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EYE-TRACKING TESTING OF GIS INTERFACES

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ABSTRACT

Eye-tracking is currently a much-used method for determining the usability of the software. For this reason, the eye-tracking was selected for testing Graphical User Interfaces of GIS software. One commercial software ArcGIS for Desktop by ESRI company and Open Source software QGIS was tested. The eye-tracking testing was composed as an interactive testing. The respondents processed five various geo-tasks. The geo-tasks were an overlay analysis with buffer, creation of thematic map with a railway network, processing raster data and querying spatial data by attribute values. The last geo-task was the design of the model for automatic processing data in ModelBuilder and Processing Modeler. This geo-task was the same as a task with overlay analysis. The reason for the same task was a comparison of work with automatic data processing and classic work in the Graphical User Interface. The respondents were the 30 students of study branch Geoinformatics at Palacký University in Olomouc.

The primary results of testing were the total time of task solution by each respondent and the information of successful fulfillment of tasks. Other outputs were eye fixations, gaze plots and video files with a complete record of user eye movements. In the interface of GIS software, the areas of interests were marked. These areas contained the main parts of the interface as a main menu bar, table of contents, and data preview. The area of interests was marked in eye-tracking software SMI BeGaze. The software can measure interactive stimuli and finally compute statistical characteristics. The significant characteristic of interactive stimuli is Dwell Time in the area of interests.

The investigation of eye-tracking data discovered several main approaches to solving geo-tasks. In ArcGIS for Desktop, some users prefer manual searching in the ArcCatalog window to start the process (tool). Other users exploit the Search form included in the tested software, the Help form or repeated manual search of processes and data connection. The latest case also occurred very often because there were individual methods and practices of each user. The case of manual searching in ArcCatalog and Processing Toolbox brings an increase of the time required to solve the geo-task. Using the Help or Search form, the work is more productive in terms of time. For example, the task of processing raster data took much higher required time with a manual search of the tool. It is due to the fact, that users did not know exactly where the toolbox with a tool for automatic digitization of the raster image is. Another reason is that this tool is not as often installed, in comparison with a tool for creating a buffer. Similar phenomena occur in another studied geo-task. Reuse of ArcCatalog and Processing Toolbox has been recorded and processed using the Area of Interest, created in SMI BeGaze software.

In generally, the main output of the usability study is a graph of time spent for user's operations solving geo-tasks. The useful recommendation is for teaching: more emphasize the use of the Search and Help form in practical lectures.

Keywords: eye-tracking, geo-task, interface, interactive stimulus, GIS.

INTRODUCTION

There are many options how to test or measure usability of GIS software User Interfaces. Eye-tracking is currently much-used method because it enables to catch the Visual Attention by using the record of human eye movements [1]. For example eye-tracking was used during preparation of e-learning Portal. Respondents were selected from the group of high school students. In the beginning, students have almost no experience with e-learning portals. During this experiment, individual students gained experiences with work in e-learning portal. Students had to acquire information by reading the content of e-learning portal, that they used to answer questions. All data were recorded interactively in eye-tracking experiment [2]. Interactive stimuli recording through eye-tracking testing is, therefore, an appropriate method for evaluation of GIS User Interfaces.

The aim of this study was an evaluation of GIS Software User Interfaces in geo-task solutions. Geo-task is such a task where the users work with spatial data. It may be an overlay analysis, work with raster data, the creation of a thematic map, spatial querying and filtering data. The users may have many approaches to solving geo-task. This implies a different way of working in GIS software and it's Graphical User Interface. Interactive stimulus recording, one of the eye-tracking method, which provides many user´s profiles. Determination of user typology is based on similar eye movement paths [3]. The special research was created by M. Haklay and A. Zafiri. The group of users proceeded the same task in GIS software. Users used the quite different order of steps in the solution of the same GIS task. Interesting figures can be when users do Screenshot of GIS product User Interface at the same time during their solutions of geo-task [4].

GIS SOFTWARE IN TESTING AND RESPONDENTS

As a basis for this study were selected two GIS products. The first is representative of commercial GIS and the second is of Open Source GIS. Esri ArcGIS for Desktop was chosen from commercial GIS software. The tested version of Esri ArcGIS was Desktop Advanced 10.2; this version was tested in autumn 2014. From the category of Open Source GIS software was tested QGIS 2.2.0 Valmiera. This testing was conducted in spring 2014. Versions of both GIS software were tested in these times the most recent.

Respondents for testing were 30 students of study branch Geoinformatics at Palacký University in Olomouc. It was necessary that the respondents had the skills of Geoinformatics to cope with the geo-tasks assigned. There was a total of two testing, for each GIS software one. Geo-tasks, which respondents were processed for each GIS software, were the same for the sake of comparison work in different User Interfaces of tested GIS software.

DESIGN OF THE EYE-TRACKING EXPERIMENT

The eye-tracking experiment was designed for interactive stimulus recording. This method is suitable for capturing the behaviour of respondents in GIS software User Interface. To record eye-tracking data was used SMI RED 250 eye-tracker with 250 Hz sampling rate. Permitted variations in user calibration were 1º in x and y axis for left and right respondent´s eye. The individual testing was recorded over SMI Experiment Center Software. The output of every individual test of each respondent is a video file and a text file with the measured coordinates of eye movements. At the start of the testing was calibration of respondent's eyes, then there was an assignment of geo-task and launch of screen recording on respondent´s monitor. There was already running the tested GIS software. Once the respondent completed the geo-task, the screen recording is stopped. It follows by respondent´s reading of next geo-task assignment, and the screen recording is launched again. The entire process is described in the following diagram; the interactive stimulus was recorded with using screen recording function in SMI Experiment Center (Fig. 1).

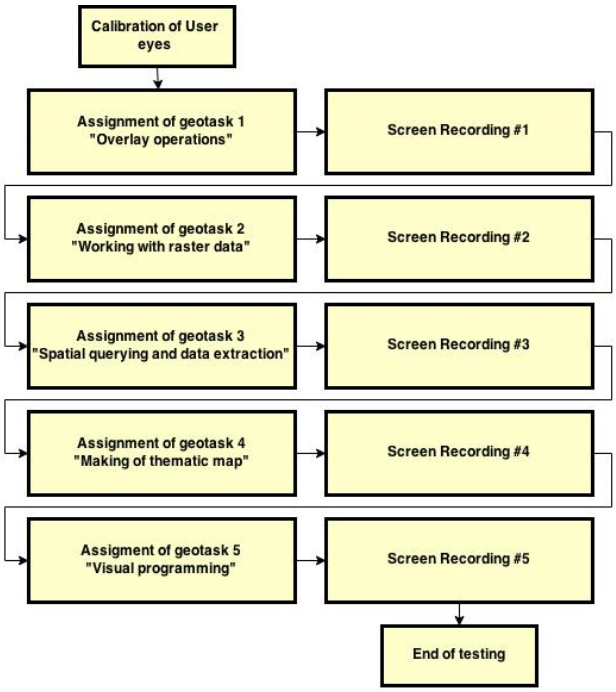

Fig. 1: Diagram of the eye-tracking experiment with interactive stimulus recording.

ANALYSIS OF DATA FROM INTERACTIVE STIMULUS RECORDING

The data measured by using the eye-tracking interactive stimulus recording were analyzed with the Area of Interest method (AOI). This method is included in SMI BeGaze software for the processing of eye-tracking data [5]. AOIs were created above the main parts of GIS software User Interfaces. AOIs can calculate the Dwell Time. This is very important value because it is the sum of all fixations observed in a created Area of Interest above the parts of User Interface [6]. There is important to make right choice of AOIs placement in GIS software User Interface. GIS software Esri ArcGIS and QGIS Valmiera have similar User Interface layout at first sight, but a closer survey brings several differences, which can have a significant impact on the overall results of

AOIs analysis. When placing the AOIs it is necessary to catch main elements of GIS software User Interfaces (Fig. 2). The main elements are the Table of Contents, where users can see the layers that are inserted in, Upper toolbars and the Data preview. Other elements are for example Toolboxes. In the toolboxes are placed individual tools for GIS operations. There is a typical example in ArcGIS User Interface, working with tools, which are categorized in several toolboxes by their focus. Sorting of tools is done by overlay analysis, raster data creation, generalization, conversion and so on.

QGIS Valmiera software had on the first sight simpler layout of User Interface. The main elements are placed similarly as in Esri ArcGIS, but Toolbox element is missed out. Tools are located in the upper part of User Interface (Fig. 2). This caused that AOIs placing is different compared to Esri ArcGIS.

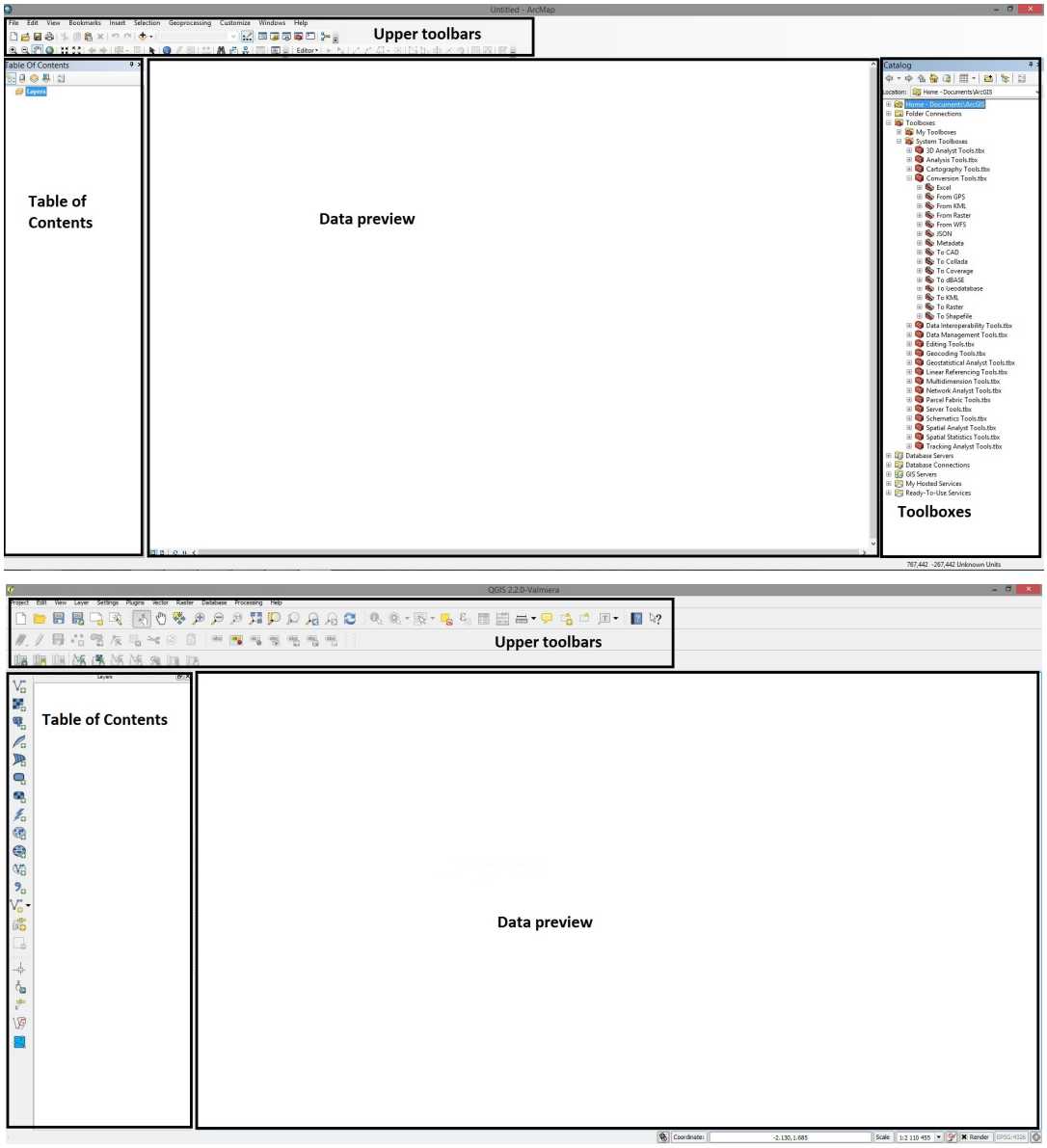

Fig. 2: The placing of AOIs, upper layout – Esri ArcGIS, lower layout – QGIS Valmiera.

RESULTS

Every testing of respondent brings one video file for each geo-task. From video files, which are the first output of interactive eye-tracking testing can be read a total time of solving assigned geo-task. The times of single video files were averaged for a total overview of time for a solution. Average total time of solution for selected geo-task is different for testing GIS software (Table 1).

Table 1: Average total time for solution of geo-tasks – 15 respondents

Geo-task	Average total time for solution – Esri ArcGIS	Average total time for solution – QGIS Valmiera	The number of respondents
1 - Overlay operations	2 min 58 s	2 min 54 s	15
2 - Working with raster data	1 min 42 s	1 min 15 s	15
3 - Spatial querying and data extraction	1 min 57 s	2 min 37 s	15
4 - Making of thematic map	6 min 48 s	2 min 50 s	15
5 - Visual programming	3 min 6 s	3 min 17 s	15

In Table 1 there are five geo-tasks with the average time for solutions with using Esri ArcGIS and QGIS Valmiera. Respondents spent the most time with geo-task 4: Making of the thematic map, total average time was 6 minutes and 48 seconds, with Esri ArcGIS software using. It was caused because this software has not included an additional window in the interface for making the composition of the map from attached data in the table of contents. Respondents had to find the single tools for the creation of legend, scalebar, imprint, map field and the title of the map on upper toolbars. QGIS Valmiera software contain additional window with a special interface, which is designed for creation map composition. This interface includes tools directly determined for insertion legend, scalebar, imprint, map field and the title of the map. It caused that the average time for the same geo-task with using QGIS Valmiera software was only 2 minutes and 50 seconds against 6 minutes and 48 seconds with using Esri ArcGIS software.

Other example, which can be read from Table 1, is the solution of the geo-task 1. The aim of geo-task 1 was to perform an overlay analysis above the 400 meters buffer around the railway network of the Czech Republic and water surfaces for demarcation of contained water areas in the case of train accident. Both tested GIS software have on the first sight similar User Interface. There is a Data preview, Table of Contents, Upper toolbars and in the case of Esri ArcGIS also Toolboxes at the right side of the Interface. The main idea how to work in the interface, finding and placing toolbars and single tools, attaching spatial data is similar. User´s approach for solving this geo-task caused that the average time for solution of geo-task 1 is with a minimum difference for both tested GIS software. It is about only 4 seconds different for QGIS Valmiera with 2 minutes and 54 seconds to the final solution of geo-task 1.

In the case of geo-task 5, there were exploited the Visual Programming components, ModelBuilder (Esri ArcGIS) and Processing Modeler (QGIS Valmiera), whose graphical notation is described by Z. Dobesova [7].

Dwell Time comparison

The main output of AOIs created above GIS software User Interface is Dwell Time value. This value is provided by the Key Performance Indicators (KPI). The key Performance Indicators method is a one of the experiment analysis methods contained in SMI BeGaze software for analysis of eye-tracking data. KPI create a bubble, which is associated with every AOI over interactive stimulus record [8]. This bubble visualizes the statistical data including Dwell Time value. Calculated Dwell Time from AOIs shows a basic set of user behaviour.

With using values of Dwell Time of each respondents, there are several values from AOIs attached to every element of GIS software User Interface. This study is aimed at assessing the User Interface within the processing of geo-tasks. Values of Dwell Time were compared between tested GIS software and suitable workflow for single geo-tasks. Below is described selected geo-task number 3, for this study.

Geo-task 3: Spatial querying and data extraction

Respondents should perform a data extraction from selected layer of towns in the Czech Republic with querying over attribute table, and selected records exported as a new layer. Task was: "Select municipalities with a population of over 500 inhabitants and less than 1 000 inhabitants from the layer city.shp. From these selected municipalities make a new layer."

Optional procedure to solve this task is attaching data to GIS software. Next step is using attribute table to find an attribute with population count. The respondent sets value more than 500 and less than 1 000 inhabitants with the wizard for querying. Finally, the respondent applies the query and filter data export for export as a new layer. That is suitable workflow for solving geo-task 3 (Fig. 3).

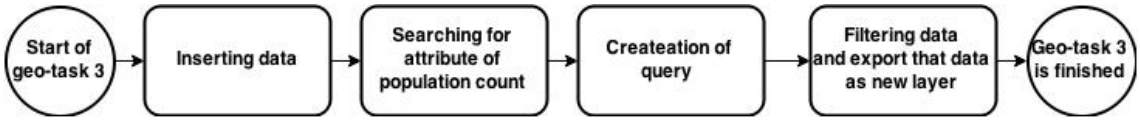

Fig. 3: Suitable workflow for solving geo-task 3.

One group of respondents used Esri ArcGIS and the second group worked with QGIS Valmiera. The task was the same for every tested group. Interactive stimulus recording was then analyzed by KPI over AOIs. The AOIs were created according to that layout (Fig. 3). Measured Dwell Time for single AOI shows great differences between AOIs, but also between tested GIS software.

Total average time for this geo-task was 1 minute and 57 seconds for Esri ArcGIS and 2 minutes and 37 seconds with using QGIS Valmiera (Table 1). When the single Dwell Time for AOIs is focused, respondents have spent significant time at Upper toolbars with using Esri ArcGIS (Fig. 4). Work in QGIS Valmiera environment was focused largely on Data preview (Fig. 4). The reason for this anomaly is locating of control panels for querying. Esri ArcGIS has located these controls in the attribute table window. QGIS Valmiera has also included these controls in attribute table window, but the same controls for querying are located in the area of Upper toolbars. During the

testing, no respondent used an option of Help window, but there is Help window occurred in both tested GIS software.

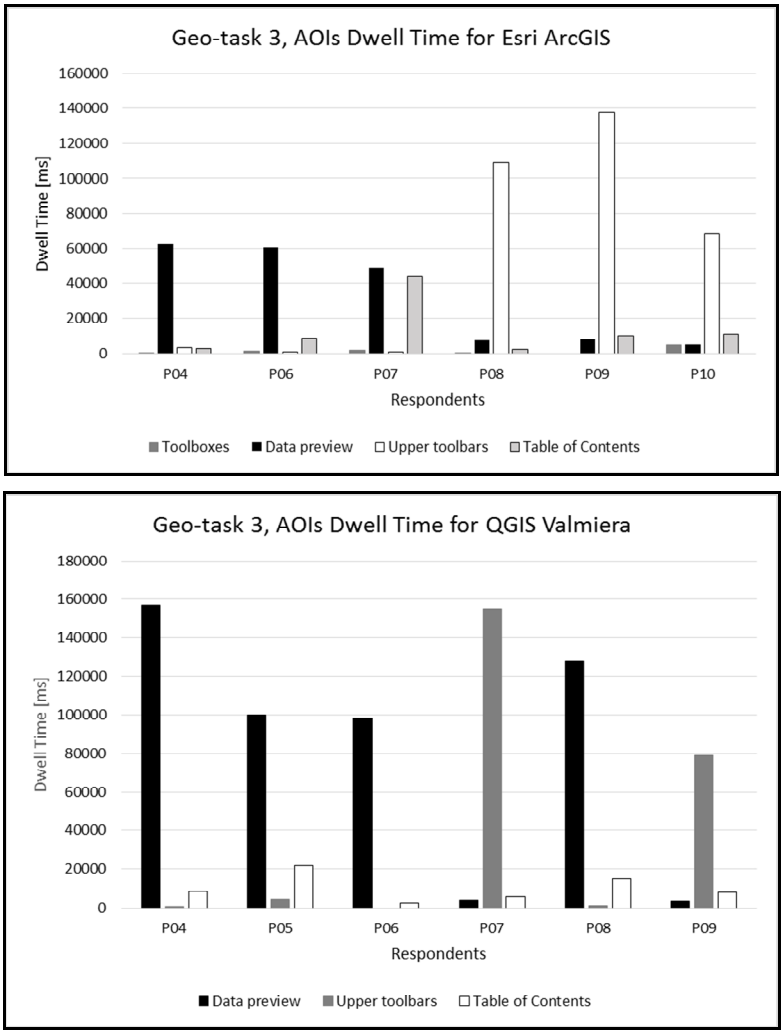

Fig. 4: Comparison of Dwell Time for Esri ArcGIS and QGIS Valmiera for selected respondents.

CONCLUSION

This study shows that the eye-tracking testing can be used for basic evaluation of basic layout User Interface of GIS products. Also, it comes with comparison method of KPI with using Area of Interest. There was analyzed the Dwell Time, as a value of fixation time that that users spent in AOI. Component AOIs created above basic elements of User Interface bring the option for reflection of a respondent's behaviour and thought.

Using of the Help window, which is included in both tested GIS software, brings the lower Dwell Time value for individual AOIs. Recommendation for education is to motivate students to use the Help window, both GIS software have included it, and activate the tools directly from Help window.

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REFERENCES

[1] Duchowski, A. *Eye Tracking Methodology, Theory and Practice*. 2007: Springer-Verlag London Limited.

[2] Popelka, S. & Vavra, A. *E-learning Portal Functionality Assessment with Use of Eye-Tracking Experiment.* 2014: ICEL Conference.

[3] Popelka, S., Dvorsky, J., Brychtova, A. & Hanzelka, J. *User typology based on eye-movements paths*. 2013: 13th International Multidisciplinary Scientific GeoConference SGEM 2013.

[4] Haklay, M. & Zafiri, A. *Usability Engineering for GIS: Learning from a Screenshot*. The Cartographic Journal Vol. 45 No. 2 pp. 87-97. 2008: The British Cartographic Society.

[5] Brychtova, A., Paszto, V., Marek, L. & Panek, J. *Web-design Evaluation of the Crisis Map of the Czech Republic using Eye-tracking*. 2013: 13th International Multidisciplinary Scientific GeoConference SGEM 2013.

[6] Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Halszka, J. & Van De Weijer, J. *Eye tracking: A comprehensive guide to methods and measures*. 2011: Oxford University Press, 560 pp.

[7] Dobesova Z., *Data Flow Diagrams in Geographic Information Systems: A Survey*. 2014: Conference Proceedings SGEM 2014, 14th International Multidisciplinary Scientific GeoConference Volume I, STEF92 Technology Ltd. Sofia, Bulgaria, pp. 541-548.

[8] SensoMotoric Instruments GmbH (SMI). *BeGaze Manual, version 3.4*. 2014: Warthestrasse 21, D-14513 Teltow, Germany.