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Evaluating Gaze-Based Interfaces for Map Interaction

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Abstract:

How will we interact with maps in the future? We can take for granted that technical evolution will bring changes to human computer interaction (HCI). Advances in eye-tracking hardware have made eye-trackers smaller, affordable and more accurate, thereby enlarging the potential of gaze-based map interaction (Liao et al., 2022). Furthermore, eye-tracking is becoming possible with common webcams. Webcam-based eye tracking can be viable and low-cost alternative to specialised infrared eye tracking hardware (Wisiecka et al., 2022). Whatever technical advancements will bring, one thing will remain - we will always be reading maps with our eyes. As we scan maps with our eyes to collect cartographic information and detect map tools, it seems natural to use an eye-controlled interface for map interaction.

This work evaluates performances as well as user experiences of gaze-based map interaction. Two sets of completely gaze-controlled as well as gaze-assisted interfaces have been implemented. Three gaze-based map interfaces were implemented to a standard desktop computer with an eye-tracker. These consist of a purely eye-controlled navigation, a gaze-based interface with keyboard assistance, as well as a conventional keyboard and mouse interface for comparison (Serrao, 2020). A further three gaze-based map interfaces were implemented into Mixed Reality (MR) using see-through head-mounted MR glasses. For the MR environment the set of interfaces had to be adapted to conventional hand gestures and gaze-based interfaces. The MR interfaces are set up as purely gaze control, a combination of gaze and voice control and one interface controlled by hand gestures (Kurumbayeva, 2021).

The gaze-based map interactions have been evaluated by user testing. 16 participants took part in the desktop computer experiments. 22 participants took part in the MR experiments. The users performed map controlling interactions, such as panning, zooming and rotating, as well as information retrieving actions.

Each user had to complete a set of navigating tasks on the desktop computer for each of the three interfaces. Table 1 shows that the mean completion times were lowest using conventional mouse and keyboard interface. The map interface taking the user´s gaze to direct interaction triggered by keyboard buttons was 2nd lowest at around 30% longer completion time. This was rather promising considering it was a new way of HCI for all test persons. However, the purely eye-controlled navigation shows the longest mean completion times with some very high single user completion times.

	Gaze control	Mouse and keyboard	Gaze and keyboard
	Navigating tasks	Navigating tasks	Navigating tasks
Min	34,8	20,0	22,8
Max	501,0	148,9	234,3
Mean	209,8	64,8	99,9

Table 1. User completion times on the desktop computer for the navigating tasks [seconds]

The user task completion performances of different interfaces in MR were more close to each other (see Table 2). Notable is that the completion time for a combination of gaze and voice control is lower than for gaze control only.

In the following survey it showed that the desktop computer interface using the user´s gaze to direct interaction triggered by keyboard buttons required less mental and physical demand by the users than a gaze-only interface. These findings are similar to the MR experiment results. Here, the interface using a combination of gaze and voice control required less mental and physical demand by the users than a gaze-only interface (see Figure 1).

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	Gaze control – Overlay	Hands control – Overlay	Gaze and voice control – Overlay
Min	7,3	6,1	5,7
Max	39,3	66,2	23,6
Mean	14,3	15,4	13,7

Table 2. User completion times MR for the Overlay task [seconds]

One main conclusion is that the user´s performances were very similar in both environments in regard to the gaze-based level of interaction. Gaze-assisted interfaces enabled generally faster average completion times for the same tasks as with a gaze-only controlled interface. This is partly down to the Midas touch in purely eye-controlled map interactions. Based on this work, gaze-assisted interfaces seem to be more promising as well as notable for future map interaction interfaces.

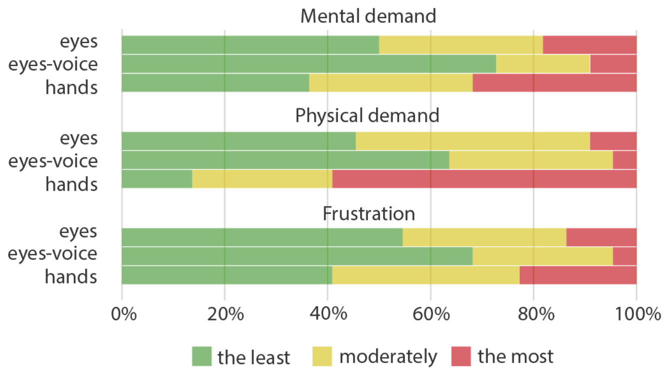

Figure 1. Task load results for MR interfaces: mental demand, physical demand and frustration.

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