Space-Time-Cube visualization of Eye-tracking data

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ABSTRACT

Department of Geoinformatics is concentrated on the elements, measurement, modelling, propagation, and cartographic portrayal of geospatial data. To find out best cartographic representations or maps of these geospatial data, we decide to use evaluation with eye-tracking system. The poster describes visualization method of Space-Time-Cube for analysing the large amount of eye-tracking data. In Space-Time-Cube, time is shown as the third (vertical) spatial dimension while two planar dimensions represent geographical space.

Author Keywords
Space-Time-Cube; Temporal data; Time geography; Uncertainty; 3D

INTRODUCTION
Visualization is essential for gaining and understanding structure of the data and underlying phenomena. Peuquet (2002) distinguished three elements in spatiotemporal data: location, attribute and time. This data approach is widely accepted in geovisualization research. Eye movement data has similar characteristics as spatio-temporal data, therefore it can be structured accordingly (Li et al., 2010). The record's time stamp for one gaze point corresponds to the time component in Peuquet's model. The X and Y of a gaze point (screen coordinates) represent the location component, and attributes could be for example validity, event data, gaze point content or AOI metadata. Li also argues that eye movement recordings have many similarities with spatiotemporal data and can be visualized as such.

A common problem with visualization of any movement data is the data volume. It is necessary to analyse and make use of the huge amounts of collected eye movement data efficiently, because overlaps may cause misunderstanding of the data. The most common way of representing eye-tracking data is to draw a scan path on top of the target image. Scan path visualizations are typically more useful than visualizations of the individual data points, since they group the information into meaningful chunks. (Räihä, 2005).

SPACE – TIME – CUBE
Overlapping and impossible subsequent interpretation of results are happened very often in the case of visualization through the scan path. The cause of this problem is displaying three-dimensional data (X, Y, time) in two-dimensional space (X, Y). Several options exist to cope with this problem. Space-Time-Cube (STC) is the most sophisticated of them. Space-Time-Cube is the most important element in the Hägerstrand space-time model (Hägerstrand 1970). STC brings possibilities to combine spatial data with a time component. Coordinates X and Y describe the spatial distribution of fixation and the time is displayed on the Z axis. Space-Time-Cube is used for visualization of all types of spatio-temporal data. Visualization methods via eye-tracking by STC are precisely described in Li et al. (2010).
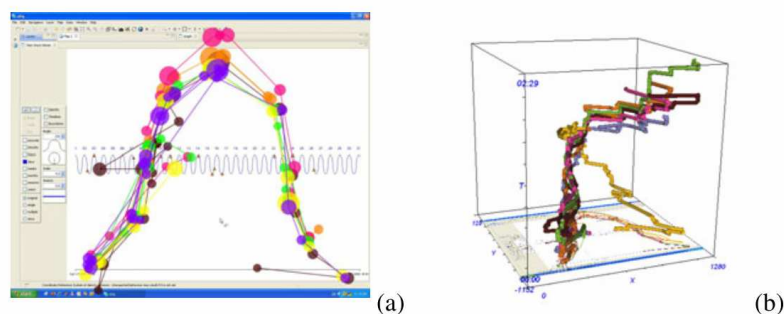

Fig. 1. Eye movement data for the same task as a gaze plot (a) and in the STC (b) (Li et al., 2010)

OUR RESEARCH
At Department of Geoinformatics of Palacký University, we are dealing with evaluation of user cognition and perception in case of maps and cartographic outputs from GIS. We are analysing user's cognition of map composition, role of compositional elements and map legend. Next part of the project deals with 3D maps. As the Haeberling (2005) states, perspective perception of a generalized and symbolized geographic space offers a better understanding of spatial

coherences often. Different perceptions of 2D and 3D maps are examined in this part of the research. Last research target is coping with representing uncertainty in spatial data.

Tests should help to answer questions like "Which map composition is the best?", "Is the legend necessary in every map?", "Is structured legend better than unstructured?", "For which cases is the use of 3D map better than 2D?" or "Which uncertainty visualization method is best understandable for the users?"

Group of students of Department of Geoinformatics was chosen for testing. This group represents users with cartographic knowledge. Each test was tested by 10 participants finally due to calibrating a testing question. Larger groups of students will be chosen for final testing in the future. Second step of this research will be comparing these results with participants, which have no experience with cartography. Testing of participant's attention and spatial intelligence will be a necessary condition for deeper understanding of participants.

VISUALIZATION IN SPACE – TIME – CUBE

Many of testing questions were difficult for the participants and time consuming. It is problematic to analyse output data in these cases due to their overlaps. For analysing these data and better visualisation methods Space-Time-Cube visualization in software called CommonGIS (an upgraded version of the system Descartes described in Andrienko and Andrienko 1999) was chosen.

For visualization of eye-tracking data in CommonGIS, it is necessary to adjust output data in a text editor. Output raw data from eye-tracker has three important columns: timestamp and X and Y coordinates of user's point of regard. Timestamp is given in microseconds, but in CommonGIS the minimum units are seconds. It was necessary to convert seconds to minutes and milliseconds to seconds. Data from eye-tracker has still the same step, so it is irrelevant if the units are seconds or minutes. Next step was to invert Y coordinates. After these adjustments, we can visualize the data in CommonGIS and then use the function "View temporal data in Space-Time-Cube".

In this environment (Fig. 1), it is possible to rotate with the cube to view data from each side, select an individual path (which corresponds to the participants) or move the underlying map to simulate the time.
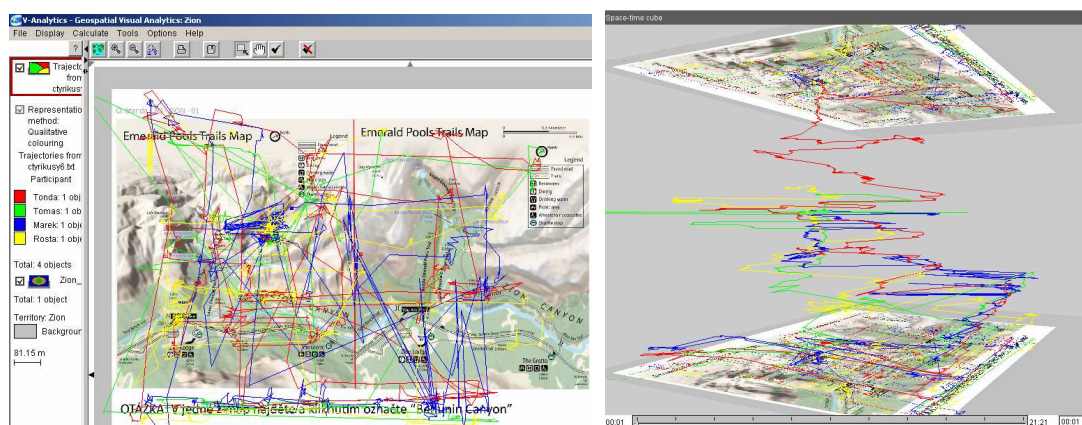

Figure 1. Example of eye-tracking data in the Common GIS environment (left) and the same data in Space-Time-Cube (right)

CONCLUSIONS

The eye-tracking technology was not fully utilized yet in the field of cartography or geography. It is clear that it will have significant influence in optimization of cartographic products and visualization of geographic data in the future. Usage of visualization environment of Space-Time-Cube helps to answer research questions relating to cartography. It also brings new possibilities how to simplify and analyse a large amount of eye-tracking data.

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