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弱視者のための視線計測を用いたウェブアクセシビリティの向上

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あらまし　視野狭窄のある弱視者はウェブページの必要な部分だけをスキャンする視線移動が難しい。本研究ではこの視線移動を助けるため、視線計測に基づく視野狭窄シミュレーターを用い、ウェブページの全体像把握のための視覚的なナビゲーションをデザインし、その評価を行った。
キーワード　弱視, ウェブアクセシビリティ, デザイン

Enhancing Web Accessibility for Low Vision Users using Eye Tracking

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Abstract　Low vision users with limited peripheral visual field are significantly challenged in making efficient scan path over a web page to visually locate its important regions. We design and evaluate the navigational aid for enhanced spatial contextual understanding. Throughout the process of our iterative design, we utilize a system created with eye tracking technology that offers a simulated experience of visual field loss to find usability needs.
Key words　Low Vision, Web Accessibility, Design

1. Introduction

The World Health Organization estimates that there are 246 million people living with low vision (LV) in the world today [1]. While this demographic suffers from a profound vision loss that cannot be adequately corrected, people with LV are beginning to show a high level of web proficiency with the advent of multiple assistive technologies [2]. For example, screen magnifiers that enlarge contents on a browser or screen readers that provide textual content via audio are commonly used to enhance web accessibility. However, we found limitations with the existing web accessibility tools for people with peripheral vision loss, commonly seen in LV diseases such as Retinitis Pigmentosa (RP) [3]. Based on our user study at the local job training facility for the visually impaired, they cannot grasp the general picture of a web page instantaneously with their small field of view. Moreover, RP members of the facility in the past four years make up 26.4%, representing the largest group of LV individuals.

Our work proposes to design visual navigational markers that indicate directions to specific locations on a web page. The proposed aid aims to systematically guide the user's gaze movements and as a result, support scanning behaviors of users with limited peripheral visual field. In addition, we present design possibilities of interactive, gaze-controlled interfaces for LV users. By detecting where LV users are currently looking on the web page using eye tracking, we intend to display the navigational marker on their visual field.

We take the iterative design process [4] involving user research and usability testing to discover appropriate user needs and design requirements of our proposed aid. Throughout the process, we introduce gaze-tracking-based LV simulation [5] as a key approach. We estimate the gaze of a person on a display screen and display only a small portion of content at an estimated gaze point, offering a system that simulates the "tunnel vision" environment. We analyze LV-simulated web experiences to find representative usability needs and requirements.

In this paper, we contribute to the first-hand grounding of design iterations with both LV users and simulated-LV users for the development of our web accessibility system. Based on our initial field study with LV individuals, we identified user needs and goals and defined design requirements for satisfactory accessibility solutions. We then built prototypes and tested them in two evaluation stages, involving 1) sighted individuals under simulated tunnel vision and 2) LV individuals. We evaluated whether the prototypes are actually effective and gaze-based interfaces are even feasible. Following the iterative studies, we conclude with design considerations of the navigational aid. What's more, we discuss consider-

Table. 1 Field Study Participant Description.

Subject ID	Diagnosis	Visual Condidion
P1	Retinitis Pigmentosa	• Visual field within 10 degrees • Partial color blindness • Blurry vision (Cataract)
P2	Retinitis Pigmentosa	• Visual field within 10 degrees • Partial color blindness • Night vision
P3	Retinitis Pigmentosa	• Visual field within 20 degrees • Color blindness • Blurry vision (Cataract)
P4	Right Homonymous Hemianopsia	• Blindness on the right side of each eye's visual field
P5	Optic Atrophy	• Impaired acuity

able challenges for gaze-based interfaces. As part of this, we believe that we can offer first insights to the future design of LV assistive systems that enhance web accessibility.

2. Related Work

A substantial amount of research has been done to help the LV community access existing web systems. Automatically transcoding web content for tailored UI design [6] [7], adding perceptual information such as highlights or popouts for important content [8] [9], and offering optimal audio navigation for browsing content [10] [11] have been approached. Moreover, accessibility evaluation of web pages has been an important aspect to facilitate web designers to improve their accessibility design. Following accessibility standards [12] was a common method but now simulating possible interaction patterns caused by disabilities has been introduced for the design and evaluation of assistive interfaces. Many LV simulation programs, from a simple graphical simulation [13] to a predicted model of LV simulation [14] are available. Furthermore, LV simulation has applied gaze tracking to offer real-time simulation of LV experiences [5] but this type of simulation has been assigned for simply understanding eye movements of LV individuals, not for designing and evaluating assistive systems. We will run an iterative design of web accessibility system using real-time LV simulation via gaze tracking.

3. Field Study Findings

We conducted a field study to understand LV users' attitudes and uses of the Web with existing assistive tools. We held semi-structured interviews and user observation of search tasks with 5 LV participants (3 female, 2 male) at the job training center for the visually impaired. Their age ranged from early-twenties to early-sixties, and 3 participants were diagnosed as RP but their level of progress for the disease varies. Table 1 provides a distribution of vision impairments of the participants who will be referred to as P1, P2, P3, etc in this section. In the interview, we asked questions about visual disabilities as well as habits and accessibility restrictions when using the Web. Following the interview, we observed their challenging experiences when given a task on their computers with familiar assistive tools to find contact information of the facility on its official website.

3.1 Mobile for Personal Use, Desktop for Work Use

LV participants were seamlessly adapting to the growing variety of mobile devices for their daily usage. iFamiiy devices (iPhone, iPad, and iPod touch) were used respectively by 3 of our 5 participants. Plus, the eldest participant had an Android smartphone. P2 explained the frequent use of mobile apps to check train schedules and route information and search for the platform number to navigate inside the train station. Two participants who were in their early 20s mentioned using social media like Twitter on their mobile devices.

Gaining the ability to access desktop computers revealed to be beneficial especially in the work environment. All of the participants were in training to use desktop interfaces because desktop computers are commonly used in the professional field. With their big screens, keyboards, and ability to open multiple windows, desktop computers increase productivity of performing office tasks such as creating Word or Excel documents, along with collecting information online.

3.2 Keyboard, Mouse, Fingers as Input Device

Three participants used only the keyboard. P1 stated using the mouse cursor as "stressful." The participant had to move the cursor to the edge of the screen in order to find it. However, the other two participants described more ease in using the mouse than the keyboard because they were used to performing in such a way. They tried to avoid losing the mouse pointer by magnifying its size. On the other end, P3 reported the ease of manipulating digital content under their fingers. The participant yet reported the ease of typing using the keyboard as it provided tactile feedback in identifying each key. Also, P2 described often tapping wrong links or buttons because of the natural touchscreen UI.

3.3 Usage of Web Accessibility Features

All of the participants made use of the zoom setting in the computer browser to 150% to 200%, as its default state of the entire web page. In addition, three participants mentioned the necessity of screen magnifiers that could enlarge a portion of a web page but none of them used the feature during the task observation. They instead moved up close to the computer screen.

Screen readers were found to be the back-up option; the participants would use the readers if they were unable to see the content even in the magnified setting. Interestingly, P5 mentioned that "acquiring content visually is more reliable in its accuracy than what is acquired via audio." While two participants reported relying heavily on magnification of content, the other three participants reported using screen readers but only one relied on them frequently.

The "inverted color" display setting was also mentioned for its use. The web page appears in grayscale but the color is inverted. Two RP participants articulated the need for this inverted color setting, as it offers high contrast and too much white space on the page is extremely bright to their eyes.

3.4 Concerns with Web Accessibility Features

Enlarging content or outputting audio content inhibited the participants to gain spatial contextual understanding. We observed P4 often exploring wrong links to different pages near the top of the home page, even though the target information to be searched was located in the footer section.

Also, the high magnification level of the content led to heavy horizontal scrolling, and this caused some users to lose where they were currently looking on the page. P1 described the experience of losing which line or paragraph to shift after scrolling horizontally and then moving back to the left. Similarly, while the audio interface jumped through the elements one by one starting from the top, P5 reported the inability to locate which content on the page was being read.

The quality of searching for information was high with screen readers, provided that the two participants who made use of the tools were able to accomplish the task. However, P5 who relied on the screen reader double checked by seeing if the audio content the participant found was actually correct. The participant added that: "I prefer to see with my eyes if I want to accurately perceive the information." In addition, the eldest participant had the most progressive condition of RP but did not utilize the screen reader. Due to the participant's age and experience with computers, screen readers were harder to access, requiring more in-depth training and cognitive effort than screen magnifiers.

4. Proposed Designs

We propose a route-based system that visually offers navigation information (e.g. directions, distance) in reaching important regions of a web page on the desktop interface and allows for comprehending the global picture of the page. Furthermore, our target audience of the system are those with limited visual field especially in their periphery because they are most challenged in receiving spatial contextual information with their "tunnel" view. Since every web page has a different layout and content, we will not propose detailed solutions in detecting the regions to locate. They could be brand logos, navigation bars, headings and sub-headings, or pictures. Also in what order we guide users to these regions influence the comprehension experience. We thus focus on the design elements of the visual navigational aid where the regions to scan are predefined.

We have come to this design proposal considering three key requirements revealed through our field study for enhanced web accessibility. One requirement is to support scanning behaviors so that the target users can efficiently shift their gaze to locate the salient regions of the page. Another key requirement is making great use of their residual vision. Perceiving the overall layout of an existing web page strongly requires their visual effort, and receiving visual content even with their remaining vision is faster in information processing and more intuitive compared to audio content. Third key is facilitating desktop interaction; accessing information through desktop computers is crucial for LV individuals when seeking employment.

Importantly, we articulate gaze-controlled applications, which we display the navigation aid over their remaining central visual field. As seen in the case of mouse pointing and content scrolling or panning, users with limited visual field often lose finding necessary information located outside of their visual field. Eye tracking technology thus serves as a significant element in facilitating a natural UI where less physical and cognitive demands are employed compared to the interaction with the mouse or touch.

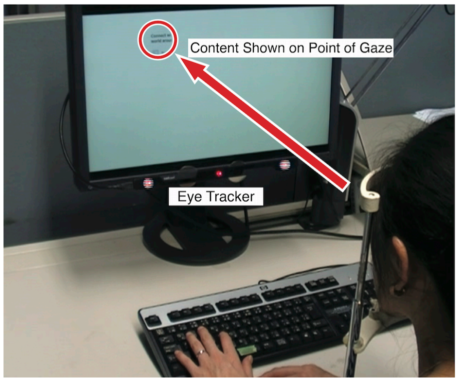

Figure. 1 LV simulation setup.

5. Low Vision Simulation

Another field of application for gaze tracking other than the proposed navigational aid is the simulation system of our target LV condition. Even though we aim for a participatory design process with the target users, this is significantly difficult considering the high cost of involving LV participants in the iterative studies and the nature of varying LV conditions. We thus enable the sighted users to actively participate under simulated-LV web experiences. As shown in Figure 1, we highlight only the "tunnel vision" under a five degree field of the content in the point of view on the desktop interface. The main reason for simulating such particular condition is that it would lead to another usability problem other than scanning inabilities if we focus to include other visual factors such as blurred vision or light-sensitivity. Moreover, the five degree central field of view appropriately visualizes the challenge of visual field loss of our target users.

5.1 Apparatus

Gaze tracking is provided by a commercially-available eye tracking peripheral called Tobii EyeX. It can be mounted below the bottom of both desktop and laptop screen sized up to 27". The device allows for sight correction where calibrations can be done under one eye or both eyes, and with or without corrective lenses. In our work, the device is connected to a Windows laptop and positioned on the bottom of the 22" monitor and 60cm away from the user. The computer receives real-time gaze data via the UDP connection built over openFrameworks.The simulator is developed under the Processing environment that receives the data with the rate of 60 frames per second.

5.2 Evaluation of LV Simulation

Before employing the simulator in iterative prototyping and usability testing, we evaluated the effectiveness of the system, whether it actually illustrated the challenging experiences of tunnel vision. We recruited 12 sighted individuals and asked them to conduct visual search tasks on websites under LV-simulated and regular viewing scenarios. To reveal the impact of the simulator on the participants' behaviors, we measured the frequency of large gaze shifts made over a five degree angle in a certain time frame for each web page session. The participants first viewed two web pages under the LV simulator and then the other two pages on a fullscreen display. They searched for 5 predefined regions per web page. The order of given web pages were randomly provided using

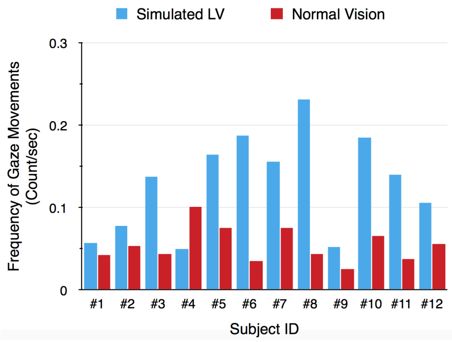

Figure. 2 Distribution of large gaze shifts (over a five degree angle) made by 12 subjects under simulated LV and normal vision.

Latin squares. We aimed to see the difference of how their gaze moved to complete the search tasks with tunnel vision.

5. 2. 1 Evaluation Results

The frequency distribution of large gaze shifts is available in Figure 2. Based on this data, the pairwise Wilcoxon signed ranks test revealed a significant effect when the participants conducted the search tasks under the LV simulator compared to the performance done without the simulator. The pairwise significance ($p \approx .00001$) was measured.

5. 2. 2 Evaluation Analysis

The simulator was able to impact gaze behaviors of the participants. We analyzed that due to the small field of view provided by the simulator, the participants made large eye movements to compensate for the lack of spatial contextual information. They had to move their gaze more frequently across a web page to understand the general picture. In contrast, they can comprehend the overall layout of regular visual interfaces almost instantaneously, with less large gaze movements are required for scanning the page.

6. Prototypes

We developed five interactive navigational markers, as shown in Figure 2, that become visible over web content. Each of them (labeled as N1, N2, N3, etc.) represents graphical based information that indicates the direction and distance from their current viewing region to the predefined target region. By providing such navigation information, we aim to support users in achieving efficient scan path to locate interesting parts across the page. To explore if gaze-based navigational markers can be actually used, the prototypes were built under two categories where three aids utilize gaze tracking and the other two function independently from gaze tracking.

The gaze-based markers, from N1 to N3, are visible on the detected area of the point-of-gaze, and their interface changes adaptively depending on the current gaze location in respect to the target region. N1 has a shape of an arrow which points the direction towards the target region. Its movement within a short distance becomes faster as it gets close to the target and slower as it gets further away from the target. N2 has a shape of a compass stick without a pointer that shifts its direction towards the target. How far away from the target is visualized by the thickness of the stick: the further away, the thicker it gets. N3 shows the current gaze-estimated region in inverted colors. As the visual field gets closer to the target region, the inverted color display is represented close to a 360 degree circle, and the angle gets less (visualized more like an arc) as the visual field gets far away from the target. Direction can also be indicated by the amount of inverted-color region shifted towards the target.

N4 and N5 are displayed over the whole window of web content. N4 has a radial design where lines branch out starting from the target region in a circular way. Tracking the lines can lead the vision to reach the target, and the distance is represented as the lines become densely packed near the target and sparse when far from the target. N5 has a vector field design which visualizes a collection of arrows with a given magnitude and direction depending on the location of the target.

7. User Testing

The prototypes were evaluated through two stages of user testing with different sets of participants (Test 1: Twelve sighted individuals under simulated tunnel vision, Test 2: Six LV individuals). The common protocol for both tests was that the participants were asked to complete six stages of visual-search tasks, each performed under one of the six experimental conditions (five types of navigational markers and no use of marker). We also launched the calibration program offered by Tobii EyeX and made sure to check the calibration accuracy in prior to the task per stage. For the task, the participants pressed a SPACE key to display the navigational marker and F key once they found the specified region to search. The Latin square was used to counterbalance the order of the prototype presentation to reduce learning or fatigue effects. At the end of every stage, the participants were asked to answer rating questions regarding their task done on a scale of 1 to 6 with no middle rating, though the questions vary slightly between the two tests. After finishing all of the stages, the participants ranked the five prototypes plus the state of having no visual aid (with 6 being most likely to use again to complete search tasks).

7. 1 Test 1: With Simulated Low Vision Users

The sighted participants (9 males, 3 females) were assigned with two sets of visual-search tasks per experimental condition were assigned. Task 1 was to find 5 red dots displayed sequentially over a white screen, whereas Task 2 was to find 5 regions specified by an experimenter one at a time over a webpage image. The objective of this user test was to evaluate the UI elements of the prototypes while controlling individual visual differences that could heavily influence the evaluation data. From Task 1, we asked the participants to rate the ease of direction and distance (6 = very easy, 1 = very difficult) for each navigational marker to reveal the usability needs when users registered graphical based information without getting impacted by web content. In addition, the ease of task under the condition of with and without markers was rated for both Task 1 and 2. We also asked the participants whether the markers were distracting (6 = unobtrusive, 1 = obtrusive) when accessing web content in Task 2.

7. 2 Test 2: With Low Vision Users

RP participants (3 males, 3 females) were recruited and asked to conduct Task 2 per experimental condition. The

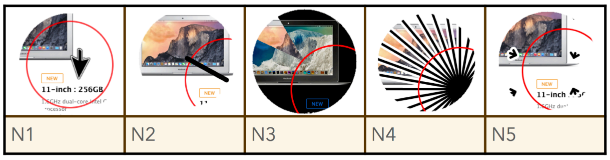

Figure. 3 Prototypes. Red circle indicates the target region.

Table. 2 Results of Wilcoxon signed-ranks test for user test evaluation. Experimental condition (L / R) with higher significance is indicated by p-values aligned to the left or right, or by a red or blue highlight respectively. The color opacity reflects its level of significance, likewise noted by “**”($p \leqq .01$), “*” ($p \leqq .05$), & “ † ” ($p \leqq .10$)

	Q1: Ease of Direction	Q2: Ease of Distance	Q3: Ease of Task			Q4: Unobtrusiveness		Rankings		
Task	1	1	1	2	2	2	2	1	2	2
Subjects	Non-LV	Non-LV	Non-LV	Non-LV	LV	Non-LV	LV	Non-LV	Non-LV	LV
L R										
N1 / N2	.13	.04*	.85	1.00	1.00	.39	.77	1.00	.23	.24
N1 / N3	.02*	.39	.08†	.01**	.59	.04*	.17	.50	.06†	.09†
N1 / N4	.85	.04*	.21	.66	.09†	.20	.85	.23	.55	.04*
N1 / N5	.41	.04*	.48	.10	.20	.05*	1.00	.58	.63	.52
N2 / N3	.46	.08†	.27	.05*	.42	.03*	.09†	.64	.69	.53
N2 / N4	.23	.82	.10	.42	.05*	.03*	.75	.19	.84	.09†
N2 / N5	.04*	.90	.45	.40	.50	.06†	.89	.64	.55	1.00
N3 / N4	.02*	.10†	.03*	.03*	.18	.93	.42	.09†	.41	.40
N3 / N5	.01**	.04*	.05*	.22	.59	.59	.37	.38	.38	.67
N4 / N5	.24	.92	.30	.21	.78	1.00	1.00	.24	.78	.09†
N1 / None			.01**	.00**	.41			.07†	.02*	.03*
N2 / None			.01**	.01*	.29			.15	.10†	.06†
N3 / None			.02*	.24	.28			.19	.11	.04*
N4 / None			.01**	.01**	.05*			.12	.12	.03*
N5 / None			.01**	.10	.10			.04*	.04*	.14

objective of this user test was to see if the prototypes are even usable for our target users in locating specified regions on a webpage image. In addition, we aimed to evaluate the experience of LV users interacting with gaze-based applications. As given in the first user test, we asked verbally to rate the ease of search task and whether the markers were distracting.

7.3 Results and Findings

As presented in Table 2, Wilcoxon signed-ranks test was run to define statistical significance when comparing two sets of the experimental conditions. We analyzed these results to find usability needs that users seek from our prototypes.

7.3.1 Effectiveness of Navigational Aid for Search Task

Our proposed navigational aid was found to impact the search-task experience of the participants in a positive manner. Based on the Q3 rating of prototypes in comparison with having no navigational marker for sighted participants, all of the prototypes revealed significance ($p \approx .01$ except for N3: $p \approx .02$) in completing Task 1, and likewise N1, N2, and N4 showed significance ($p \approx .01$ except for N1: $p \approx .00$) in completing Task 2. In the case of Q3 rating by LV participants, only N4 showed statistical significance when compared with None ($p \approx .05$). However, their ranking of prototypes revealed that they would use the navigational markers except N5 for Task 2. Statistical significance was shown in comparison with their preference of having no visual marker (N1: $p \approx .03$, N2: $p \approx .06$, N3: $p \approx .04$, N4: $p \approx .03$). Interestingly, one LV participant left the experiment room saying “I definitely need the guide, or else I can’t find it.”

7.3.2 Need for Global Path for Search Task

The majority of user test participants showed preference towards using the navigational markers that guide the global path to the destination and do not reflect on where they were currently looking on the screen (e.g. N4, N5). For Q3, in completing Task 1, statistical significance was revealed for N3/N4 ($p \approx .03$) and N3/N5 ($p \approx .05$), with a higher ease-of-task rating on N4 and N5. In addition, for Q3 rated by LV participants, only N4 showed a strong tendency towards statistical significance when compared with N1 ($p \approx .09$) and significance when compared with N2 ($p \approx .05$). In terms of registering direction and distance information from the prototypes, statistical significance was revealed from N3/N5 ($p \approx .01$), N3/N4 ($p \approx .02$), and N2/N5 ($p \approx .04$) for Q1, and N1/N5, N1/N4, and N3/N5 ($p \approx .04$) for Q2. This indicated that identifying graphical information that was fixed on the screen required less cognitive and perceptual effort compared to the versatile indication of directions and distance offered by gaze-based interfaces.

7.3.3 Need for Unobtrusive UI for Sighted

Sighted participants yet showed a lack of favor for global map interfaces when presented over images in Task 2. For Q4, N1 was significantly higher than N5 ($p \approx .05$), and N2 was significantly higher than N4 ($p \approx .03$) and showed a significant tendency over N5 ($p \approx .06$). The participants found N4 and N5 distracting since they overlaid the overall content at once, whereas N1 and N2 were more preferred when perceiving content. Even though the purpose of this user test was to find whether the prototypes could lead them to the target regions, the obtrusive quality of the UI could hinder accessing web content. Therefore, based on the prototype ranking by the sighted, a significant tendency was found in N3/N4 ($p \approx .09$) reflecting the higher rating of a global map interface in Task 1, as well as in N1/N3 ($p \approx .06$) indicating the higher preference on the less distracting interface in Task 2. We could also notice that N3 received the lower usability rating under both task scenarios because the sighted participants were least adapted to seeing inverted-colored content and distracted with its visual interface.

7.3.4 Need for Noticeable yet Unobtrusive UI for LV

In contrast with the results from sighted participants in Task 2, N1 and N2 were found to receive low preference over N4 by LV participants. Based on their prototype ranking, a considerable trend towards significance was revealed for N1/N4 and N2/N4 ($p \approx .09$). They articulated N1 and N2 to be difficult to detect because they blended in with the background content. The participants yet did not get attracted to the other kind of the global map interface (N5) as many of the participants reported the arrows to be distracting. N5/None in the prototype ranking thus did not reveal any significance. In addition, out of all of the gaze-based interfaces, N3 was revealed to be useful unlike the prototype ranking given by the sighted. N1/N3 showed a significant tendency ($p \approx .09$) because the inverted-colored interface was easy to notice under actual low vision with a loss of visual acuity and clarity.

8. Discussion

8.1 Design Elements of Navigational Icons

We noticed that using obtrusive or enlarged markers gives poor web browsing experience by hindering the content appreciation but offers great performance in reaching the goal of finding target regions. This phenomenon represents the goal-oriented versus task-oriented behaviors of our users of the navigational aid. LV users tend to behave in a goal-oriented manner whereas sighted users tend to be task oriented when scanning and locating target web content. Even though a simple layout of N1 or N2 that does not interfere with web content visibility is preferred by sighted users, prominent design offered by N3 or N4 is crucial for LV users to accommodate for their loss of visual acuity and clarity when achieving their task goal. However, complex layout such as in the case of N5 with arrows of varying sizes is found to be distracting yet still hard to track under low vision.

8. 2 Design Considerations for Gaze-Based Interfaces

In supporting scanning behaviors of LV users, we discuss that there has to be a balance between the needs to present spatial contextual information and the ability to perceive the content-of-interest itself. For visual-search tasks, giving instantaneous global representation of the direction path to the destination is efficient. This helps the users to locate important parts of the page necessary to understand the spatial context but it does not assist them to perceive the content located by their vision. We thus need to consider how gaze-based interfaces can be applied for enhanced perceptual experience of web content. If a user wants to immediately search for a section on a web page with contact information, the "radial" aid would be a better choice than the "inverted color" aid. However, once reaching the contact section, if the user wants to find a telephone number, the "inverted color" aid would be a better choice to actually pick out the information. Adaptive visual guides using gaze tracking become useful when we want to perceive higher detailed information within a small region.

8. 3 Design Tactics with LV Simulation

To incorporate LV simulation in the design process of LV assistive technology, the system needs to enable the configurability of multiple visual conditions. The LV simulator is useful considering the high cost of involving LV users for accessibility evaluation and controlling heterogeneous visual conditions for the evaluation data. However, this is still limited in achieving our design goal; as we allow the users to locate parts of a web page through the navigational icons, we need to offer them the ability to perceive located regions. Moreover, user tests revealed that how sighted participants found some design elements distracting was different from that of LV participants. It is thus necessary for the simulator to visualize the experience of varying visual parameters and test prototypes under each parameter to bring about idiosyncratic needs related to web accessibility.

9. Conclusion and Future Work

This paper presents an analysis of qualitative and quantitative findings from the iterative user studies in designing a web accessibility system for LV users. Our unique contribution is that we incorporated simulated-LV users in the studies. This work provides a starting point for utilizing the LV simulator in the process of iterative prototyping and usability evaluation. Moreover, we propose eye tracking technology as a feasible tool for our target users in facilitating gaze-based interaction.

We believe that the interactive navigational aid is a new paradigm for assisting in locating and perceiving important parts across the page for enhanced web accessibility. It is then crucial to find methods to detect the regions to locate for spatial contextual understanding. In our future work, as researched in [15], we will collect gaze data from sighted users when seeing the page and analyze important regions of the page. We will also enable the simulator to offer varying visual factors such as blurred vision or light-sensitivity to consider multiple usability problems in perceiving scanned content. We aim to repeatedly test the redesigned prototypes with both LV and simulated-LV users and hope to provide LV users with efficient scanning to access the global picture of the web page for its general ideas and layout.

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