Lost & Found: Gaze-based Player Guidance Feedback in Exploration Games

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Abstract
Gaze could be harnessed as a powerful tool for guiding players. By knowing where players are looking, a game could provide support players in finding relevant objects. With this assumption in mind, we made our first steps regarding the investigation of gaze-supported player guidance in a 3D first-person exploration game prototype called *Lost & Found*. Specifically, we investigated the feedback channels that could be combined with a gaze-based guidance approach. A comparative study was carried out to examine the impact of visual (i.e., vignette effect on screen), auditory (i.e., sound cues), and haptic (i.e., controller vibration) feedback on the players' game experience. Results show that visual and audio feedback appeared to be very appealing for players, While haptic feedback received relatively low scores. The next steps involve the development of more elaborated variants of the visual and auditory feedback.

Author Keywords
Player guidance; gaze-based interactions; feedback types.

CCS Concepts
•**Human-centered computing** → **Interaction techniques;** *Interaction devices;* HCI design and evaluation methods;

Figure 1: Screenshots of the game prototype *Lost & Found*.

Introduction

Gaze-based interactions have found their way into the games domain (e.g., [46, 33, 49, 36, 31, 28, 27, 2, 34, 14, 1, 13]) with the aim to provide players a more intuitive form of game interaction [44]. Gaze input is mainly employed as a supporting element or as a complete replacement for other game input devices [48]. However, we argue that the current approaches do not make use of the full potential that gaze in games could provide. In this paper, we propose harnessing gaze as a means to guide players in a 3D first person exploration game called "Lost & Found". By knowing where players are looking, a game could offer support in case players are lost within a game level. Accurately, this work describes our first steps in this research area: *We focused on gaining a basic understanding concerning the experience of visual (i.e., vignette effect on screen), auditory (i.e., sound cues), and haptic (i.e., controller vibration) feedback integrated into a gaze-based guidance approach.* In doing so, we could build on these findings to create more elaborated feedback types (e.g., variants of visual feedback, combination of feedback types).

Related Work

In general, player guidance forms a crucial part in shaping the gaming experience and guarantees that a player is successfully able to master a game without getting frustrated or lost [21]. It has the potential to assist players when it is required and can generate a feeling of autonomy [38]. This aspect requires preserving the equilibrium between not helping at all and supporting the player too much [21, 45]. Games with an exploration theme, such as *What remains of Edith Finch* [40], extensively utilize visual signals to guide players [37]. These games typically consist of visually complex scenes with a high number of objects that are designed to encourage exploration. One main challenge for game artists is to point players in the right direction without decreasing the challenge that is vital to keep the player's interest [9]. Eye-tracking technology could offer a solution to this matter as gaze data can be collected and analyzed [41] to guide the players' gaze into the desired direction. Insights on gaze-based guidance in the context of games are hard to find as current research converges around other media (e.g., images, movies) [23, 30, 12, 29, 10, 5, 24]. One of the few examples can be seen in the work of Bailey et al. [4], who suggest that gaze direction could be adopted to guide a player's gaze into a particular direction, away from a distinct area in a scene that demands more rendering time. Moreover, Ben-Joseph et al. [6] found out that gaze-based guidance is more effective in helping users to find an object in a virtual reality (VR) scenario than they would have without the help of gaze direction techniques. Unfortunately, detailed information on the quality and intensity of gaze-based guidance in the context of games is not available. We address this issue by comparing feedback types of gaze-based interaction in the following sections.

Our Approach

This paper reports on the first steps in the field and aims at investigating the effects of different feedback modes on the players' immersive experience. To solve the issue, we selected a specific genre (i.e., exploration games), which we deem is very suitable for a gaze-based guidance system. Exploration games, such as *The Vanishing of Ethan Carter* [3], confront players with visually complex game scenarios and support them through various guidance means (e.g., color [7] or animation [21]). This is often done playfully by challenging players through a specific game mechanic (e.g., [42, 11, 35, 32]): The position of crucial game elements and the distance between them in relation to the player are only indicated through various feedback modalities (visual, sound, and haptic) and are not fully revealed. In our case, we use gaze as the guiding element: Players are guided

Figure 2: Gaze-supported player guidance in the game *Lost and Found*: if players (1) look at a gaze-sensitive area (2) where a game object is located (3), they get feedback via either visual, auditory, or haptic cues. The closer to the object, the stronger the feedback.

Figure 3: Condition *Visual*: Gaze-supported player guidance was combined with visual feedback.

by gaze-based cues that are triggered when the players look at specific gaze-sensitive areas in the game scenery. These particular areas do not directly point to the object of interest, but only hint that the required game element is concealed somewhere within the vicinity. The withholding of information and indirect guidance are the main driving forces for exploration. The first question that we wanted to address was, which feedback channel (visual, auditory, haptic) could be combined with gaze to grant players an immersive player experience. To find answers, we carried out a study that will be described in the following sections.

Game Prototype

The game, called *Lost and Found* and used in the comparative study, was conceptualized as a first-person exploration game. The game's design is similar to other exploration games (e.g., [17, 3, 43]), where players are required to find particular objects to progress in the game. This is also reflected in the game's premise: three weeks ago the player's avatar moved with his fellow students into a new flat, and many of his/her belongings are still packaged in boxes. Unfortunately, after an all-night game session, the player's avatar lost all of his/her four keys. Now it is his/her job to find what happened last night and to retrieve all lost keys. Players control the game with a Xbox 360 game controller (i.e., left analogue stick for movement & "A-"button for picking up objects) in conjunction with an eye tracker (i.e., guidance feedback). The gaze-supported player guidance approach was embedded in the following way (see figure 2): To find the four keys, the player could interact with more than 300 game objects and could scan the area for cues. During play, the player's current gaze position was constantly tracked with the help of an eye tracker. If the player looked at a sensitive gaze area, he/she would get feedback via either visual, auditory, or haptic cues. It is important to note that the gaze-sensitive area was designed to foster exploration. Therefore, it indicated a larger section where one of the keys was hidden. To address the aspect of proximity, the feedback intensity was increased when the player moved closer to the target. To make sure that the game was perceived as an exciting quest, the level design encourages the player to explore the scenery via environmental storytelling. This was achieved by areas that grant information on the protagonist. The feedback is driven through two dependent parameters: (1) the distance between the player's avatar and the gaze-sensitive area (i.e., the effect only kicks in, when the player is in close distance to a key - in our case: 2 meters in Unity), (2)the distance between the gaze and a key in screen space within the gaze-sensitive area (i.e., the closer the gaze position is in relation to a key, the stronger the effect - in our case: gradual intensity transition - 1/2 screen width distance between gaze and key: 0% effect strength; 0 distance: 100% effect strength).

Comparative Study

A comparative study was set up to investigate the impact of the proposed approach that consisted of three conditions that differed in the way the player guidance was implemented (i.e., three feedback variants of the gaze-supported player guidance approach). In the first condition, called *Visual*, the gaze-supported player guidance was combined with visual feedback (see figure 3). To give players a challenging experience and to include the aspect of exploration, players got visual feedback through a vignetting effect. When the player looked at a gaze-sensitive area (where one of the keys was located), a vignetting screen effect appeared. The closer to the game object, the stronger the effect was set. In the second condition, *Auditory*, auditory cues were linked with gaze input. If the player attended a gaze sensitive area, a sound cue was played. The closer the player got to the game object, the higher the volume and pitch values of the audio component were set. The third condition, *Haptic*, featured vibration feedback provided by an Xbox360 game controller. If the player gazed at a relevant area, the controller started vibrating. If the player was far away from the object, the vibration was relatively subtle. If the player reduced the distance between him/her and the target, the vibration became stronger. The design rationale behind the feedback types and the intensity was based on the categorization by Fagerholt & Lorentzon [16]. A meta-interface solution was chosen, where guidance representations can exist on a meta-layer between the player and the game world. By using a meta interface, our approach can be integrated into different genres.

Technical Setup

The game prototype was developed with the Unity game engine [47] in conjunction with the First Person Exploration Kit [18] that contains building blocks typically present in exploration games. For the gaze-based input, we used the Tobii EyeX eye tracker [19] with the Tobii Unity SDK for Desktop [20]. Regarding the vibration feedback in *Haptic*, we used the XInput package [22]. The hardware setup consisted of a desktop PC with a 27-inch monitor and standard stereo-headphones for sound output. Players used an Xbox360 controller to play the game.

Participants and Procedure

The experiment was conducted at the University of Applied Sciences Upper Austria and took about 60 to 80 minutes per participant. Recruitment of subjects was carried out by utilizing mailing lists provided by the involved institution. The experimenters invited subjects by providing information on the type of experiment (i.e., experimental study in the field of games), the study location, and the duration of the experiment. No incentives were offered. In total, 22 people between the age of 21–46 participated (M=24.82, SD=3.42), 10 were female. Concerning the procedure: As a first step, the experimenter provided an introduction (i.e., control scheme, eye tracker,). Subjects were given a questionnaire dealing with basic demographic information (i.e., age, gender, playing habits). After that, they played the first out of three levels. Each level was combined with one of the three conditions (i.e., *Visual*, *Auditory*, *Haptic*). Both the level and the conditions were randomized in each playtest to avoid biases. When the first level was completed, players were asked about their perceived game experience. Additionally, participants were asked what they liked and disliked about the interaction form. Then, the experimenter presented the second out of three levels, followed by a questionnaire. All subjects were asked to play all three conditions (within-subject design). In the end, an informal interview was carried out.

Measures

The immersive experience questionnaire (*IEQ*) by Jennett et al. [26] was employed to measure the perceived immersive game experience. It was used in various studies, such as Iacovides et al. [25], and measures the experience via five factors: cognitive involvement (*CoIn*), real-world dissociation (*ReWo*), emotional involvement (*EmIn*), control (*Cont*), challenge (*Chal*), and a single question to indicate the perceived immersive experience (*Imer*) (total: 31 items). Apart from the *IEQ*, two open-ended qualitative questions were asked by the experimenter ("What did you like most about the game interaction?" and "What did you dislike most about the game interaction?").

Results

This section presents the results and is subdivided into two parts: the first section deals with the analysis of the quantitative data, while the second section explores themes based on the carried out interviews.

Statistics (1)

CoIn: Sig. difference: ($F_{3,63} = 7.81, p = .00, \eta^2 = .27$); Pairwise comparisons: Sig. difference: *Visual* (M=5.29, SD=1.29) - *Haptic* (M=4.58, SD=1.08 $p = .02$), No sig. difference: *Visual* - *Auditory* (M=5.15, SD=.93, $p = 1.00$)

ReWo: Sig. difference: ($F_{3,63} = 9.69, p = .00, \eta^2 = .32$); Pairwise comparisons: Sig. difference: *Visual* (M=4.63, SD=1.52) - *Haptic* (M=3.83, SD=1.44 $p = .02$). No sig. difference: *Visual* - *Auditory* (M=4.38, SD=1.44, $p = 1.00$)

EmIn: Sig. difference: ($F_{3,63} = 10.39, p = .00, \eta^2 = .33$); Pairwise comparisons: Sig. difference: *Visual* (M=3.08, SD=1.35) - *Haptic* (M=2.42, SD=.77 $p = .01$), No sig. difference: *Visual* - *Auditory* (M=2.85, SD=1.07, $p = 1.00$)

Cont: Sig. difference: ($F_{3,63} = 20.79, p = .00, \eta^2 = .49$); Pairwise comparisons: Sig. difference: *Visual* (M=5.20, SD=.99) - *Haptic* (M=4.48, SD=.88 $p = .02$), No sig. difference: *Visual* - *Auditory* (M=5.08, SD=.98, $p = 1.00$)

Quantitative Data

All analyses were conducted using repeated-measures analysis of variance *(rANOVA)*. A benefit of the repeated-measures *rANOVA* is the limited number of subjects required. All parametric tests were performed after validating the data for assumptions of *rANOVA* use. Reliability of the scales was good and was calculated via Cronbach's α. Significance was set at α = 0.05. First calculations dealing with mean values and standard deviations of each *IEQ* scale per condition showed that *Visual* received the highest ratings on all scales, followed by *Auditory*. *Haptic* was rated with the lowest scores. In-depth analysis through pairwise comparisons (see left box: statistical analysis) revealed that *Visual* and *Auditory* differed significantly concerning *Haptic* on most scales. The only exception could be seen in *Chal*. Furthermore, no significant difference between *Visual* and *Auditory* on all scales.

	Visual	**Auditory**	**Haptic**	**Cronbach's α**
CoIn	5.30(1.29)	5.15(.93)	4.57(1.09)	.92-.80
ReWo	4.62(1.44)	4.38(1.44)	3.83(1.44)	.91-.81
EmIn	3.08(1.35)	2.95(1.07)	2.41(.77)	.90-.72
Cont	5.20(.99)	5.08(.98)	4.48(.89)	.91-.71
Chal	3.89(.99)	3.68(1.18)	3.27(1.09)	.92-.71
Imer	7.27(1.52)	6.59(1.40)	3.77(1.15)	.82-.73

Table 1: Means and Standard Deviation for *CoIn*, *EmIn*, *ReWo*, *Cont*, *Chal* on a scale from 1 to 7. *Imer* on a scale from 1 to 10. Internal consistency of scales is shown by Cronbach's α.

Analysis of Qualitative Data

Qualitative data was analyzed through a thematic analysis [8]. Two researchers were involved in the analysis process that included data review, code generation, search, review, and define themes. The researchers created a set of initial research codes that were transferred to three themes.

Feedback quality The interviews revealed that the type of feedback had an impact on the game experience. Player 17, for instance, mentioned that the vibration feedback diminished the feeling of being in the game. When the controller started vibrating, the subject immediately became aware that she holds a game controller in her hands. Player 21 noted that "I think that vibration feedback is usually used in games when something negative happens, such as the game character is taking damage". Thus, the connection between haptic feedback and gaze input in an exploration setting did not seem to be logical. One exception could be observed in the *Chal* scale. The perceived challenge was not affected by the type of feedback. 13 players mentioned that the gaze-supported conditions gave them a feeling of being challenged in a positive way.

Feedback consistency *Visual* was received very positively by players: One participant (Player 5) noted that the *Visual* condition fitted well to the game's objectives and the visual theme of the game world. It was rated positively that the high visual complexity of the game scene was toned down through a visual element (vignette effect). It appeared to be more consistent (same modality) and more subtle (visual element as part of a visually complex scene) in comparison to other feedback conditions. Not only the *Visual*, but also *Auditory* condition was perceived positively. However, players also criticized that, like in the *Haptic* condition, the logic behind the connection between the gaze input and the auditory feedback is hard to grasp.

Feedback Intensity: Not only the type of feedback but also the intensity was reflected in the interviews. *Haptic* was felt as being either too strong or too weak. Furthermore, seven players did not notice the difference in the vibration intensity, when they got closer to a relevant area. In the *Auditory* condition Player 22 commented that "...it was quite domi-

Statistics (2)

Chal: Sig. difference: ($F_{3,63} = 15.98, p = .00, \eta^2 = .43$); Pairwise comparisons: No sig. difference: *Visual* (M=3.89, SD=.99) - *Haptic* (M=3.27, SD=1.09 $p = .02$), No sig. difference: *Visual* - *Auditory* (M=3.68, SD=1.18, $p = 1.00$)

Imer: Sig. difference: ($F_{3,63} = 64.01, p = .00, \eta^2 = .75$); Pairwise comparisons: Sig. difference: *Visual* (M=7.27, SD=1.52) - *Haptic* (M=3.77, SD=1.15 $p = .00$). No sig. difference: *Visual* - *Auditory* (M=6.59, SD=1.40, $p = .11$)

nant in some situations as only a limited number of sounds were in the game". Another player added that it might be reasonable to lower the intensity of the vignetting effect in the *Visual* condition. This issue could be addressed by decreasing the vignetting effect.

Discussion

The study showed that *Visual* seemed to be most appealing for subjects, as it was described as "consistent" (Player 5), "logical" (Player 16), and "fits the game world" (Player 21). As gaze input was linked to the visual sense, it was not associated with other senses. What is more, it was reported that the haptic feedback reduced the feeling of presence (i.e., being in the game) [39]. It was also noted several times in the interviews that the chosen genre (i.e., exploration game) fits very well to the gaze-based player guidance. However, we also argue that the proposed approach is not only suitable for exploration games but also could be employed in various genres. For instance, it could be integrated into an action-adventure game with a thief theme, such as Thief [15], where the player's goal is to steal valuable artifacts. The player guidance could indicate the location of items as well as quest markers. Furthermore, it would fit into the game's narrative as the gaze-based feedback could be explained as a unique skill of the thief character (i.e., a particular form of intuition).

Gaze-based player guidance could also be harnessed as a navigation tool (i.e., a breadcrumb system) in open-world games, where navigation beacons could lead the player from one location to the next. These are just a few examples, where a gaze-based guidance system could add to the game experience. Although the comparative study led to some interesting findings, several limitations have to be acknowledged. First, the paper explored the potentials of a gaze-based player guidance approach in an exploration game: to broaden the field of application and to explore the transferability of the concept thoroughly, further research is required that deals with the implementation and the evaluation of gaze-based guidance in the context of different game genres presented. Secondly, it has to be noted that the demographics of the test subjects were relatively narrow, primarily comprising of subjects at the same age with a high level of education. In future studies, it is planned to include different age groups in a comparative study. Other types of feedback (i.e., different forms of visual feedback) and the combination of different feedback types (e.g., a combination of auditory and visual feedback) are also not covered in this paper. Last but not least, the aspect of when the gaze-based guidance should be enabled was not investigated. It is anticipated that an adaptive system (i.e., only triggered when needed) could have an effect on the perceived experience (especially on challenge).

Conclusion

This paper introduced gaze-based guidance in the context of games and reported on a comparative study that examined the potential effects of the approach regarding the game experience in a first-person exploration game. The gathered data showed that the feedback type influenced the results. While haptic feedback received relatively low scores, visual and audio feedback appeared to be very appealing for players. Regarding future work, it is planned to investigate the following aspects: As the gathered results imply that the *Visual* variant appears to be the most promising feedback condition, we plan to compare the introduced approach with other visual gaze guidance strategies (e.g., diegetic interface). Another research direction forms the investigation of multi-modal feedback conditions. Furthermore, we deem that gaze-based player guidance appears to be a relevant topic in the context of VR.

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