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# A Participatory Approach to Develop Missing Geospatial Data Visualisation

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**Abstract:**

Missing and incomplete data may result in flawed conclusions and understanding of reality. Having a visualisation strategy that can make the users and decision-makers aware of the lack of data can bring attention to such hidden uncertainties. This study aims at evaluating the users' perception of missing data in an experiment using augmented reality technologies to have a better understanding of the best visualisation strategies for missing geospatial data.

Missing data arises from the absence of expected data in a dataset, while it might be just as significant as data that we have (Hand, 2020). It may pose a great threat to obtaining the results from data (McKnight et al., 2007). Because incomplete data are so common, observation, modelling, imputation and being aware of missing data have received attention by researchers, in particular in statistical analysis (Hartley and Hocking, 1971). Visualisation of missing data can help communicate the existence of such uncertainties, raise awareness regarding the flawed conclusions, and to do more data exploration (Templ et al., 2012). This paper focuses on the communication and visualisation of missing data, so the users become aware of the absence of data and the uncertainty associated with incomplete data. This requires having a good understanding of how the users perceive missingness. Depending on how missing data is presented to the users, the significance of the impact on people's perceptions and decision-making can be observed.

The cognitive perception and preferences of the users about how missing data can be communicated have been subject of several (Andreasson and Riveiro, 2014, Song and Szafir, 2018, Twiddy et al., 1994). However, they have been limited to non-geographic data that are missing. Andreasson and Riveiro (2014) examined the effect of visualisation of missing data on decision-making systems. It has been revealed that three different visualisation techniques used emptiness, fuzziness, and emptiness plus explanations affect decision-making and decision confidence. A study was conducted by Song and Szafir (2018) to evaluate how the process of visualising missing data might have implications for making inferences about the perception of data quality and confidence in study results when performing data analysis. It has been observed that designs that represent missing data will greatly affect the perception of nature of data and the level of reliability. Twiddy et al. (1994) eliminated the distraction that can occur in the visualisation of missing data by using the technique of matching the missing data with pseudo-colours and grayscales.

In this research, we aim to visualise missing geospatial data using augmented or virtual reality technologies using some devices such as HoloLens which is 3D perspective holographic glasses with a holographic processing unit (HPU) and a graphics processing unit (GPU). Mixed reality can add information on top of the existing data and allow the user to interact to explore more about the environment that they cannot see. Several recent studies have shown that augmented reality, mixed reality, and virtual reality are important technologies used in 3D visualisation and communicating invisible or additional information allowing the users to "see" what is useful or missing.

Augmented reality (AR) is a technology that combines 3D virtual objects and a 3D real environment (Azuma, 1997). Augmented and mixed reality technologies help us to combine the virtual world with the real world, in which 3D models and audio data or video streams of the real world can take place (Farshid et al., 2018, Eve, 2017). It is thought that visualising missing data with this technology can contribute to the literature because instead of perceiving 3D Geographic Information using a 2D computer screen, presenting it to GIS users with a 3D holographic perspective using mixed reality glasses helps users to use a real 3D GIS by changing their perception and interaction (Wang et al., 2018, Wang et al., 2019).This study will evaluate and measure the perception of the participants with respect to the missing data in indoor environments using AR as the basis of the visualisation of missing geospatial data. We have designed a pilot area using Sketchup (Figure 1a). These designed indoor spaces were transferred to the Unity3d game engine, and after the necessary


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coding steps using C# to allow interactivity of the 3D models, they were transferred to the HoloLens2 deviceThis 3D visualisation has visualised some missing parts of some objects, such as one arm of the chair and part of the chair leg to measure the perception of users, as shown in Figure 1a, but the change in the colour (Figure 1b) and patterns indicate there are missing parts and so the users are expected to be aware of missingness or invisible parts of the models which are blocked. Although there are some missing parts of 3D models, if they are not available or the "unknown unknowns", they are able to distinguish them too . In addition to the colours, we plan to allow graduated level of transparency and interaction (Figure 1c) to observe the perceiving of users for these differences and missingness using HoloLens. The application will be limited to the users' interaction with the models that are included in this experiment.

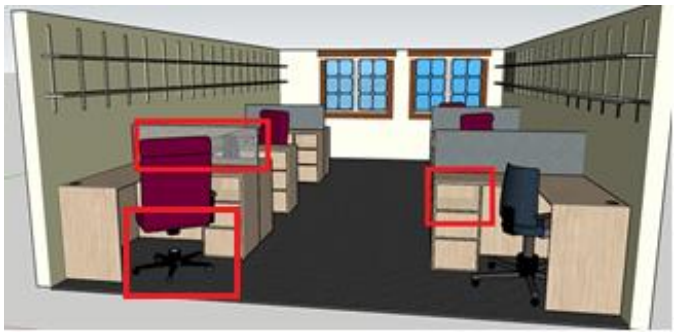

Figure a

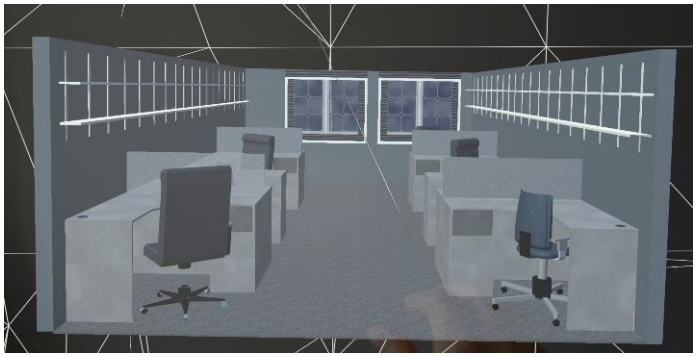

Figure 1b

Figure 1c

The survey, to be conducted in the summer 2022, will provide the users with interactivity in real-time using the HoloLens device. With this technology, it will be observed to what extent the users' understanding and perception of missing data will be compared to the real world in a controlled way. This helps us to observe the user behaviour in response to the two scenarios where the parts of the environments that are not visible because they are behind some 3D models, depending on the user's position while using this device, as opposed to the unknown unknowns and what are the most effective ways of visualisation to distinguish the two. Based on this study and literature studies, it is planned to visualise missing geospatial data in 3D using different imputation techniques and present it to the user in a way that will enable user interaction.


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