INTERACTIVE 3D MAP GENERATION VIA OSM

ABSTRACT

The proposed project will include creating an interactive 3D map of Lancaster city centre and Lancaster University campus. To achieve this, OpenStreetMap's 2D maps and large database of objects with properties, such as height, will be used to generate a 3D environment that can be navigated through. This is important as it will help both new students and old students at the university to easily traverse both these areas in a 3D environment, as well as anybody who lives in or is visiting the area.

MOTIVATION

Over the past decade, smartphone ownership has increased from 66% to 99% for 16- to 24-year-olds and from just 19% to 82% for 55- to 64-year-olds [1]. With this, most services now have an online presence in some way, from shopping to media consumption and, of course, navigation. You can find almost any landmark, shops, and people's houses instantly at the click of a button. Navigation systems are so important to exploring and discovering unfamiliar places and apps like Google Maps make it many times more accessible. Google Maps stood as the fourth most popular mobile application in the United Kingdom in September of 2021, with an audience reach of 66.2% [2]. To put that into perspective, that is more than Facebook Messenger, Instagram, and Amazon, just to name a few [2]. This shows the reliance we have on navigation software to help us navigate our lives.

As smart devices have gotten more accessible over the years, the demand for navigational apps has increased. Solving navigational mapping issues for people that live rurally is especially tricky due to the lack of popularity of those places. For example, cities most certainly take precedence over towns and villages as seen by the way Apple releases new features to their Maps app [3]. Open-source mapping software allows for easy editing of the software which is perfect for residents of rural areas as they can keep the place they live up to date constantly.

OpenStreetMap is an open-source, collaborative project that aims to build up a database of information on every building, street, river, shop, and more, on the planet. If a user would like to contribute, all they have to do is sign-up and start contributing via a browser or a number of different applications. This makes it extremely accessible for people to use and give back to the community. On the 26th of October 2022, 257,094 'ways' (can be buildings, roads, rivers, etc) were added, 194,337 were modified, and 23,471 were deleted [4]. All these modifications of the database come from the contributors in a single 24-hour period.

For this project, the data needed to create a 3D map will come from OSM's large database of objects. Each object has a set of parameters; from these parameters, a 3D model of the area can be generated. This allows for the system to evolve as the database is updated. For example, a new computer science building could be constructed on the Lancaster University campus and this new building would automatically be added as a 3D object to the model with no intervention. Since Q4 of 2020, 70,856 new objects tagged as buildings have been added to the OSM database in Lancashire alone [5].

When it comes to traditional navigation apps, the default view for most of them is a top-down 2D view of the area. This is great for applications such as driving as you can see upcoming streets with ease

therefore allowing for better planning as you are driving. However, when it comes to walking this top-down view has little benefit as you are not travelling at speed and decisions do not need to be made in a timely manner as you do when driving. This is where a 3D perspective comes in. Generating a 3D interactive map grants the user a more realistic view of the buildings and area around them, allowing them to use specific buildings as anchor points to better connect themselves to their environment, thus helping to acclimatise new visitors/students of the areas.

For people that suffer with physical disabilities, movement can often be difficult and in their daily lives they often worry about issues, such as 'does this route have a ramp or and elevator?', and 'what type of pavement and road surface is there going to be?'. An interactive 3D map could help make these stressful questions easier to answer, alleviating some of the daily pressures they face.

For people that suffer with mental illnesses, such as anxiety disorder with agoraphobia, they often struggle with visiting unfamiliar places, especially places that are going to be busy, such as the university campus. An interactive VR 3D map may be beneficial to them as a research done into the efficacy of virtual reality exposure therapy on agoraphobic participants found a positive impact over their usual treatment [6]. This project is not a means of therapy but it may just give them a slight confidence boost that they know where they are going and what to look for, therefore, reducing their anxiety levels.

Currently, the OSM database is not fully populated with every parameter and object in the two areas. To improve the generated map, extra information will be added to the database. This will create a richer experience for the user, making identifying your current positioning based on surrounding structures easier. It will also make it easier to identify a specific building, for example, if the colour of the building is the same on the map as it is in real life.

Related Work

One of the main advantages of using an open-source mapping database for building 3D structures over Google Maps' and others implementation of using 360-degree images is that when somebody contributes to the database, whether a deletion or addition, the change will immediately be reflected on the map. This means that once the solution has been programmed, there is not much to be maintained. Whereas, with street imaging, if something changes in the real world, e.g., a building is demolished, those street images need to be updated otherwise the software will not reflect the real world.

A close example of what this project is aiming for is Robert Kaiser's VRMap. His implementation also uses OSM's map data to extrude a 3D model. There are quite a few limitations with his implementation, such as most buildings are the same colour, it can only load one place at a time, and there is no navigation feature. My implementation for this project will fix these issues.

Objectives

The focal objective for this project is to create a 3D model of Lancaster and the university campus from OSM data and then use that for interactive 3D navigation. However, this overarching objective can be broken down into seven sub-objectives:

1. Leverage OSM's map data and build a 3D model of the two areas.
2. Make this map interactable.
3. Make this system VR capable.
4. Identify weaknesses in the map data and rectify them by adding data to the database.
5. Implement a navigation system using the 3D model.
6. Conduct a user study on people and collect their thoughts.
7. Analyse the data and decide how well the system was implemented.

METHODOLOGY

For this project, an iterative prototyping approach would best suit its development. This is due to the fact that when new information is added to the OSM database, new structures will need to be programmed into the project and testing will need to be done. An agile approach would also have the benefit of being able to redesign the front-end of the website as to allow for a quick and easy front-end to be programmed at the beginning for testing purposes.

HTML and CSS will be used for the creation of the website. At the start of the project, a basic website will be developed. This will allow for more time allocation to the development of the actual 3D map.

For the 3D interactive map, JavaScript and A-Frame will be used. A-Frame is an open-source JavaScript web framework designed to display 3D shapes and to allow for easy integration of VR/AR experiences. This should allow for relatively easy implementation of the 3D buildings and other structures comprising the map. Attaining the OSM database will be done by querying 'Overpass API'. This API is a read-only API that serves custom areas of the OSM map data. This data will be used and a 3D model will be generated from it.

The method used for adding new data to the OSM database will be done through a combination of an iOS application named 'Go Map!!' and OSM's own online editing software. The reason for using both is that 'Go Map!!' only allows for the addition, deletion, and editing of points of interests and their parameters, such as a bicycle parking bay and whether it is undercover, whereas the OSM website allows for every type of edit. The reason for not solely using the latter is that it is much more difficult to operate than the application is due to the spacing of the website. The application uses OSM's database to display a detailed map of the area and uses a simple interface to allow for easy additions to the database.

The user study will consist of 8 participants. This will give me a reasonable spread of information to collect from each of them without being too difficult to find that many people. Each will be given access to the interactive map. They will then be instructed to find and navigate to three specific buildings on campus. After this, they will complete a questionnaire. The questionnaire will contain mostly qualitative questions, such as, "how did you feel about x feature?", "what did you feel about the UI?", "would you say the 3D view made it easier to explore/find your way?".

PLAN FOR ANALYSIS

For the user study, mostly qualitative questions will be asked, such as how the user felt about certain aspects of the system. To get a greater range of data to analyse, quantitative measurements will be

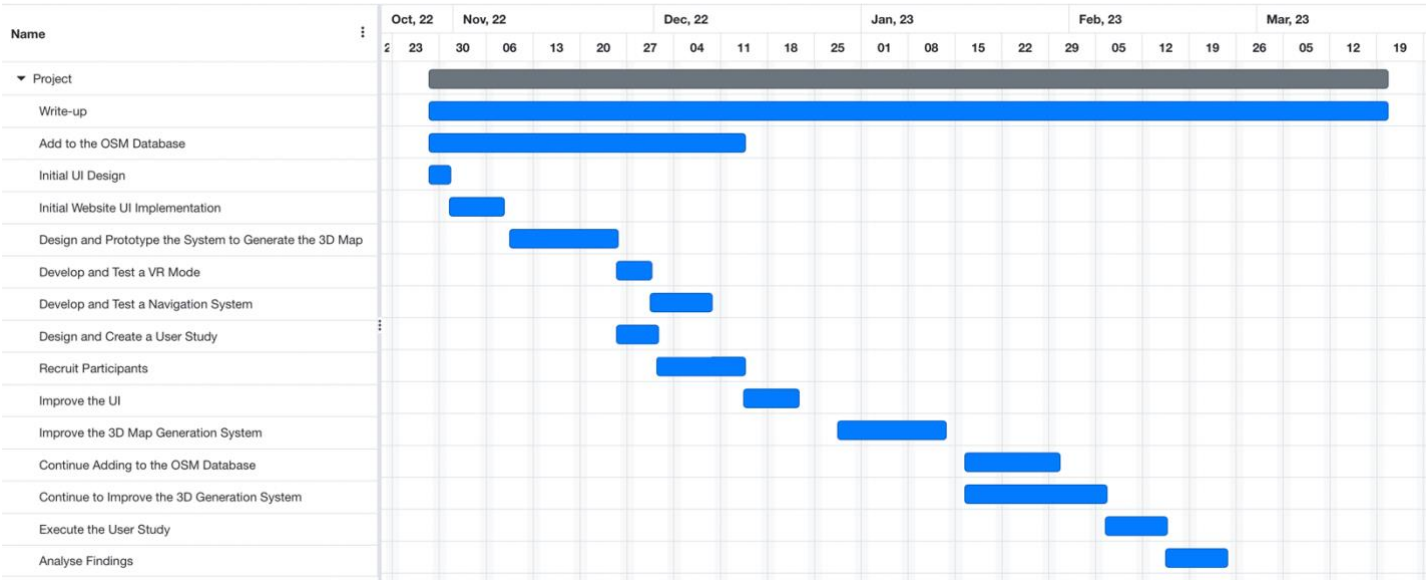
taken, such as time to find a route. Analysis of both these types of data will help demonstrate whether a 3D environment better helps people navigate rather than a 2D birds-eye view.

Overall Workplan

The project will run from late October 2022 to the 24th of March 2023. Step-by-step workplan:

- **Initial UI Design –** From the 28th of October 2022 to the 31st of October 2022, the UI will be designed via digital sketches.
- **Add to the OSM database –** From the 28th of October 2022 to the 14th of December 2022 (will be an ongoing objective), travel around the university campus and the Lancaster city centre area and update the OSM database. Updates will include new structures and updates to already existing structures, such as colour.
- **Write-up –** From the 28th of October 2022 to the 20th of March 2023 (ongoing objective), slowly complete the write-up over the weeks.
- **Initial Website UI Implementation –** From the 31st of October 2022 to the 8th of November 2022, the UI of the website will be created, using HTML and CSS. The UI only needs to be functional at first to allow for the 3D map generation to take precedence.
- **Design and Prototype the System to Generate the 3D Map –** From the 8th of November 2022 to the 25th of November 2022, design and prototype the system that will generate the 3D Map and then make the map interactable.
- **Develop and Test a VR Mode –** From the 25th of November 2022 to the 30th of November 2022, program a toggle so that the user may view the map in virtual reality. This will be done via the A-Frame framework.
- **Develop and Test a Navigation System –** From the 30th of November to the 10th of December, develop and test a navigation system.
- **Design and Create a User Study Design –** From the 26th of November 2022 to the 1st of December 2022, create a user study design.
- **Recruit Participants –** From the 1st of December 2022 to the 14th of December 2022, the recruitment of participants will take place.
- **Improve the UI –** From the 14th of December 2022 to the 22nd of December 2022, update the UI to improve its ease of useability and appearance.
- **Improve the 3D Map Generation System –** From the 28th of December 2022 to the 13th of January 2023, code in the ability for the generation system to add new structures or parameters that will have been added over the past term.
- **Continue Adding to the OSM database –** From the 16th of January 2023 to the 30th of January 2023, continue making additions to the OSM database.
- **Continue to Improve the 3D Map Generation System –** From the 16th of January 2023 to the 5th of February 2023, continue to code in the ability for the generation system to add new structures or parameters that will have been added over the past term.
- **Execute the User Study –** From the 5th of February 2023 to the 15th of February 2023, execute the user study.

- **Analyse Findings –** From the 15th of February 2023 to the 24th of February 2023, analyse the findings from the user study.



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