

# **Adapting the Design of Thematic Information for Miniaturised Non-photorealistic 3D City Models to Users Cognitive Skill of Visual Attention**

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## **INTRODUCTION**

Non-photorealistic rendering (NPR) applies artistic techniques to computer graphics. Much technology-driven research focuses on the optimisation of rendering methods to reduce computational effort. Only few cognition-based studies investigate the potential of non-photorealism to effectively represent geographic information. Based on psychological characteristics of visual attention and cartographic design principles, we propose a cognitive design approach that aims to support users in processing relevant information in 3D city models on miniaturised displays.

## **THEORETICAL BACKGROUND**

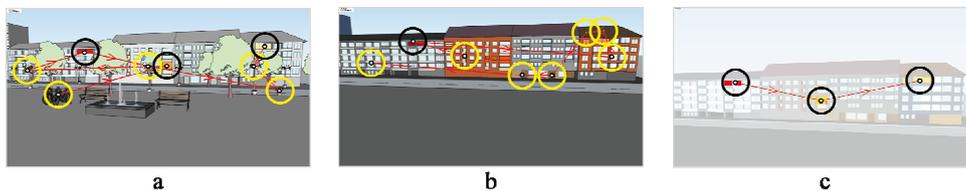
Our research is based on a neurocognitive design approach that relates external information design to user's internal visual information processing abilities. The fundamental objective is to precisely adapt the design of 'where' and 'what' information characteristics (locations and semantics) to brain area functions along cerebral 'where' and 'what' information processing pathways. This dual route cortical network converges into association brain areas. Accordingly, the approach aims to support users in promptly locating (where) and correctly decoding (what) relevant information to enable effective decision-making (how). Here, we concentrate on optimising the design of relevant locations. To tackle this challenge, we follow a visual scanning efficiency model that relates information complexity to performance-oriented cognitive workload models. Correspondingly, we reduce information complexity to release the cognitive workload and optimise the visual performance respectively.

## **DESIGN METHODOLOGY**

In a first step, we retrieve as much information as needed but as little as possible by means of relevance-based filtering methods. In a second step, we follow the thematic map design principles 'simplicity' (reducing visual complexity), 'visual hierarchy' (organising and structuring information into visual layers), and 'conciseness' (designing important information in a salient way) to design effective visual feedback. One fundamental characteristic of the design methodology is the artistic principle of figure-ground segregation to stimulate the biological centre-surround mechanism that dissociates objects from the background. To code the relevance classes of filtered information, we make use of the variables 'hue', 'saturation', 'value', and 'size' that are supposed to be appropriate for coding ordinal data. The design methodology aims to provoke fast and accurate execution of eye movements.

## EVALUATION

For a proof of concept, we evaluate three design cases representing three relevant accommodation units of interests that are displayed in a non-photorealistic 3D city model from the street-level of view. Case 1 represents unfiltered information following the design methodology. Case 2 displays filtered information neglecting the design methodology. Case 3 represents the design approach and visualises filtered information following the design methodology. We evaluate these design cases with a computational saliency-based attention model (Itti et al., 1998). The model simulates the biological centre-surround mechanism by computing differences between fine and coarse scales. The focus of attention scans the visualisation in the order of decreasing saliency and helps to predict possible scan paths and gaze fixations) as illustrated by figure 1. As a result of the evaluation, case 3 reveals the most favourable visual scanning pattern. The model accurately predicts the locations of relevant units in the order of decreasing relevance values if (1) we reduce information complexity based on relevance-based filtering, and if (2) we adapt the design of filtered information to the cognitive skill of visual attention.



**Figure 1:** a) Case 1 represents unfiltered information following the design methodology. b) Case 2 displays filtered information neglecting the design methodology. c) Case 3 represents the design approach and visualises filtered information following the design methodology.

## CONCLUSION AND OUTLOOK

The hypothesis of this work is that combining relevance-based filtering and cognition-based design can support users in locating relevant information in non-photorealistic 3D city models on miniaturised displays. On the theoretical basis of psychological characteristics of visual attention and a visual scanning efficiency model, we show that it is favourable to combine relevance-based filtering methods with cognition-based design.

We also show that thematic 2D map design principles may optimise the design of relevant information in 3D non-photorealistic visualisations. We hypothesise that our approach contributes to the release of the cognitive workload to optimise the visual scanning performance of users, i.e. users apply faster and more accurate sequences of gaze shifts to detect information of interest.

However, multiple research questions remains to be discussed. We consider the effective balancing of information as of particular importance. To visually separate relevant information from context information we envisage (a) to define stimulus thresholds for information complexity between focal and global information, (b) to define stimulus thresholds for salience degree between focal and global information, and (c) to identify cognitive dependencies between information complexity and salience degree.

## BIBLIOGRAPHY

Itti L., Koch C. and Niebur E. (1998), A model of saliency-based visual attention for rapid scene analysis, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 11, 1254–1259.