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Cartographic Visualisation within Immersive Virtual Environments

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Abstract:

Lately, cartography has begun its shift towards the use of immersive virtual environments (iVEs) and virtual reality in general (Medyńska-Gulij et al., 2021); be it in the case of visualisation of geospatial data (eg. Carbonell-Carrera et al., 2018; Quach, Jenny, 2020; Yang et al., 2019), or interaction with maps within iVEs (eg. Dong et al., 2020; Satriadi et al., 2020; Yang et al., 2018). This represents a "new frontier" in the field of cartography that has not been thoroughly explored yet. One such area of interest that we can identify are multivariate mapping methods that encode multiple data variables using multiple cartographic visual variables and can, in the case of point symbols, change their dimensions (or dimensions of their parts), form, or notable features (examples of such methods can be found in Slocum et al., 2005). Due to their nature, these symbols can be represented as either 2D or 3D objects.

However, these methods have been mostly used in non-immersive mediums that do not allow for true 3D visualisation, free user movement along all three axes of the 3D space, or any advanced user interaction; nor has there been any research done regarding their suitability for use in iVEs. Thus the fitness of each individual method and its usability in iVEs may vary (even compared to their "traditional" use in 2D). The main factor that could influence the fitness of these methods is the concept of "six degrees of freedom" mediated by VR HMD (virtual reality head-mounted display) (the ability to move forward/backward, left/right, and up/down while simultaneously being able to tilt one's head) which can change the perspective through which we assess the visual stimuli and therefore can influence the way we perceive, compare, and discern particular objects from one another. This can in turn highlight certain methods preferable to others. The virtual environment also allows for possible increased interaction with visual stimuli.

The main goal of this study is to present and analyse the user differences and limitations of perception of different 3D multivariate symbol methods in iVEs. The study consists of: 1. Initial research of scientific papers concerning this topic. 2. Design and conversion of selected multivariate symbols into 3D (examples can be seen in Figure 1.). 3. Creation of an iVE with tasks focused on work with various 3D multivariate point symbol methods (for example finding a symbol with the highest/lowest/specified value of a given variable) (Figure 2.). 4. An experiment in iVE with several tasks aimed at determining the differences and limitations of perception of different 3D multivariate point symbols conducted with the use of a VR HMD (with user interaction logging). 5. Analysis of the acquired data followed by the conclusions and recommendations as to which multivariate mapping methods should be considered when visualising data in iVEs, or even possible modifications of said methods for the use in iVEs. This is still a "study in progress", but results are expected to be available in mid-2023.

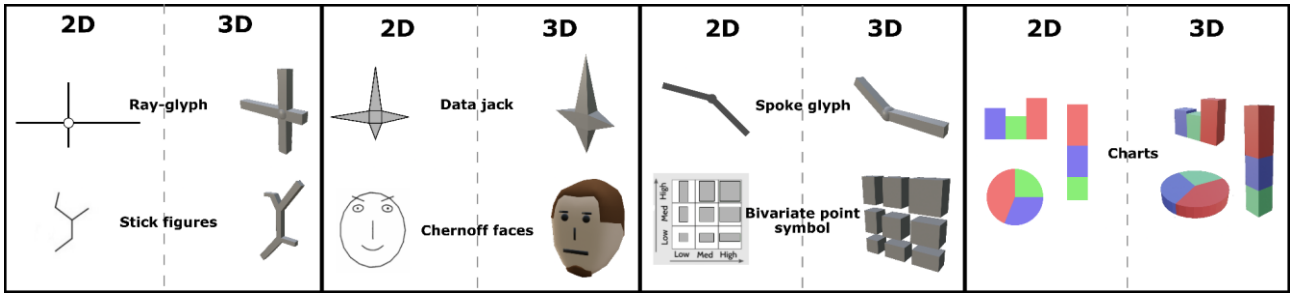

Figure 1. A model example of different 2D multivariate symbols and possible 3D equivalents.

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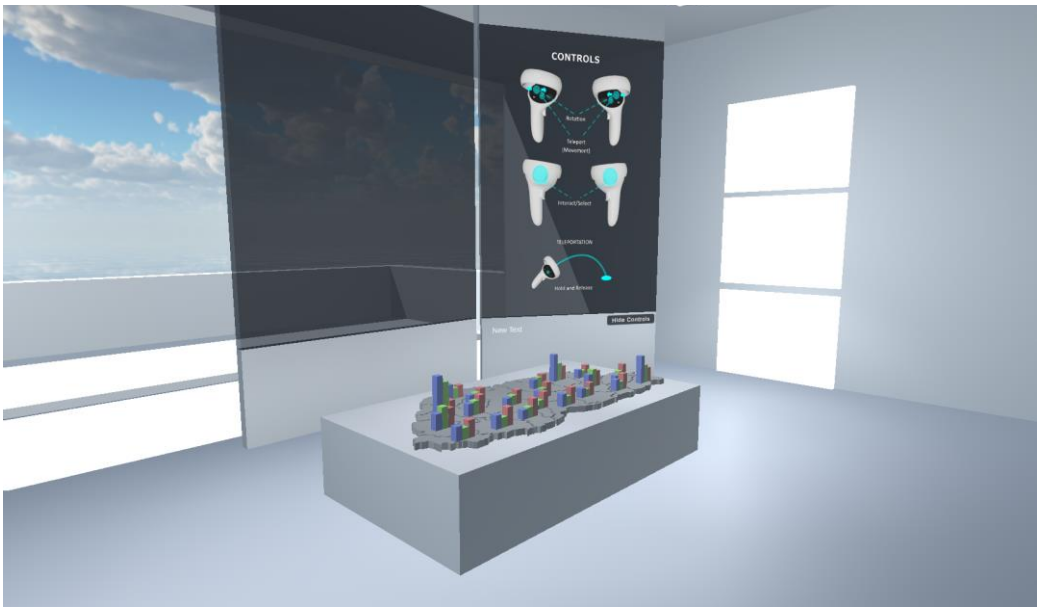

Figure 2. An early design of the iVE used for the experiment along with model data.

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