Game Controller Research from the Lab into the Wild: The Case of Eye Tracking

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Keywords
Eye tracking, game controllers, input devices, gaze interaction

INTRODUCTION
Games with eye tracking support have existed for a long time, but have remained confined to research labs due to the prohibitive costs, inaccuracies, and awkward usage requirements of older eye trackers. The recent release of inexpensive eye trackers, combined with AAA games offering support for eye-based game mechanics have created an interesting moment for academic research, in which an input device transitions from research labs into the wider consumer market. This paper discusses how this transition has impacted academic research in the topic. We argue that the wider availability of eye trackers and accompanying development tools have led to mechanics where the eyes play an increasingly more central role and research more focused on player experiences than on the technology itself.

Isokoski et al. in an earlier review of gaze-controlled games identified for ways of implementing eye tracking in games: (1) no modification, where the eye tracker emulates mouse actions; (2) additional software, which bridges the output from the eye tracker into game actions; (3) game source code modification; and (4) building a game from scratch (Isokoski et al., 2009). As development tools mature, making it easier to build new games, the focus of the problem begins to change towards the novel game experiences that could only be enabled by eye tracking—what Velloso et al. call EyePlay (Turner, 2014, Velloso et al., 2016).

In this paper, we argue that the role of the eyes in the mechanics enabled by eye tracking technology has undergone three stages of evolution. First, the eyes were seen as an **alternative** input modality to other game controllers. Second, the eyes played a **complementary** role to other input modalities that provides additional and often optional functionality to the game. Finally, the eyes increasingly play a more **central** role in the game's core mechanics, enabling new experiences that could not have been achieved with other input modalities. As this transition progresses, it substantially impacts current research themes and methods as well as industry practices and commercial games.

Proceedings of DiGRAA 2016 Conference: Tensions

THE EVOLUTION OF THE ROLES OF THE EYES IN GAMES

Early work in eye tracking in games was mainly conducted at Computer Science and Psychology labs, often as a means of pushing what to do with the technology and to enable input to disabled users. The prohibitive cost of eye trackers kept gaze-enabled games out of mainstream studios, with the few commercial games being developed by or funded by the eye tracker manufacturers to be shipped with their products (Spakov, 2005). Because much of this work was motivated by the accessibility potential of eye tracking, they often employed it as an **alternative** modality, focusing on interaction techniques and corresponding game mechanics that required eyes-only input. These were works that were focused on the technology itself and what it could enable. The gaming aspect was secondary as a driver for research, with examples in the literature exploring emulating mouse control in pre-existing games (e.g. *Neverwinter Nights*, Smith and Graham, 2006), modding open-source copycats of commercial games (e.g. *Breakout*, Dorr et al., 2007), or developing a custom version of existing game mechanics in a new game (e.g. *EyeGuitar*, Vickers, 2010).

With the decrease in cost and increase in robustness and availability, eye tracking started to look like a more promising input modality for gaming as a **complementary** modality. In academia, this led to research on multimodal and cross-device interaction techniques that employed the eyes in a supporting role (Velloso et al., 2015a). In commercial games, this led to games that offer additional functionality if the player has an eye tracker. For example, in *Assassin's Creed*: *Rogue*, part of the camera rotation can be assigned to the eyes, and in *Deus Ex: Mankind Divided* the eyes can be used to aim at enemies and to interact with game objects. These are all mechanics that could be accomplished with other input modalities, but offer additional play experiences for players that happen to have an eye tracker that are not central to it.

Finally, as eye tracking technology and its development tools mature, more mechanics are being developed that leverage the specific capabilities and limitations of the human eye. In this stage, the eyes are **central** to the play experience, and the corresponding mechanics would not make sense if used with a different input modality. However, because of the still low adoption rates of eye tracking, games in which the eyes play a central role are still mostly limited to research projects and indie games. Examples include games that use the eyes as a social cue (e,g, *The Royal Corgi*, Vidal et al., 2014), that play with the dual role of observation and actuation (e.g. *Shynosaurs*, Vidal., 2014), and that challenge the player to use their peripheral vision (e.g. *Virus Hunt*, Velloso et al., 2015b).

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