The role of hill-shading in tourist maps

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Abstract. The paper is focused on eye-tracking evaluation of two variants of Czech online tourist maps.
Terrain in the first type of maps was depicted with contour lines and elevation points only. In the second type of maps, visualization was enhanced by hill-shading. The purpose of the case study was to evaluate if the hill-shading helps users with better imagination of the terrain. The experiment was complemented with a short questionnaire focused on users' subjective opinion about suitability and aesthetics of both map types.
The task was to find out one particular place (village or hill) in the map as fast as possible and mark it with the mouse. Two aspects were investigated - if hill-shading helps users to find the hill, and at the same time, if the hill-shading make it more difficult to find the village.
The data were analysed statistically and with the use of visual analytics methods. Preliminary results denotes that respondents prefer shaded maps from the aesthetics point of view, but there is no statistically significant difference for any of used eye-tracking metrics. The results of the study will answer the question, if hill-shading used in tourist maps helps users to perceive the terrain better.

Keywords: Shading, Tourist maps, Eye-tracking, Cartography, Evaluation

1 Introduction

Lot of visualization techniques for representation of the terrain exist. In tourist maps, the terrain is usually represented by contour lines. Many inexperienced map users have troubles to read 2D topographic maps. To help these users, cartographers have increasingly turned to 3D perspective maps, which allow users to more easily visualize three-dimensional landscapes [1].

Limits of perspective maps lie in perspective distortion, hidden objects, countless scales within one view and incomparable geometries of objects [2]. Because of these limits, perspective views are not appropriate for depicting of large areas (i.e. tourist map of the country). Tourist maps with contour lines can be enhanced by adding the psychological depth by "shading", which helps the observer to perceive depth [3].

There is still little known, if the shading helps to the map users to imagine the relief better than contour lines.

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2 Case study

The aim of the case study presented in the paper was to evaluate the role of hill-shading in tourist online maps. As stimuli, screenshots from Czech map portal Mapy.cz were used. The task was to find as fast as possible particular location in the map; hill or village. Two versions of stimuli were created; with and without hill shading. Purpose of the study was to analyse, if the hill-shading helps respondents to find the hills, and in the same time, if it does not distract them while finding the villages.

Study was performed in within-subject design. Stimuli were presented in random order. To unite the starting point of the eye-movement trajectories, the fixation cross was displayed for 500 ms prior to the stimulus. Respondents had maximum time of 45 second to find the target. This time amount was sufficient for majority of the maps, just for the most complex one, which contained huge amount of labelled places, this time was not sufficient for some respondents.

For the case study, an eye-tracking device SMI RED 250 was used. This device is capable of recording eye-movements with the frequency of 120 Hz. Eye positions are recorded every 8 ms. For the unification of lighting conditions; the device is situated in laboratory with blinded windows. Eye-tracker was supplemented with a web camera, which records participant during the experiment. This video helped to reveal the cause of missing data, respondents' reactions to the stimuli and their comments to the particular maps.

Total of 40 participants (24 females and 16 males) attended the eye-tracking experiment. Before the experiment, respondents filled out the short questionnaire with personal information. Respondents were originated from different fields. Some of them were cartographers, some of them were not. Majority of participants were 20-25 years old.

The experiment contained 12 static stimuli with tourist maps in two versions – with and without shading. To avoid learning effect, the target was different for each map in the pair, but the target was located in similar distance from the centre of the image. Example of the stimuli is in the fig. 1.

Fig. 1. Pair of stimuli. Map without shading on the left, shaded map on the right. The target (hills "Pelousek" and "Horka") are marked with red arrows

3 Analyses

Data were analysed in two ways. At the beginning, the answers on the short questionnaire focused on maps suitability and aesthetics were summarized. In the second part, eye-movement data were analysed statistically and with use of visual analytics.

After the experiments, respondents were asked to answer two questions. In the first one, they had to decide, which map was better for the answering the question. Answers were almost balanced (see fig. 2; left). 14 respondents found maps without shading better for answering the tasks, 13 found shaded maps more suitable. Remaining 13 respondents think that it depends on the task (if they are finding hill or village).

In the second question, respondents had to decide which version they like more. Majority of them (27) prefered shaded map (see fig. 2; right).

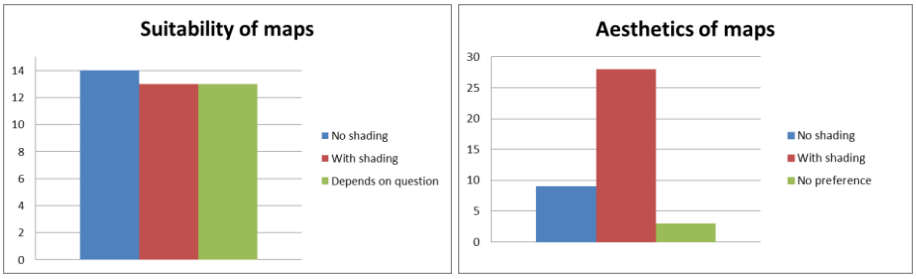

Fig. 2. Summarized answers for the short questionnaire presented after the experiment.

Trial Duration and Time to Click were analysed (fig. 3). The highest difference between variant with shading and without shading was observed in case of the last map (task 6), which was the most complex one.

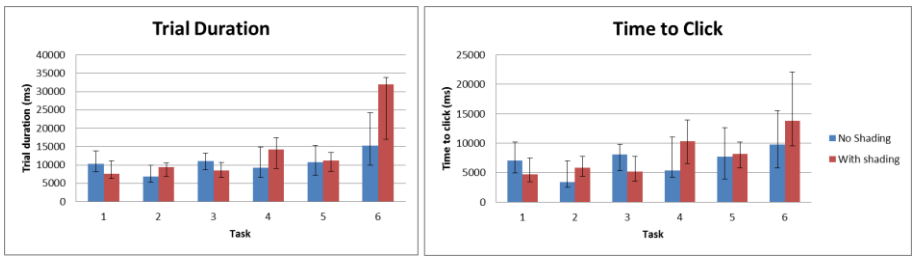

Fig. 3. Median values of Trial Duration and Time to Click. Error bars corresponds to the Interquartile range

Eye-movement metrics Fixation Duration, Fixation Count and Scanpath Length were investigated. From the preliminary results it seems, that there is no significant difference in these metrics between maps with and without shading. (see fig. 4) In the next part of the research, data will be tested with use of Wilcoxon sum rank test.

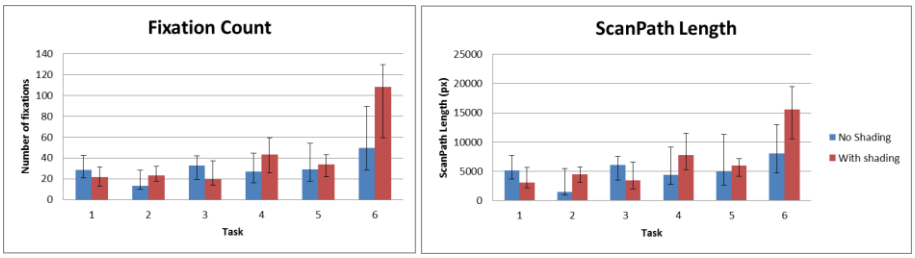

Fig. 4. Median values of Fixation Count and Scanpath Length. Error bars corresponds to the Interquartile range

Next part of the analyses used the method introduced by Kristien Ooms [4]. The stimulus is divided into the grid of cells and number of fixations in each cell is counted. The output grid is coloured based on the number of fixations. To compare both variants of the stimuli, the grid without shading was subtracted from the shaded one.

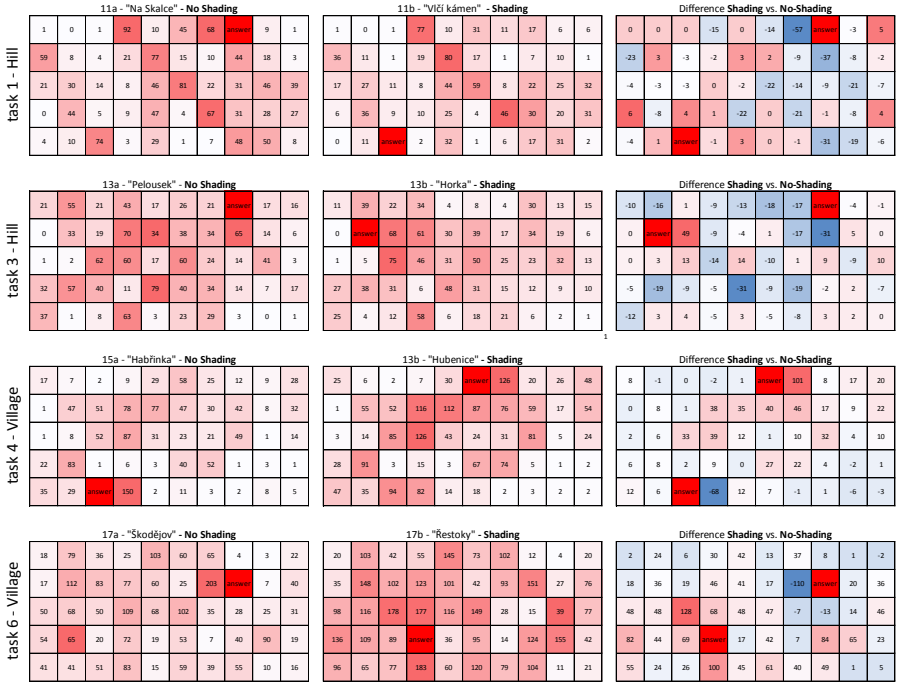

Fig. 5. Grid representation of number of fixations for two pairs of stimuli.

Figure 5 shows result of this analysis for four pairs of images. The image on the left represents the map without shading. Shaded maps are in the center. On the right, there is a difference in the number of fixations between each pair. Red cells with "answer" label represent the location of the target, where the number of fixations was the

highest. These values were excluded from the visualization. From the image, it is obvious that in the tasks 1 and 3 (upper rows of images), more fixations were recorded for the maps without shading (difference images contain majority of negative values). For the tasks 4 and 6 (bottom rows of images), the situation is opposite. A higher number of fixations in the task 6 indicates problems with target finding.

4 Conclusion

The paper describes ongoing eye-tracking study focused on the role of hill-shading in tourist maps. Preliminary results suggest that respondents subjectively like shaded maps more than maps with contour lines only. From the evaluation of eye-tracking data, it seems that there is no statistically significant difference for three eye-tracking metrics (Fixation Duration, Fixation Count and Scanpath Length). First outputs from visual analytics methods show interesting facts about user reactions on the particular map pairs. Among the above mentioned analysis, also Flow Map and Time Bar methods, described in [5] will be used for evaluation of the eye-tracking data in further research.

5 References

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