A User Study of a Gaze Window User Interface

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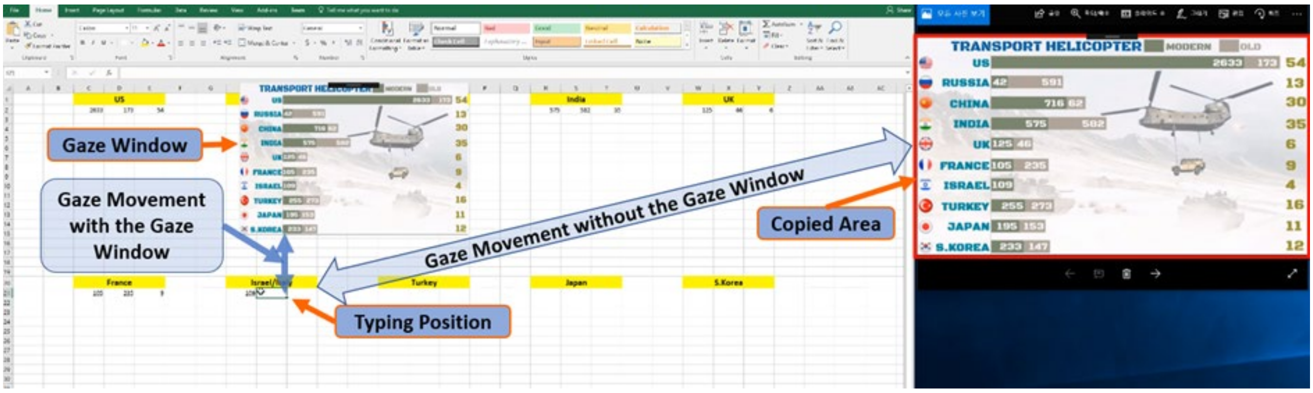

Fig. 1. A user types into a spreadsheet base on the information from the right image

***Abstract*— We have proposed a proof of concept of a gaze window interface. A gaze window interface uses the user's gaze point to show the relevant content nearby the current gaze point. A system of a gaze window interface has been implemented that allows users to manage looking at multiple objects of interest on the screen while the system is responsive to the user's gaze points with relevant information shown in the gaze window. We also conducted user studies to investigate the effects of the interface on user performance and behaviors. In this paper, we report on a user study in which the gaze window was compared with a mouse window for supporting single user data entry tasks. We describe details of the study design and conduction and present the results.**

Keywords*— *Gaze window; mouse window; eye tracking; eye movement; user interface.

I. INTRODUCTION

Nowadays, the gaze tracking technologies has become increasingly advanced and affordable [2, 8, 9]. More and more eye tracking tools and system have been developed to help users with natural human computer interaction and with disabilities. More specifically, eye gazes have been used for data inputs and for interaction methods.

In designing a gaze interface, Jacob [7] reported on the Midas Touch problem. Because a fixation can be used either for perception or for interaction, a user cannot look anywhere without the triggering the interactions if interactions are made with every eye fixation on the objects in the scene. To fix this problem, the system should distinguish between observing gaze and interaction gaze behaviour. To do this, the authors used the dwell time interaction which distinguishes the interaction gaze from observing gaze by the time the user gazes on an object or area. Jones et al. [6] conducted a study that compared the performance eye gaze tracker with that of two other methods in control of robot arms. Some other researchers used gaze for controlling the view when looking at the edges of the screen or virtual arrow buttons [10, 11].

Recently, we have proposed a novel proof of concept of gaze window interfaces [1]. The proposed gaze window follows movements of the user's eye gazes and displays in the window the information that is of the interest. In a previous study [1], we have investigated the pros and cons of showing the remote partner in the gaze window in supporting tele-conference tasks. It was found that showing a partner's headshot close to their gaze point helped users feel a higher level of emotional interdependence. Baris et al. [5] used gaze to display an area of user interest close to the user gaze. However, their study was limited to touch screen interface and did not exploring displaying partner close to the user gaze in a teleconferencing system.

In this paper, we present a user study exploring how gaze window can help with single user data entry tasks, in which we compared the gaze window condition with a mouse window for usability and task performance.

II. THE EXPERIMENT

To investigate benefits of our gaze window system for usability and task performance, we conducted a user study for a single user data entry task. In this section, we briefly describe the systems we developed for the user study and the details of the experiment.

A. The gaze window and mouse window systems

The gaze window is a viewport in a graphical user interface. This small window indicates an area where the

TABLE I. THE RESULTS OF THE TASK COMPLETION TIME, AMOUNT OF GAZE MOVEMENT ON THE SCREEN, SUS, AND SMEQ

	Mean (*Std.Dev.*)		Method	Result
	MW	GW		
Completion Time (in seconds)	316 (101.3)	311 (109.9)	Paired t-test	$t(7)= .345, p=.740$
Gaze Movement (in pixels)	110207 (15664)	104871 (14208)	Paired t-test	$t(7)= 1.163, p=.283$
SUS	78.1 (6.6) - Good	77.5 (16.0)- Good	Wilcoxon	$Z = -.070, p = .944$
SMEQ	9.51 (4.99) - not very hard to do	11.81 (11.77) - not very hard to do	Wilcoxon	$Z = -.368, p = .713$

user's interest is. The window is to follow the movement of the user's gazes within the interface. It is close to their gaze point where the next area of user interest is displayed. We have proposed 7 design requirements for gaze windows [12]. They are:

- The gaze window content should be pre-defined
- The gaze window and gaze point should be next to each other
- Gaze inputs and gaze movement should be distinguished
- An area to accommodate gaze dwell should be determined
- Gaze window should not block the gaze view
- Gaze fixations should not cause gaze window to move
- The size of gaze window should not be too big or too small

Based on these requirements, we developed a gaze window system. The system was developed to use a series of hardware components to make the gaze window working as required. The hardware we used included a desktop computer with an Intel Core i7-7700K 4.2GHz quad core CPUand a NVIDIA GeForce GTX 1070 graphics card. To track the user's eye gaze, a desktop eye tracker was also used. As the user task for the experiment is more about looking at multiple objects and typing data from left to right, the gaze window was positioned above or below the gaze point. Figure 1 shows an screenshot of the gaze window interface.

For the mouse window condition, we used drag and drop interactions to move the mouse window. Apart from the interaction method for moving the window, the other factors were same with the gaze window.

The gaze window and mouse window were always on top of the screen, so a user could see them while opening other windows or application.

B. *Participants*

We recruited 8 participants (6 males and 2 females) aged 24 to 39 years old (*Mean* = 29; *Std.Dev.* = 4.8). Three of them did not know about eye tracking systems, one had heard about them but had not used them before, and four participants had prior experience of using eye trackers.

C. *Experimental procedure, task and hypothesis*

The experiment has two conditions: (1) the gaze window and (2) mouse window conditions. A within-subject design was employed, which means each participant needed to perform the task in both conditions.

The task was to read data from an infographic image and enter the data into a spreadsheet displayed on the left screen with either the gaze window or mouse window. Overall, the task included 215 and 216 key inputs and 111 and 109 cell selection.

The procedure is: participants first signed the consent form, answered a demographic questionnaire, and then was informed of the purpose of the study. The participant sat in front of a desktop and used a mouse and a keyboard to complete the data entry task. The task was performed in both the gaze and mouse window conditions. After that, two questionnaires was distributed. The participants need to answer two questionnaires: a questionnaire, SUS, was about the system usability and the other questionnaire, SMEQ, was about their mental effort during the task performance. They were also asked about their preference between the two systems and the reasons for the preference. In addition to responses to the questionnaires, objective measures such as the amount of gaze movement and task completion time were also collected for data analysis.

We hypothesize that the gaze window and mouse window conditions have different benefits and disadvantages.

III. RESULTS

For convenience, in this section, we use the abbreviations GW and MW to represent the gaze window and mouse window conditions respectively. Since the data of the task completion time and the amount of user gaze movement were normally distributed according to Shapiro-Wilk tests (completion time: GW - W(8)=.938, p=.453, MW - W(8)=.892, p=.225; gaze movement: GW - W(8)=.950 p=.716, MW - W(8)=.913, p=.373), we analysed them using a paired t-test (α = .05). For the data from questionnaire, we used the Wilcoxon Signed Rank test (α = .05). Table 1 shows the results.

Interestingly, the gaze window did not produce a benefit compared to the mouse window (see Table 2). There was no significant difference in task performance between the GW and MW conditions in a paired t-test ($t(7)$=.345, p=.740). On average, participants completed the task in 316 seconds (SD = 101.3) with the MW condition, and in 311 seconds (SD = 109.9) with the GW condition. They made very few typing mistakes, eleven with the MW and twelve with the GW. The amount of gaze movement in the screen space (in pixels with the resolution of 1920 by 1080) also did not show a significant difference between the two conditions (t(7)=1.163, p=.283). The participants' gaze moved 110207 pixels (SD: 15664) on average with the MW condition and 104871 pixels (SD: 14208) with the GW condition.

From the SUS rating, the average score of the GW condition was 77.5 (SD: 16.0), which is in the range of 'GOOD' in the adjective rating by Bangor [51]. The MG condition had an average of 78.1 (SD: 6.6) which is also in the range of 'GOOD'. A Wilcoxon signed ranks test showed that there was no significant difference between the two conditions in usability (Z = -.070, p = .944).

The results of SMEQ also showed similar trend. Participants did not feel a significant difference in required mental effort when using both conditions (Z = -.368, p = .713). The average score with the GW condition was 11.81 (SD: 11.77), and with the MW condition it was 9.51 (SD: 4.99). Both conditions in the range were referred to as 'not very hard to do'.

Participants were equally split into two groups according to their preference. Four of them preferred the GW condition and the other four preferred the MW condition. This may come from the advantage and disadvantage of each condition and the typing style of the participants. Regardless of the conditions, two participants (participant 4 – P4, and P6) reported the usefulness of positioning the window close to where they typed in, so having less gaze and head movement.

The reported benefit of the GW condition was that participants were not disturbed by using the mouse for positioning the window but kept the benefit of close display of the content. Comments from participants about these benefits are "I feel the gaze is easy for me to finish the task, while the mouse one is distracting me" by P1, "Easy to focus on typing rather than moving the window by a mouse" by P2, "Window was following gaze and moved to adequate position" by P3, and "I do not use mouse any more" by P4. Some participants were satisfied with the gaze-following function as they commented "eyes movement detecting was great" by P6, "move with gaze is interesting" by P7, and "The eye track function makes it more convenient to read" by P8.

The disadvantages of the GW were sudden movements because participants could not exactly know when the system started the gaze dwell time and started moving the window, and slow response with the dwell time. Comments from participants about these drawbacks are "I finished the task (typing data) quickly, but the window was too slow and sometimes moved suddenly" by P2, "Could not predict when the window will start moving" by P3, "slow updating sometimes" by P5, and "The eye track function has a few second delay" by P8.

One of the interesting comments from P1 was that "the tracking sometimes did not work and resulting in the window not moving." However, according to our observations, this was because of his typing behaviour involved having a comparably short time looking at the target cell to type in but longer-time looking at the keyboard. This also happened to P2, because he spent most of the time looking at the information image while quickly glancing the target cell to check his typed numbers. We note that the unmoved window issue did not happened frequently; twice for P1 and three times for P2. After encountering this issue, they tried to change their typing pattern to look at a target cell to move the gaze window accordingly.

In the participants' comments, the main benefit of the MW condition was being more predictable and controllable than the GW condition, which sometimes suddenly moved according to user's gaze. P1 reported that "I like controlling everything by myself (with MW condition). The gaze interface automatically moves the copied view, but its sudden move was annoying" and P6 commented that "I could control the window as I needed". However, this benefit required additional mouse interaction during the typing task and it was cumbersome to participants doing the task. P1 mentioned that "moving the window manually sometimes distracted me (doing task)" and P5 reported that "It is annoying to move the window while typing with a keyboard".

IV. Concluding Remarks

Compared to the mouse window, the benefits of the gaze window were not revealed in the questionnaire results. However, from the qualitative data, we found a difference between the gaze and mouse windows, and participants were split in the preference between them. Some participants liked the gaze window condition because they did not need to use mouse inputs but could focus on only key board typing inputs. The others liked the mouse window condition because the mouse window condition was more controllable compared to the gaze window condition. Thus, our hypothesis that gaze window and mouse window conditions have different benefits and disadvantages is supported.

It should be noted that the experiment has limitations. For example, our sample size was small. We only had 8 participants. Given the difficulty in accurately tracking eye movements which is often the case in general eye-gaze focused human computer interactive systems and the difficulty in controlling how participants performed data entry tasks in a coherent way, it is likely that there were large variations in the measurement data which could affect the analytical results. Future studies are needed to recruit a large sample of participants and test whether our findings could be replicated.

In summary we conducted a user study to evaluate a novel concept of a gaze window interface that copies and displays an area of user interest close to the user gaze point for supporting single user data entry tasks. In this experiment, the gaze window has similar performance compared to the mouse window in terms of user task completion time and usability. This was because both gaze and mouse windows had different benefits and participants were split between two conditions in terms of their preference.

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