Processing Gaze Responses to Dynamic 2D Stimuli

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Introduction

It has been suggested that visualization tools are necessary for facilitating the understanding of large volumes of data because the visual cortex dominates perception. Moreover, the key aspects of the perception process occur rapidly without conscious thought [1]. The huge amount of data collected during the experiments on gaze behavior necessitates researchers to seek efficient tools for visualization of the data. There has been a steady stream of improvements in the techniques for analysis and visualization of the eye tracker data for static 2D stimuli [2, 3, 4].

Several suggestions can be found in the literature on the characteristics that a good tool for performing gaze data analysis should possess. In addition, some researchers have developed prototypical systems to illustrate their individual approaches [5]. Some academic prototypes, such as GazeTracker, have even evolved into commercial systems becoming very popular [6].

Despite the ability of today's analysis tools to support observations of static 2D stimuli, progress on processing and visualization of gaze data in response to dynamic stimuli has been quite modest. Most of the available techniques are based on frame-by-frame analyses of video data that are very tedious and time consuming. Therefore, there is a strong demand for a simple and intuitive way to visualize gaze data recorded in the experiments with dynamic 2D stimuli.

This paper presents our approach in handling experimental data on behavior of eye gaze in dynamic settings. Details on the software that implements our analysis and visualization techniques are described below.

Fig. 1. Selection panel: selection creator

Selection Creator

The proposed interface has a panel for defining and managing fixation selections. The panel consists of two parts: selection creator (Fig. 1) and selection manager (Fig. 2).

Selection creator consists of the list of selection creation options, the list of selection criteria, the selection range, and the button for creating a selection. If the chosen selection creation option is *New*, all the previously made selections of the current criterion will be deleted and the new one will be added. Alternatively, the option *Add* simply allows adding a newly created selection to the already existing one. All fixations that satisfy the conditions of this selection are added to the list of the selected fixations. The remaining two values of the creation option are useful when treating all fixations as a mathematical set of values.

The creation option *Subtract* creates a selection that is subtracted from the existing selections. All fixations satisfying the conditions of this selection are removed from the current list. The creation option *Intersect* allows creating a selection that will intersect with the existing selections. All fixations satisfying the conditions of this selection remain in the list of the selected fixations, whereas other fixations are removed from the list. The subtraction and intersection operations are identical to the mathematical operations on sets and subsets. Together with the adding function, they allow creating a subset of selected fixations of any complexity.
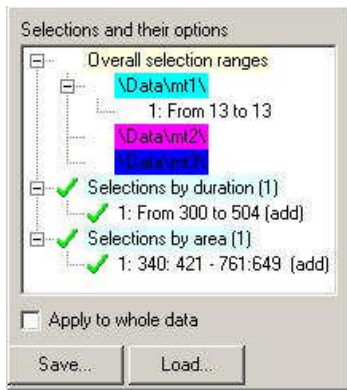
Fig. 2. Selection panel: selection manager

Selection criterion defines the property of fixation used in the selection creator to filter fixations by applying a selection range. The criteria of the fixation's plain data are *Number* (fixation ordinal number), *Time* (fixation start time), *Duration*, and *Area*. While the first three criteria require a simple range (e.g., from 10 to 20 for numbers), *Area* requires two ranges – by X and Y.

The range bar cannot be used for creation of selection by area, so this kind of selection must be created with the mouse: the user "draws" a rectangle of the area to be selected. This value in the selection criteria list serves only to notify about the ongoing selection by area using the mouse – it is not necessary to select this option before drawing the area-of-interest rectangle.

When the user completes defining the selection by area, a prompt appears for naming the selection. Naming helps to operate by selections since the names can reflect the existing objects in the selected area.

One of the selection criteria is derivative – the data used for comparison in the selection routine does not appear in the fixations file. This is *Angle* – the angle of the saccade vector (0° – 360°). Fixations that follow the saccades of the angles within the selection range are selected.

The range bar contains a sizeable thumb. However, the functionality of this range bar is similar to that of a scroll bar. If the selection creation type is *New*, the selection is created right after the user has adjusted the range bar. Otherwise, the user must press the button *Create* to create the selection of a specified creation type, criterion and range. Two buttons labeled "*E*" surround the range bar when the selection criterion is *Time* (Fig. 3).

Fig. 3. Range bar with buttons "E"

Upon clicking on either of these two buttons, a dialog appears showing the events on the time axis (Fig. 4). Each event is represented by a triangle (tick) of a particular color. Information on the event including its time of occurrence is shown in the hint. The hint is visible when the mouse cursor moves over the associated tick. Color of the ticks represents the type of event. The check boxes at the bottom of the dialog are used to control visibility of the events on the time axis. The user can click on an event's tick to select its time value, which then transfers it to the selection range bar.
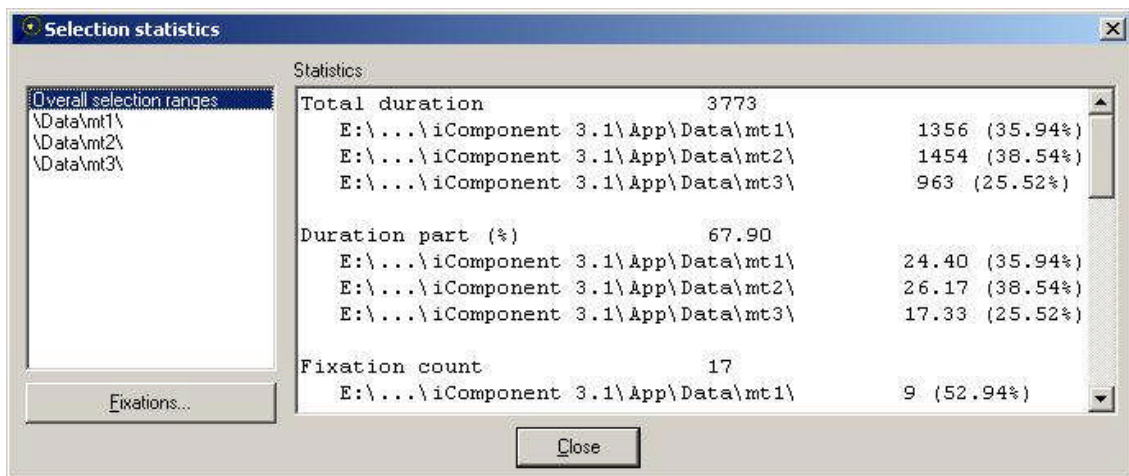

Fig. 4. Dialog to select time of event

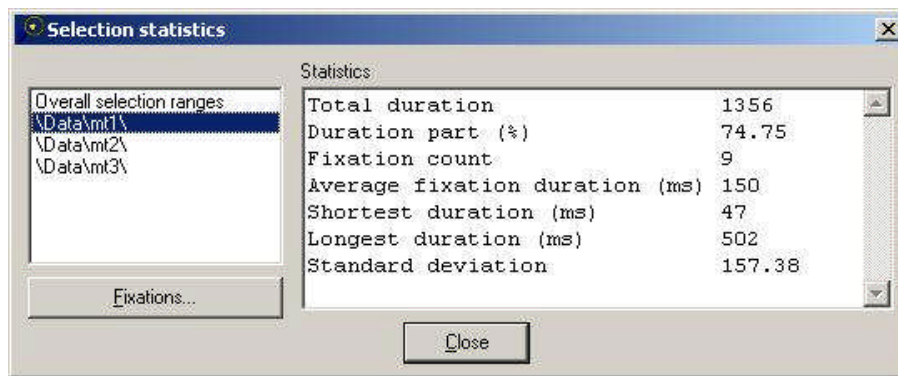**Fig. 5.** Selection statistics of all recordings

Fig. 6. Selection statistics of a single recording

Selection Manager

The lists of selection ranges and fixations selected are shown in the second part of selection panel – selection manager (Fig. 2). The lists are implemented as branches of a tree. The branch *Overall selection ranges* contains a list of the loaded recordings. Each branch of the next level contains a list of fixations selected (numbers) united into ranges. For example, if the selected fixations are numbers 4, 5, 6, 8, 15, and 16, then the list will have three items: (1) 4 – 6, (2) 8, and (3) 15 – 16.

Other branches from the root contain lists of selection ranges by a particular criterion. The branch of a particular criterion does not appear if there are no selections by this criterion. Each branch has an enabling icon, a description and a number of selection ranges. For example, the string "√ Selection by duration (2)" means that all selections by duration are active (if not disabled individually), and also that there are two of them. Red cross instead of a green check mark means that all selections in the list are disabled.

Each item in the list of selections consists of an enabling icon, a selection range and a selection type. For example, the string "*X From 300 ms to 500 ms (add)*" means that the selection by duration includes all fixations with the duration between 300 and 500 ms. However, since the current selection is disabled, it does not affect the list of selected fixations. The selection ranges that remove fixations from the selection list, or limit other selections, have *sub* and *int* abbreviations in brackets, accordingly.

If the user clicks the right mouse button on the selection manager, a popup menu appears (Fig. 7).

Fig. 7. Selection manager popup menu

If this menu appears after the *Overall selection ranges* branch or any of its sub-branches has been clicked upon, only the item *Statistics...* is enabled in the menu. It opens a window displaying the statistics of the fixations selected (Fig. 5).

This selection statistics window contains the list of recordings on the left, and the statistics on fixations belonging to the selected recording on the right. However, when selected, the first item in the left list is the name of the first branch in the selection manager, whereas the right part contains summarized statistics by all recordings with contributions from each recording. In this case the statistics window looks exactly as shown in Fig. 5. If the user selects a particular recording in the recordings list, the right part of the window shows only the statistics on fixations from this recording (Fig. 6).

The statistics correspond only to the fixations selected. On the left panel, there are the following values: (1) *Total duration* – the total duration of all fixations, (2) *Duration part* – the part of selected fixation in all fixations in the picture, (3) *Fixation count*, (4) *Average fixation duration*, (5) *Shortest duration*, (6) *Longest duration*, (7) *Standard deviation*.

The list on the left in the dialogs of Fig. 5 and Fig. 6 appears when the popup menu is called over the branch *Overall selection ranges*. If the menu is opened via any of its first-level sub-branches, the list contains the name of this branch and all the ranges of the fixations selected as shown in Fig 8.
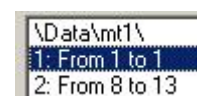

Fig. 8. List of selected fixations in the selection statistics dialog

If the first item of this list is selected, statistics is shown on all the fixations selected in this recording, and the statistics list appears on the right exactly the same as in Fig. 6.

Conclusions

This paper describes software that allows processing of experimental data on behavior of the human eyes subjected to dynamic two-dimensional stimuli. Graphical user interfaces are presented in detail along with comprehensive explanations how to take the best advantage

of the functionality provided by the built-in analysis and visualization tools.

References

1. **Zeki S.** The visual image in mind and brain // Scientific American. – 1992. – Vol. 267. – P. 42–50.
2. **Lankford C.** Gazetracker: software designed to facilitate eye movement analysis // Proceedings of the Symposium on Eye Tracking Research & Applications. – ACM Press. – 2000. – P. 51–55.
3. **Wills G. J.** 524,288 ways to say "this is interesting" // Proceedings of the IEEE Symposium on Information Visualization. – IEEE Computer Society Press. – 1996. – P. 54–61.
4. **Wooding D. S.** Fixation maps: quantifying eye movement traces // Proceedings of the Symposium on Eye Tracking Research & Applications. – ACM Press. – 2002. – P. 31–36.
5. **Reeder R. W., Pirolli P. L., Card S. K.** WebEyeMapper and WebLogger: tools for analyzing eye tracking data collected in Web-use studies // Extended Abstracts of the Conference on Human Factors in Computing Systems. – ACM Press. – 2001. – P. 19–20.
6. **Leung Y. K., Apperley M. D.** A review and taxonomy of distortion-oriented presentation techniques // ACM Transactions on Computer-Human Interaction. – 1994. – Vol. 1. – P. 126–160.

O. Špakov, D. Miniotas. Processing Gaze Responses to Dynamic 2D Stimuli // Electronics and Electrical Engineering. – Kaunas: Technologija, 2008. – No. 5(85). – P. 89–92.

Huge amount of data collected in experiments on gaze behavior requires efficient tools for analysis and visualization of the data to facilitate its interpretation. Although there are a number of tools available today that support observations of static 2D stimuli, the handling of dynamic stimuli remains a major challenge. The traditional approach analyzes the data frame-by-frame, which is very tedious and time consuming. We propose a simplified and intuitive way to visualize gaze responses to dynamic 2D stimuli. Graphical user interfaces are presented in detail along with comprehensive explanations how to take the best advantage of the functionality provided by the built-in analysis and visualization tools. Ill. 8, bibl. 6 (in English; summaries in English, Russian and Lithuanian).

О. Шпаков, Д. Миниотас. Обработка информации о реакции глаз на двумерные динамические стимулы // Электроника и электротехника. – Каунас: Технология, 2008. – № 5(85). – С. 89–92.

Огромный объём информации получаемой при экспериментальном исследовании движений глаз диктует спрос на эффективные средства, предназначенные для облегчения анализа и визуализации этой информации. Хотя в настоящее время имеются несколько средств, пригодных для экспериментов с двумерными статическими стимулами, обработка динамических стимулов по прежнему создает немало трудностей. Традиционные методы анализируют информацию последовательно кадр за кадром, а это требует больших ресурсов и отнимает много времени. В настоящей работе предлагается облегчённый способ для визуализации реакции глаз на двумерные динамические стимулы. Подробно описываются графические интерфейсы пользователя, предводятся рекомендации для оптимального использования предлагаемых средств анализа и визуализации информации. Ил. 8, библ. 6 (на английском языке; резюме на английском, русском и литовском яз.).

O. Špakov, D. Miniotas. Informacijos apie akių reakciją į dvimačius dinaminius stimulus apdorojimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2008. – Nr. 5(85). – P. 89–92.

Eksperimentiškai tiriant akių judesius, gaunamas milžiniškas informacijos kiekis, todėl reikia efektyvių priemonių šios informacijos analizei ir vizualizavimui palengvinti. Nors yra keletos priemonių, pritaikytų eksperimentams su dvimačiais statiniais stimulais, dinaminių stimulų apdorojimas vis dar kelia nemaža sunkumų. Tradiciniais metodais informacija analizuojama nuosekliai, kadras po kadro, o tam reikia didelių išteklių ir daug laiko. Siūlomas palengvintas būdas akių reakcijai į dvimačius dinaminius stimulus vizualizuoti. Detaliai aprašomos grafinės vartotojo sąsajos, pateikiama rekomendacijų, kaip optimaliai naudotis siūlomomis informacijos analizės ir vizualizavimo priemonėmis. Il. 8, bibl. 6 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).