

Gaze Visualization Embedding Saliency Features

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ABSTRACT

Visual information such as gaze movement and visual stimuli are clues to analyze human attention intuitively. However, it is not easy to analyze how visual stimuli affect gaze since existing techniques focus excessively on the eye movement data. In this paper, we propose a novel gaze visualization for analyzing eye movements using saliency features as visual clues to express the visual attention of an observer. The visual clues that represent visual attention are analyzed to reveal which saliency features are prominent for the visual stimulus analysis. We visualize the gaze movement data with the saliency features to interpret the visual attention.

Index Terms: Visualization—Visualization application domains—

1 INTRODUCTION

The visual attention competition diversifies according to visual stimulus and subjective state of an observer [11]. The human eye selects information through a visual attention competition even if it sees much information at the same time.

The visual salience is a bottom-up and stimulus-driven signal indicating that the reference position is sufficiently different from the surrounding environment [10]. The feature maps are required to create a saliency map for the visual salience computation. The feature maps are composed of three saliency features from a visual stimulus. Three saliency features include the intensity, color, and orientation, which are classified as undoubted attributes that significantly influence visual salience in the visual search guide [12]. In order to analyze the influence of the saliency feature on gaze behaviors, detailed information, such as gaze movement data and the composition ratio of the saliency features for the most prominent feature of the visual stimulus, is necessary.

In this paper, we propose a novel gaze visualization technique that enables to analyze the gaze movements according to the visual attention by employing the saliency features of visual stimuli. Our proposed technique is a saliency-based gaze visualization embedding the saliency features for intuitively providing clues to subjective information selection of an observer in the analysis. We represent three saliency features, such as intensity, color, and orientation, that constitute a saliency map from a visual stimulus as the visual clues. We analyze the gaze data with the visual attention.

2 RELATED WORK

The gaze is mainly analyzed through visualizations. Blascheck et al. [1] summarize common technologies on the gaze data visualization. The most ordinarily used visualization techniques include scanpath and heatmap. Kurzahls et al. [8] analyze the flow of gaze-concentrated areas by proposing an image-based visualization with

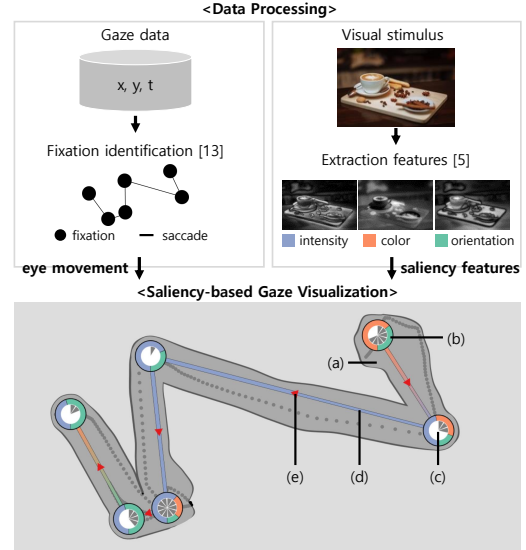


Figure 1: An overview of the data processing and our visualization.

gaze stripes. Burch et al. [3] attempt to reduce the complexity of the gaze data analysis by proposing clutter-free color-band visualization with time-varying (x;y) coordinates. Blascheck et al. [2] propose a visualization technique for the gaze comparisons of common and non-common patterns with various AoIs. Also, the gaze is utilized in evaluations. Many researchers show how information is perceived through the eyes and how the gaze can be an evidence to evaluate the efficiency of visualization techniques [4, 9].

Pioneering research for the visual saliency proposes a model of saliency-based visual attention for the rapid scene analysis [5]. The visual saliency map plays an important role in visualization to emphasize the potential human attention that can be categorized as features. Jänicke et al. [6] provide a guide for the visual attention to relevant parts that can be applied in visualization areas. They propose a salience-based quality metric by adjusting color, intensity, and orientation elements. Since the gaze and the visual saliency are closely related to the human perception, Matzen et al. [9] propose a new visual saliency model and present the relationship between the visual acuity and the visual salience. There is study on the gaze in connection with deep-learning [7].

Existing technologies utilize various visualizations to analyze the gaze. However, the visual stimulus is only provided as a visualization overlaid with the gaze data, which is less useful in the gaze analysis.

3 GAZE VISUALIZATION

We have collected the gaze data including spatial coordinates and time from the eye tracker Tobii pro X2-30 (30Hz) with Tobii Pro SDK. We introduce an overview of our data processing and proposed saliency-based gaze visualization as illustrated in Figure 1. In this work, we employ the DBSCAN with interquartile range to identify the fixation from gaze data [13]. We also extract the saliency features from the visual stimulus. The saliency features are extracted using the saliency model proposed by Itti et al. [5].

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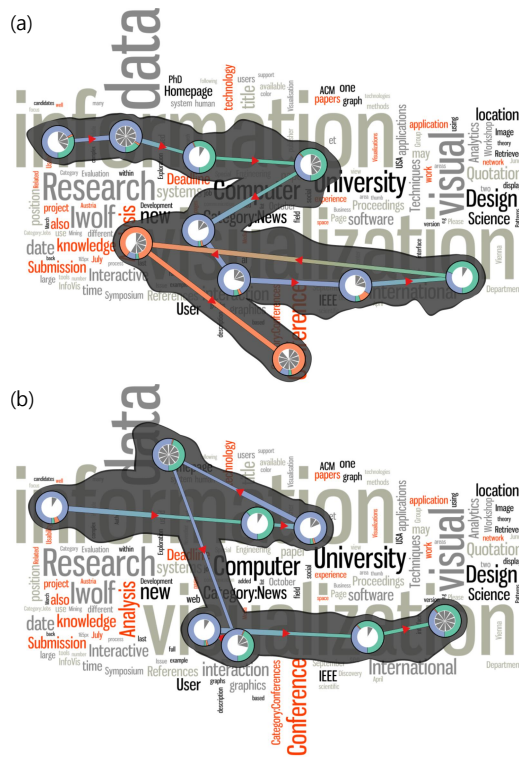


Figure 2: Gaze analysis on the tag cloud visualization.

Figure 1 illustrates the proposed saliency-based gaze visualization, which consists of a field of view in (a), a fixation in (b), a fixation time in (c), a link between fixations in (d), and the gaze direction in (e). The color encoding includes intensity, color, and orientation as blue, orange, and green, respectively. Note that, the dark gray circles rendered on the field of view are the raw gaze data points, and only the field of view is presented in the gaze analysis.

4 GAZE ANALYSIS

We analyze the influence of visual attention on gaze movements such as the search task. Figure 2 (a) and (b), we compare two gaze datasets with the same visual stimulus but with different responses from two observers. The stimulus used in Figure 2 is a tag cloud visualization¹ including keywords related to the information visualization.

We have collected the gaze data from two observers. We have also asked the observers to mark the most prominent words from the visual stimulus for 10 seconds. In this experiment, we compare the data of two observers with and without the red-color weakness to control only the color features that the observers respond to in the same environment. (b) presents the gaze visualization of an observer having a red-color weakness. In the post-experiment interview, the observer in (a) mentioned that *information*, *visualization*, and *conference* are the most memorable words, while the observer in (b) specified *data*, *information*, and *visualization*.

Both observers commonly remembered *information* and *visualization* as the prominent words, but the observer in (a) referred to *conference* and the observer in (b) referred to *data* as the most memorable word, respectively. To find the reason for the difference, we can utilize our gaze visualization with the saliency features. The saliency feature compositions of the two words are different. The most striking saliency feature in the area containing *data* is the intensity and orientation features, while the color feature is most prominent in the area containing *conference*. The observer in (b) responded sensitively to the intensity and orientation features rather than the color feature. Thus, he seems to remember the word *data*

since it contains a large amount of intensity and orientation features. On the other hand, the observer in (a) responded to all three features. He could not recognize the word *data* since *data* is not obviously prominent in terms of the saliency features while he explored the visualization. The observer in (a) continued to discover the information even after seeing the word *visualization*. Therefore, he found and remembered the word *conference*. When comparing the differences between these two observers, the observer with the color weaknesses in (b) did not respond to the color feature as compared to one without the color weakness in (a).

5 CONCLUSION

In this paper, we proposed a novel visualization technique embedding the saliency features for analyzing the visual attention of an observer through the gaze movement data. Our proposed visualization provides intuitive visual clues for the saliency features such as intensity, color, and orientation of visual stimuli in the gaze movement data analysis. In our study, we have only examined the gaze data collected from static visual stimuli. We will study a methodology for analyzing dynamic visual stimuli.

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¹<https://infovis-wiki.net/>