Using eye tracking to assess the effectiveness of geovisualisations for multidisciplinary decision making in environmental engineering

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Abstract

Within large engineering consultancies, multi-disciplinary projects are common, incorporating large volumes of varied and volatile high-dimensional data, usually geospatial in nature, and often containing some uncertainty. Environmental Impact Assessments (EIAs) are legally embedded in engineering practice as an EU directive, use a combination of data types, sourced from numerous disciplines. These provide information for stakeholders, including planners, local authorities, and the public, in projects which affect neighbourhoods, districts, and landscapes. Contemporary geovisualisations can incorporate and leverage use of the outputs from a variety of analysis and models, enhancing multidisciplinary decision-making processes inherent in all engineering projects.

Although sometimes overlooked in industrial practice, geovisualisations act as formal communication tools for improved map and spatial understanding, reducing potential loss of information within the design and analysis flowline (MacEachren *et al.*, 2005). It is important to consider geovisualisation as a critical element of the whole information retrieval and decision-making process in EIA. The EIA process requires assessment of the likely significant environmental effects arising from proposed development, in a systematic, data-informed system, ensuring a reduction in risk of damage to the environment (UK Government, 2011). Much of the data generated for EIA is processed through analytical models, meaning there are margins of error and uncertainty present in the data, and subsequent. Traditional cartographic methods can be effectively applied to the representation of such uncertainty (Maceachren *et al.*, 2012), such that the viewer can enhance information about the data, rather than just observe location and attributes allowing for relationships and patterns to be uncovered.

This study will look at user interaction within a standard working environment for decision making situations, with an aim of understanding how different users interpret and make decisions based on spatial data in an EIA simulation. This will include the order in which users look at data, what information they use to make their decisions, and any other requirements which would help them come to a more informed result. Users will be presented with three different scenarios in an online interface, presenting three discrete decision-making scenarios covering typical arenas where EIA is applied in engineering consultancy: a rural study relates to flood risk, an urban example addresses traffic risk near a school, and an environmentally sensitive area must consider environmental risk from the construction of a new cable route. In each case, the effectiveness of the visualisation, the realism of the scenario, the impact of uncertainty, the nature of the user interaction, the variability of the audience/test subjects, the undertaking of EIA, and the tasks performed and decisions made, will be studied.

Eye tracking using the *Tobii X2-30* will be the main method used to evaluate user interaction. Such experimental testing reflects vision as the strongest of the senses in humans, revealing both physiological eye movements and also reflecting a subconscious representation of the user's internal thoughts (Çöltekin, Fabrikant and Lacayo, 2010). Unlike some user interaction testing methods, eye movement recordings do not rely on self-reporting, and can thus be considered objective, as well as

being used to enhance traditional performance tests (Goldberg and Kotval, 1999). Figure 1 below demonstrates how non-invasive and discrete the *Tobii X2-30* is when installed on a laptop. Eye tracking, plus the recording of keyboard and mouse clicks and recording of screen images, will be monitored to understand the user's subliminal interaction with the data. Once data is collected from 30 – 40 employees with a variety of backgrounds (in terms of decision making role within the consultancy) the eye tracking data will be analysed through established areas of interest (eAOI), used to categorise the points of gaze (where the user looks), fixation time (how long they look for), fixation count (how many times the user looks at the same object) and saccades (the movement of the eye from one fixation point to another), through *Tobii Pro Studio* software. Capture of associated screen and keyboard interactions will also be incorporated, with statistical tests being used to establish the significance in the results.

Figure 1 – The Tobii X2-30 installed on a laptop (Tobii Pro, 2018).
Available at: https://www.tobiipro.com/product-listing/tobii-pro-x2-30/

It is hoped that the results from this study will help assist engineering consultancies, allowing for collaboration between teams, and streamlining of decision making, resulting in better practice. Leading into future work this study is a foundation for informing the best practice for decision-making using spatial data in environmental engineering consultancies. In addition to EIA and the role of visualisation, this form of user testing and interaction study will incorporate aspects of cognition and understanding of risk. By considering each one of these throughout the study, a knowledgeable approach will allow for identifying issues and establishing best practice for common industry tasks, allowing for an informed and well rounded project with usable and adaptable outcomes.

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