A case study of visualising environmental monitoring data: Northumberland Street Regeneration

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1. Introduction

This project explored using 3D gaming software to present geographical information. The aim was to develop a workflow to visualise environmental monitoring data from Northumberland Street, Newcastle upon Tyne, in a 3D gaming environment.

Figure 1: One of the ten air quality sensors located on Northumberland Street.

2. Data Collection

Air quality data was measured using ten sensors located along the length of Northumberland Street, one of which is seen in Figure 1. The sensors were deployed as part of the Urban Observatory project being run by Newcastle University. The Urban Observatory project is the UK's largest collection of publicly accessible, real time, urban data. Since the sensors are part of the Urban Observatory's network of sensors, all the data, both live and historical, was accessible through their website, in reasonably easy to use formats. Each sensor measured ten variables: Temperature, Particle Count, Humidity, Pressure, Nitric Oxide, Nitrogen Dioxide, Ozone and three size categories of Particulate Matter (10, 2.5 and 1 micrometres in diameter and smaller).

3. Data Processing

Using the Python programming language, the data was accessed from the Urban Observatory website through an application programming interface (API) and pre-processed. The pre-processing step required converting the data into the correct format for the processing stage, in terms of both the spatial metadata, defining where each sensor was located, and the non-spatial attribute data, which gave the values of each air quality variable at each location.

With the data in the correct format for processing, an inverse distance weighted (IDW) interpolation was performed to calculate the air quality value for each area between two sensors. This was an important step because it turned the discrete sensor data into a continuous dataset. Interpolation, as a method, fits with Tobler's First Law of Geography: "everything is related to everything else, but near things are more related than distant things". Finally the data was processed into a format suitable for use in the visualisation stage.

4. Data Visualisation

To generate the visualisations in 3D gaming software, the award winning Unreal Engine 4 (UE4) was used. In this project, the air quality data was entered manually into UE4; however, it would be possible to automate this process if the project was to continue.

In order to provide a sense of location, a city model was used. The city model is called Virtual Newcastle Gateshead (VNG) and was put together by the VRV Studio at Northumbria University. Whilst the VNG model gives a sense of location, it does not have any textures to the model, meaning that the end-user has to use local knowledge to work out where they are in relation to shops, etc. In order to counteract this limitation, a sample block of buildings at the northern end of Northumberland Street was chosen to trial texturing methodologies, the chosen outcome from which can be seen in figure 2. Photographs of the building facades were taken using a semi-professional DSLR camera. Using specialist photograph editing software, corrections were applied to compensate a number of distortions present, such as perspective, as seen in figure 3.

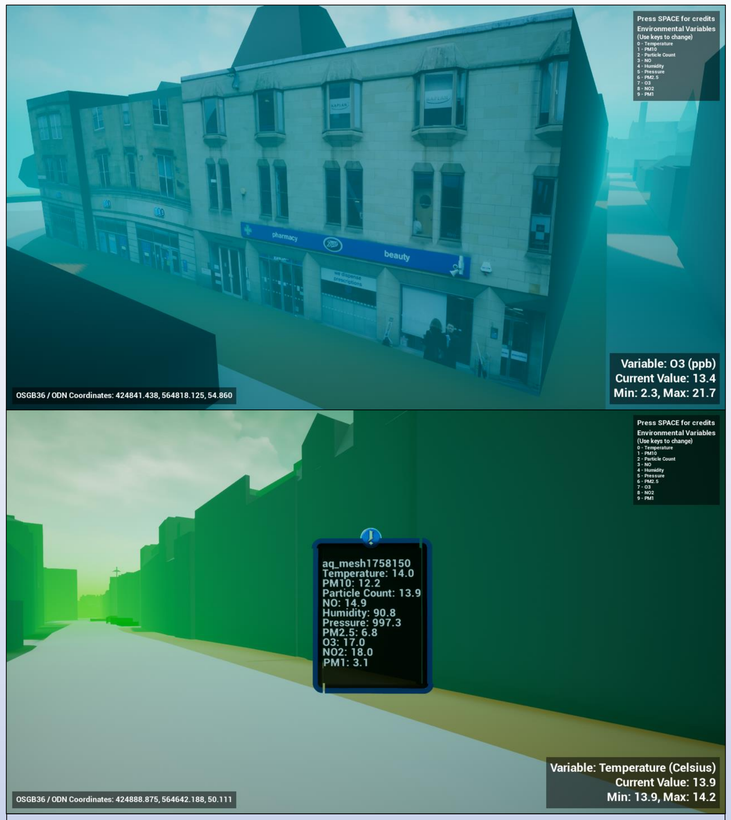

Figure 2: Screenshots of visualisation gameplay from UE4. Top – sample block of textured building facades located at the northern end of Northumberland Street. Bottom – information pop-up box for one of the ten sensors, showing air quality data.

Figure 3: Example results of the correction performed on the facade photographs. Left - pre-correction. Right - post-correction.

4. Data Visualisation (cont.)

Another method to portray information in the game was the use of pop-up boxes, or commentary boxes, at each sensor location, providing further information about the observations at that location.

To visualise the environmental variables, a fog effect was used. The main method of differentiating different levels of the variables was to use colour. Two colours, to represent the minimum and maximum of each variable, were chosen with other values being a colour between these. As a more subtle method of displaying the levels the fog density was set as a function of the value in relation to the minimum and maximum.

5. Discussion

When deciding what gaming software to use, a few were trialled for their ease of use and interoperability, with UE4 being chosen. Whilst it was hoped that the project might complete the project using solely open-source software, UE4 is not open-source; however, it does make all of its source code freely available, and it is free to use, only charging a royalty on certain revenue earning projects, which would not affect a project like this. UE4 was also chosen for its cross-platform capabilities and ability to use visual coding, also known as Blueprints.

Owing to time constraints, the photographs of the building facades included the occasional passer-by. Due to the nature of photography, to capture the facades in the best lighting meant going out during the peak of the daily footfall. Another problem was with the corrections to the photographs, with some of the corrections not being complex enough, meaning distortions were still present, as seen in the middle of the sample block in figure 2. If this was to be repeated, more complex corrections would probably be more suitable; however, that would involve using a more specialist, scientific camera.

If this project was to be continued and become publicly accessible, such as being integrated into the Urban Observatory website, more advanced features of UE4 could be utilised. The city model could be developed to make the buildings and overall terrain much more photo-realistic.

A major limitation came from the VNG model, because of the modelling technique chosen. The model is based on roof information, extruded down, meaning that building facades and overhangs are not accurately modelled.

Another limitation was that the fog colours are not clearly defined to the end user. An improvement to this would be to include a clear graduated colour bar to ensure the colours are easier to interpret.

6. Conclusions

In conclusion, the project successfully developed a workflow for environmental monitoring data to be visualised using 3D gaming software. Whilst numerous limitations and improvements were identified, these are all things which are able to be refined if the workflow is to be used in the future.

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