Gaze Visualization Embedding Saliency Features

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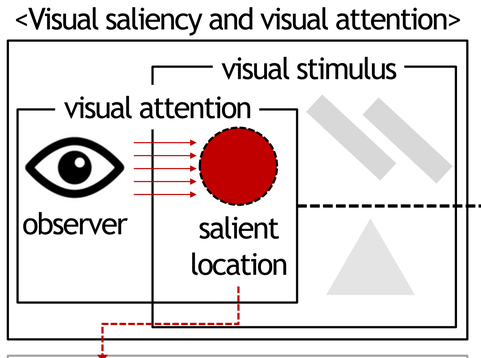
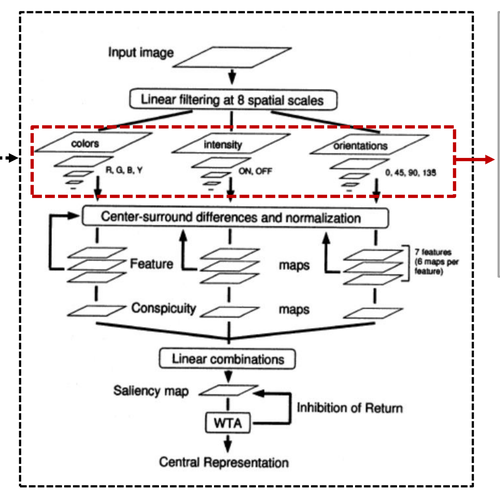
Motivation

<Visual saliency and visual attention>



Visual salience is the distinct subjective perceptual quality which makes some items in the world stand out from their neighbors and immediately grab our attention.

Visual saliency computation mechanism by Itti et al. [1]



Saliency features such as, **colors, intensity, and orientations** are used to calculate visual attention.

- The **visual salience** is a stimulus-driven signal indicating that the reference position is sufficiently different from the surrounding environment.
- In order to analyze the influence of the saliency features on gaze behaviors, detailed information, such as eye 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 for analyzing the eye movements using **saliency features as visual clues** to express the **visual attention** of an observer.

[1] L. Itti, C. Koch, and E. Niebur. A model of saliency-based visual attention for rapid scene analysis. IEEE Transactions on pattern analysis and machine intelligence, 20(11):1254-1259, 1998.

Data processing and Gaze visualization

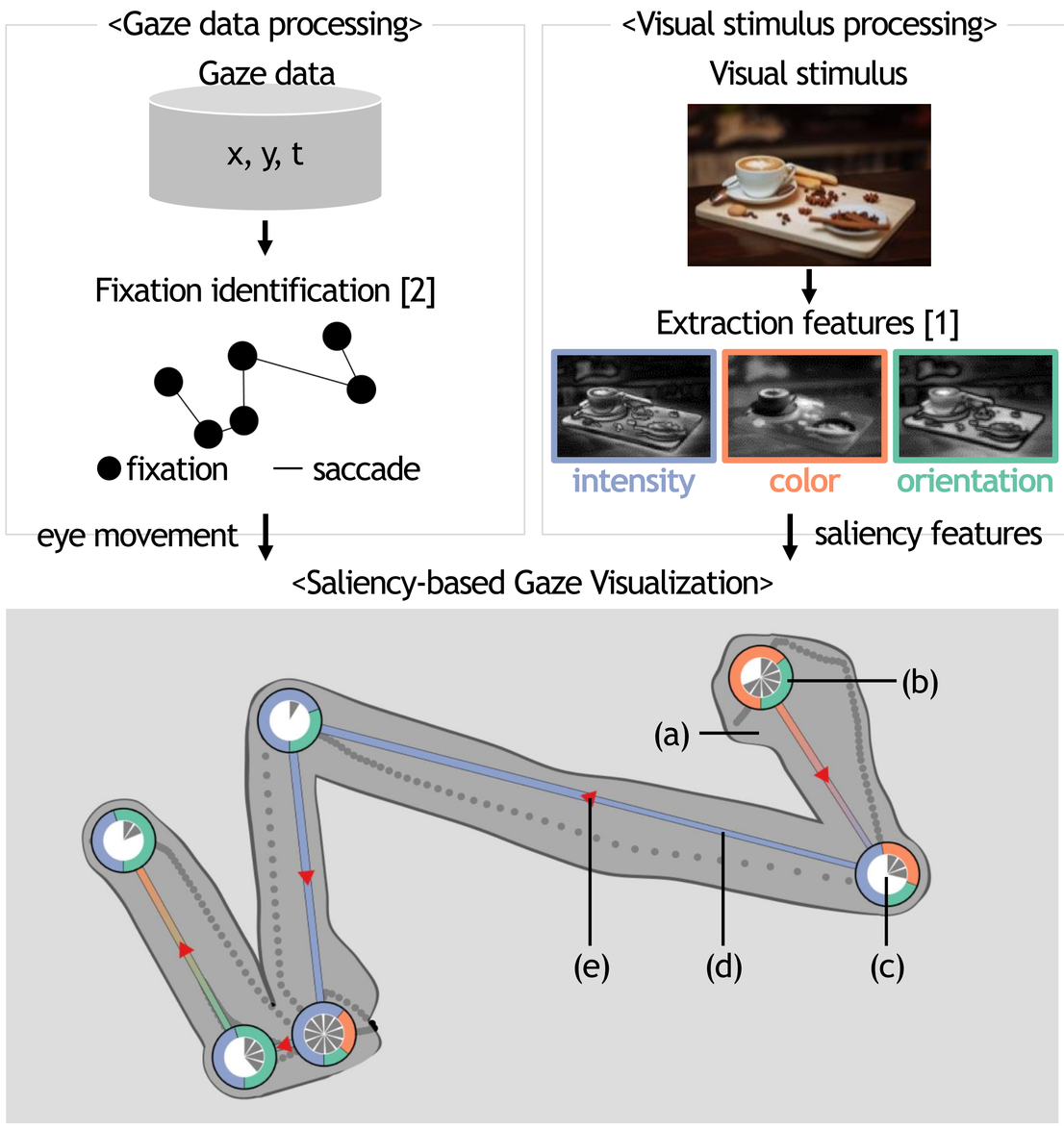


Figure 1. An overview of the data processing and our visualization

- We introduce an overview of our data processing and proposed saliency-based gaze visualization as illustrated in Figure 1.
- Implementations:
  - 32-inch monitor (3840x2160 resolution)
  - Screen-based eye tracker device "Tobii pro X2-30" with Tobii Pro SDK
- Gaze data processing:
  - We use a DBSCAN with interquartile range to identify the fixation form gaze data [2].
  - We create a scan-path with fixation-saccade.
- Visual stimulus processing:
  - We extract the saliency features from the visual stimulus.
  - The saliency features, colors, intensity, and orientation, are extracted using the saliency model proposed by Itti et al. [1].
- Gaze Visualization:
  - (a): field of view, (b): fixation, (c): fixation duration, (d): link between fixations, and (e): gaze direction
  - The color encoding includes *intensity*, *color*, and *orientation* as *blue*, *orange*, and *green*, respectively.

[2] S. Yoo, S. Jeong, S. Kim, and Y. Jang. Gaze Attention and Flow Visualization using the Smudge Effect. In Pacific Graphics Short Papers. The Eurographics Association, 2019.

Gaze analysis

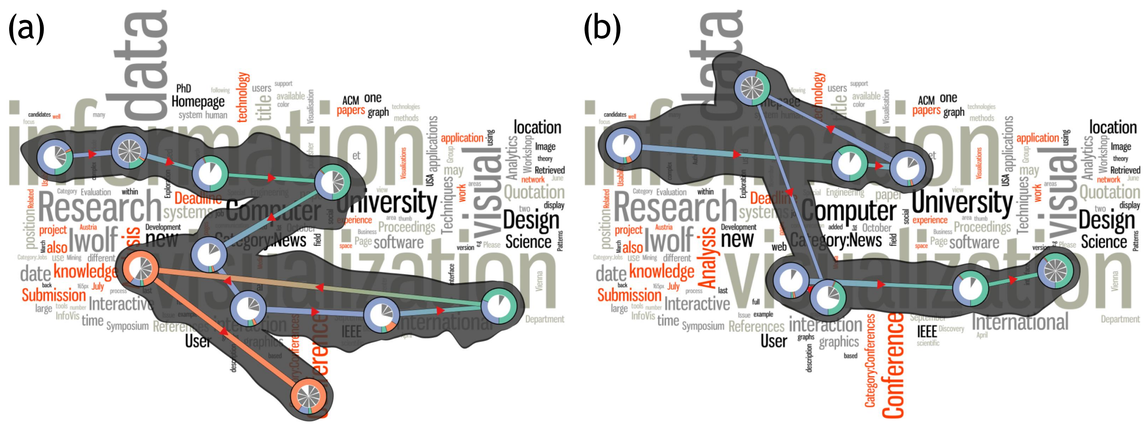


Figure 2. Gaze analysis on the tag cloud visualization

- We analyze the influence of visual attention on gaze such as the search task.
  - Figure 2 (a) and (b), we compare two gaze datasets with the same visual stimulus (https://infovis-wiki.net/) but with different responses from two observers.
  - (a) without and (b) with the red-color weakness
- In the experiment, we have also asked the observers to mark the most prominent words from the visual stimulus for 10 seconds.
  - Both observers remembered "***information***" and "***visualization***".
  - The observer in (a) referred to "***Conference***"
  - The observer in (b) referred to "***data***" as the most memorable word,
- To find the reason for the difference, we can utilize our gaze visualization with the saliency features.
  - The most striking feature in "***data***" is the *intensity* and *orientation*, while the *color* 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).

Conclusion

- In this paper, we proposed a novel gaze visualization technique embedding the saliency features for analyzing the visual attention of an observer through the eye 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.

Acknowledgments

- This work was supported by Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government(MSIT) (2019-0-00795, Development of integrated cross-model data processing platform supporting a unified analysis of various big data models) and (2019-0-00136, Development of AI-Convergence Technologies for Smart City Industry Productivity Innovation).