Psychology laboratories, but many students do not know that the path is viable because laboratories typically have restricted access.

Currently, FASS only provides a schematic to students with mobility issues, telling them which floors and buildings are connected so they can traverse them without using stairs. However, the nature and exact location of these paths is unspecified, so the map can be rather ineffective for students.

Addressing this problem is important because accessibility is a key design characteristic of inclusive social spaces in general, and educational institutions in particular. Catering to the needs of those with limited mobility helps possibly disadvantaged groups access the invaluable resource of education, which is crucial to a more inclusive, conducive, and diverse learning environment. It is our belief that being able to reach spaces of learning should be made as convenient and efficient as possible, especially in a society which prides itself on using education as a leveller for social mobility.

2. Our proposed application

Our app aims to assist users with limited mobility to ascertain the quickest and safest route to use when navigating to their desired location. In our case, we are mapping out the FASS buildings, which are notoriously difficult to navigate even for able-bodied persons due to the numerous flights of stairs, few hidden lifts, and buildings which connect at different levels. This app helps users plot the optimal route from points A to B in FASS, while accounting for various mobility needs and environmental conditions like wet weather which constrain the route (e.g. requiring an entirely sheltered route). The app will help solve the problem of navigation by identifying all possible access points—even the hidden ones—and taking away the stress of charting the quickest and safest path for a user with limited mobility.

3. Central algorithm for the application

We intend to use the A* search algorithm, a best-first search algorithm which identifies the shortest path from one node in a graph to another. Where Dijkstra's algorithm simply considers all possible paths, the A* algorithm incorporates a heuristic function, enabling it to perform informed searches by prioritising nodes judged to be better than others (Hart et al., 1968).

The algorithm would have to consider several inputs in our app. The nodes would include both access points like lifts which users would have to pass through to get to their destination, and the various starting/ending points in FASS such as classrooms and lecture theatres. The weights would include not just the horizontal distance and difference in elevation between two nodes, but also possibly the footfall data, width of pathways, lift wait times, and other measures of path popularity and subjective effort to travel between nodes on foot. The total cost of an optimised route passing through a given node n, $f(n)$, would be a simple sum of the cost to reach n, $g(n)$, and the cost estimated by the heuristic to get from n to the goal, $h(n)$ (Hart et al., 1968, p. 102). As a first pass, the heuristic function could use the Euclidean distance between nodes. As we consider other estimates of cost in developing our heuristic, we will have to ensure it satisfies the admissibility criterion of not overestimating the actual cost (Hart et al., 1968).

It is thus to our advantage that the A* search algorithm is well-documented on videos and blogs. While it is a step above Dijkstra's algorithm, requiring a moderate amount of coding ability, the mathematics needed to understand it is manageable.

4. User experience and potential issues

The app services users who aim to arrive at their lecture and tutorial locations on time, particularly when they want to estimate their travel time but face mobility restrictions which are unexpected (e.g. when injured and using a wheelchair for the first time). The target demographic would include students, faculty, staff, and administrators with limited mobility, and possibly even short-term visitors—in essence, anyone in need of navigating FASS.

One potential issue that could occur is high footfall along the routes that are accessible by those with limited mobility, thereby reducing time efficiency. Another issue could arise with temporary, real-time obstructions which occur spontaneously, such as renovations done on certain parts of the FASS buildings and elevator maintenance, etc. An issue around optimising algorithm run time is also a concern as we expect users to be in a time crunch moving from one class to another. Lastly, there is the issue of user privacy, where users do not want their mobility needs and navigation information retained in the app.

These can be addressed variously by altering the algorithm and heuristics used, as well as encrypting the location of users when running the algorithm and depersonalising sensitive user information regarding mobility (e.g. what mobility restriction they select in the app). We will continue to work to address these problems in the course of developing our application.

References

Hart, P. E., Nilsson, N. J., & Raphael, B. (1968). A Formal Basis for the Heuristic Determination of Minimum Cost Paths. *IEEE Transactions on Systems Science and Cybernetics*, *4*(2), 100–7. https://doi.org/10.1109/TSSC.1968.300136