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# Gaze-based narratives for location-based games

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## ABSTRACT

Location-based games require their players to move in the real world in order to interact with a virtual game layer which is spatially connected to the real world. It has been argued that place-related location-based games, i.e., those where the narrative of the virtual layer is closely related to the places in the real world, provide a particularly immersive experience. This position paper suggests enriching these playful immersive experiences with the interaction concept Gaze-Based Narratives. It is proposed to guide the player's eye gaze to real-world objects relevant for the game and to adapt the story of the game dynamically to the real-world objects that have been looked at previously.

## CCS CONCEPTS

• **Human-centered computing** → Interaction design theory, concepts and paradigms; *Interaction techniques*; • **Applied computing** → Interactive learning environments.

## KEYWORDS

Outdoor HCI; Outdoor Play; Gaze-Based Interaction; Gaze-Based Narratives; Location-Based Games

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**Figure 1: Gaze-based interaction with a city panorama. The system provides audio information about the buildings the tourist looks at [18].**

<sup>1</sup>For instance, the Tobii website lists 137 eye tracking enabled games at the time of writing [30]

**INTRODUCTION**

The emergence of affordable mobile phones and reliable positioning technologies at the beginning of the century have led to first research projects on *location-based games* (LBG) [4, 20, 23, 24, 27]. Different to other mobile games, LBGs use their player’s position as a crucial part of the game concept. For instance, players of an LBG may be required to move between different locations in order to collect virtual resources or to interact with non-player characters (NPCs).

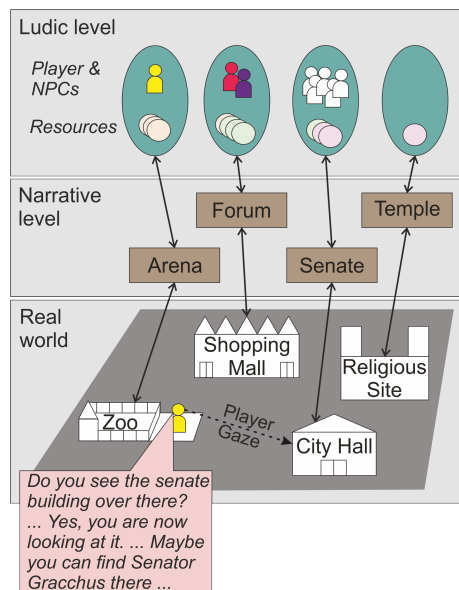
Some years after this first wave of LBG research, the first commercially successful LBGs became available, where Ingress (2013) [10] and Pokémon Go (2016) [25] are probably the most well-known ones. Research has in the meantime explored different applications of LBGs: the collection of crowd-sourced data [22], tourism [3], teaching [1], and persuasion for healthier lifestyle [6], to name a few. A recent study on parents’ perception of Pokémon Go has shown that parents appreciate the increased exercise in the outdoors, as well as family bonding experiences of playing together [28].

Despite the ongoing progress in LBG research, it appears that the interaction modalities used in LBGs do not take advantage of the most current state-of-the-art in HCI. Most LBGs are still played using touchscreens, possibly enhanced by smartphone-based augmented reality (AR). The potential opportunities for LBGs offered by developments in mobile HCI technology, such as, outdoor-capable physiological sensors (e.g., [5]), are not sufficiently explored.

In this position paper, I suggest utilizing *gaze-based interaction in the outdoors* for enhancing the experience of playing LBGs. The idea is facilitated by current developments in pervasive eye tracking which indicate that tracking users’ gaze in-the-wild may soon become sufficiently reliable for everyday use [2, 8, 13, 32]. Figure 1 displays an example for gaze-based interaction with a city panorama [18].

For desktop computer games, such as first-person shooters, commercial products using gaze as an input mode are already available<sup>1</sup>, and recent research workshops keep driving the topic forward [19, 31]. A good overview on gaze in gaming is provided by three overview articles [11, 29, 33]; none of them, however, considers gaze-input for LBGs.

My main argument in this position paper is that, in addition to those opportunities of gaze input that as well hold for desktop games [33], gaze in LBGs features the particular chance for increasing the player’s feeling of immersiveness by guiding her gaze and adapting the game’s narrative to what has been looked at (a concept we introduce as *Gaze-Guided Narrative* at this year’s CHI, [18]).



**Figure 2: Location-based games overlay the real world with a virtual world, which consists of a narrative and a ludic level [26]. This Figure sketches a hypothetical adventure-style game with a narrative of Ancient Rome. Based on the player’s gaze, the game helps with the cognitive mapping between real-world objects and their meaning in the narrative (Gaze-Based Narrative [18]).**

### OWN PREVIOUS WORK

This position paper proposes the application of gaze-based interaction techniques to LBGs played in outdoor spaces. It combines ideas from two research projects the author has been involved in.

### Geogames and LBG Relocalization

The author’s first work on LBGs in the ‘Geogames’ project was centered around the question how traditional board games can be converted to outdoor LBGs without introducing imbalance caused by small speed differences between players [27]. We were interested in the spatial and temporal aspects of playing outdoors, e.g., whether games are played at discrete locations or in a spatial continuum [16], and how these aspects influence game mechanics. Game balancing was achieved by introducing breaks, which we proposed to fill with edutainment content related to the current place [15].

One insight from the project was that one important factor for the success of LBGs is whether their narrative is related to the place or not. Place-independent games can rather easily be ported (‘relocalized’) to new places automatically [17], which facilitates their dissemination. Place-dependent games, on the other hand, have a narrative closely related to the place, which leads to more immersive experiences but at the same time makes them difficult to relocalize without a human expert.

In recent work, the author has proposed a theoretical model for the automatic relocalization of LBGs that considers also the narrative level [26]. The idea is to have several possible narrative embeddings for one LBG concept and choose the one which fits best to the points of interest available at the player’s current location. That is, the rules and game mechanics (on the ludic level) are fixed but their semantics are adopted to the spatial context automatically. For instance, the algorithm would choose an Ancient Rome narrative when the game is played in an Italian city (see Figure 2), whereas it would choose a Viking narrative in Scandinavia. Both variants would still have the same game mechanics, such as, the requirement for collecting virtual resources or interacting with NPCs.

### Gaze-Based Interaction with Outdoor Spaces

The author is currently leading the GeoGazeLab research group (<http://geogaze.ethz.ch/>), which uses eye tracking for the analysis of spatio-temporal decision making, and for gaze-based interaction with spatial information and with outdoor spaces [14].

Gaze-based interaction in outdoor spaces, with a focus on a tourism scenario, is the scope of the LAMETTA project (‘Location-Aware Mobile Eye Tracking for Tourist Assistance’, <http://geogaze.ethz.ch/lametta/>). We have developed a gaze-based tourist guide which provides audio information during the visual exploration of a city panorama (see Fig. 1). Computer vision methods are used to match the field video of a head-mounted eye tracker with a reference image in order to identify the building looked at [2]. We chose audio instead of AR in order to avoid visual distraction from the real world.

**Table 1: Applying the systematization of game mechanics relying on player’s gaze from [33] to LBGs. Examples for interaction with the real world (RW) and with the virtual world (VW) are listed.**

<b>Navigation</b>	
RW	<i>Retrieving navigation cues from environment [9].</i>
VW	<i>Steering an NPC using gaze.</i>
<b>Aiming&amp;Shooting</b>	
RW	<i>Shooting a virtual cannon ball at a real building.</i>
VW	<i>Shooting at a virtual NPC in AR.</i>
<b>Selection&amp;Commands</b>	
RW	<i>Assigning a narrative role (e.g., ‘warehouse’) to a real building.</i>
VW	<i>Picking up a virtual resource (e.g., a piece of gold) in AR.</i>
<b>Social Gaze</b>	
RW	<i>Game recognizes eye contact in multi-player game.</i>
VW	<i>Game recognizes eye contact with an NPC in AR.</i>
<b>Responsive Environment</b>	
RW	<i>Game tells story when gaze is on building [2].</i>
VW	<i>AR objects react to gaze.</i>
<b>Adaptive AI</b>	
Both	<i>Game guides user’s gaze if problems in visual search are detected [18].</i>
<b>Visual Effects</b>	
VW	<i>Placing an AR selection dialog close to the player’s current gaze.</i>

At this year’s CHI, we are presenting a novel gaze-based interaction concept and its evaluation in virtual and real urban environments (*Gaze-Based Narratives*, [18]). The system takes the role of a tourist guide which interactively guides the tourist’s gaze to buildings it is talking about. It also adapts the audio content to the objects the tourist has looked at before, e.g., by comparing the architectural style of two buildings. These two mechanisms – *gaze guidance* and *content adaptation* – could also be applied to gaze-based interaction in LBGs. Figure 2 illustrates gaze guidance for a hypothetical LBG.

## TOWARDS GAZE-BASED INTERACTION IN LBGs

Eye tracking can be used to measure an individual’s gaze on a stimulus [7]. The resulting gaze data are used as an indicator for a user’s visual attention and, quite often, also for inferring cognitive processes [12]. In gaze-based interaction, gaze is used in real-time for the control of an interactive system [21].

For desktop gaming, Velloso and Carter [33] have extracted 5 different gaze-based game mechanics from existing games (navigation, aiming&shooting, selection&commands, implicit interaction, and visual effects). Implicit interaction is further split into social gaze, responsive environments, and adaptive AI. Table 1 lists examples for each type of game mechanics from [33] applied to LBGs.

LBGs are different to desktop computer games because players interact with both, a virtual and a real world, where these two worlds are spatially connected (refer to Fig. 2). Note that the virtual world can be overlaid to the real world visually (in AR), but it does not have to. Many LBGs rely on their player’s imagination instead with the aim of avoiding visual overload. In the case of AR-enabled LBGs, almost all game mechanics as for desktop games can be applied. For instance, one could determine whether the player searches eye contact with an NPC shown in AR and adapt the NPC’s behavior accordingly. Exception are mechanics related to navigation, since they are limited to steering virtual characters. A conceptually very different situation occurs when gaze-based interaction takes place with the real-world (RW in Table 1): since the mapping between real-world objects and their meaning in the game is sometimes not obvious, I suggest using Gaze-Based Narratives to ensure that the player looks at those real-world objects the game is referring to (e.g., by audio).

## CONCLUSION

This position paper aims at starting a discussion on whether and how gaze-based interaction can be applied to LBGs – an opportunity that has not been explored in literature yet. I have particularly argued that Gaze-Based Narratives [18] could be used for bridging the gap between the real world and the game semantics in non-AR-enabled LBGs.

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**REFERENCES**

- [1] Sanne Akkerman, Wilfried Admiraal, and Jantina Huizenga. 2009. Storification in History education: A mobile game in and about medieval Amsterdam. *Computers & Education* 52, 2 (2009), 449–459.
- [2] Vasileios-Athanasios Anagnostopoulos, Michal Havlena, Peter Kiefer, Ioannis Giannopoulos, Konrad Schindler, and Martin Raubal. 2017. Gaze-Informed Location Based Services. *International Journal of Geographical Information Science* 31, 9 (2017), 1770–1797. <https://doi.org/10.1080/13658816.2017.1334896>
- [3] Rafael Ballagas, André Kuntze, and Steffen P Walz. 2008. Gaming tourism: Lessons from evaluating rexplore, a pervasive game for tourists. In *International Conference on Pervasive Computing*. Springer, 244–261.
- [4] Steve Benford, Rob Anastasi, Martin Flintham, C Greenhalgh, N Tandavanitj, M Adams, and J Row-Farr. 2003. Coping with uncertainty in a location-based game. *IEEE pervasive computing* 2, 3 (2003), 34–41.
- [5] Andreas Bulling, Daniel Roggen, and Gerhard Tröster. 2009. Wearable EOG goggles: Seamless sensing and context-awareness in everyday environments. *Journal of Ambient Intelligence and Smart Environments* 1, 2 (2009), 157–171.
- [6] Luca Chittaro and Riccardo Sioni. 2012. Turning the classic snake mobile game into a location-based exergame that encourages walking. In *International Conference on Persuasive Technology*. Springer, 43–54.
- [7] Andrew T. Duchowski. 2017. *Eye Tracking Methodology: Theory and Practice* (3rd ed.). Springer Publishing Company, Incorporated.
- [8] Wolfgang Fuhl, Marc Tonsen, Andreas Bulling, and Enkelejda Kasneci. 2016. Pupil detection for head-mounted eye tracking in the wild: an evaluation of the state of the art. *Machine Vision and Applications* 27, 8 (2016), 1275–1288.
- [9] Ioannis Giannopoulos, Peter Kiefer, and Martin Raubal. 2015. GazeNav: Gaze-Based Pedestrian Navigation. In *17th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI)*. ACM, New York, NY, USA, 337–346. <https://doi.org/10.1145/2785830.2785873>
- [10] Niantic Inc. 2013. Ingress. <https://www.ingress.com/> visited on 2019-02-11.
- [11] Poika Isokoski, Markus Joos, Oleg Spakov, and Benoît Martin. 2009. Gaze controlled games. *Universal Access in the Information Society* 8, 4 (05 Mar 2009), 323. <https://doi.org/10.1007/s10209-009-0146-3>
- [12] Marcel A Just and Patricia A Carpenter. 1980. A theory of reading: From eye fixations to comprehension. *Psychological review* 87, 4 (1980), 329.
- [13] Moritz Kassner, William Patera, and Andreas Bulling. 2014. Pupil: an open source platform for pervasive eye tracking and mobile gaze-based interaction. In *Proceedings of the 2014 ACM international joint conference on pervasive and ubiquitous computing: Adjunct publication*. ACM, 1151–1160.
- [14] Peter Kiefer, Ioannis Giannopoulos, Martin Raubal, and Andrew T. Duchowski. 2017. Eye Tracking for Spatial Research: Cognition, Computation, Challenges. *Spatial Cognition & Computation* 17, 1-2 (2017), 1–19. <https://doi.org/10.1080/13875868.2016.1254634>
- [15] Peter Kiefer, Sebastian Matyas, and Christoph Schlieder. 2006. Learning About Cultural Heritage by Playing Geogames. In *Entertainment Computing - ICEC 2006*, Richard Harper, Matthias Rauterberg, and Marco Combetto (Eds.). Lecture Notes in Computer Science, Vol. 4161. Springer Berlin / Heidelberg, 217–228. [https://doi.org/10.1007/11872320\\_26](https://doi.org/10.1007/11872320_26)
- [16] Peter Kiefer, Sebastian Matyas, and Christoph Schlieder. 2006. Systematically Exploring the Design Space of Location-based Games. In *Pervasive 2006 Workshop Proceedings, Poster presented at PerGames2006*. Dublin, Ireland, 183–190.
- [17] Peter Kiefer, Sebastian Matyas, and Christoph Schlieder. 2007. Playing Location-based Games on Geographically Distributed Game Boards. In *4th International Symposium on Pervasive Gaming Applications (PerGames 2007)*, Carsten Magerkurth, Karl P. Akesson, Regina Bernhaupt, Staffan Björk, Irma Lindt, Peter Ljungstrand, and Annika Waern (Eds.). Shaker Verlag Aachen, Salzburg, Austria.

- [18] Tiffany C.K. Kwok, Peter Kiefer, Victor Schinazi, Benjamin Adams, and Martin Raubal. 2019. Gaze-Guided Narratives: Adapting Audio Guide Content to Gaze in Virtual and Real Environments. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*. ACM, New York, NY, USA. <https://doi.org/10.1145/3290605.3300721> to appear.
- [19] Michael Lankes, Joshua Newn, Bernhard Maurer, Eduardo Velloso, Martin Dechant, and Hans Gellersen. 2018. EyePlay Revisited: Past, Present and Future Challenges for Eye-Based Interaction in Games. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*. ACM, 689–693.
- [20] Carsten Magerkurth, Adrian David Cheok, Regan L Mandryk, and Trond Nilsen. 2005. Pervasive games: bringing computer entertainment back to the real world. *Computers in Entertainment (CIE)* 3, 3 (2005), 4–4.
- [21] Päivi Majaranta and Andreas Bulling. 2014. Eye tracking and eye-based human–computer interaction. In *Advances in physiological computing*. Springer, 39–65.
- [22] Sebastian Matyas, Christian Matyas, Christoph Schlieder, Peter Kiefer, Hiroko Mitarai, and Maiko Kamata. 2008. Designing location-based mobile games with a purpose: collecting geospatial data with CityExplorer. In *Proceedings of the 2008 international conference on advances in computer entertainment technology*. ACM, 244–247.
- [23] Markus Montola, Jaakko Stenros, and Annika Waern. 2009. *Pervasive games: theory and design*. CRC Press.
- [24] Daniela Nicklas, Christoph Pfisterer, and Bernhard Mitschang. 2001. Towards location-based games. In *Proceedings of the international conference on applications and development of computer games in the 21st century: ADCOG*, Vol. 21. 61–67.
- [25] Nintendo. 2016. Pokémon Go. <https://pokemongolive.com/> visited on 2019-02-11.
- [26] Simon Scheider and Peter Kiefer. 2018. (Re-)Localization of Location-Based Games. In *Geogames and Geoplay*, Ola Ahlqvist and Christoph Schlieder (Eds.). Springer, Cham, 131–159. [https://doi.org/10.1007/978-3-319-22774-0\\_7](https://doi.org/10.1007/978-3-319-22774-0_7)
- [27] Christoph Schlieder, Peter Kiefer, and Sebastian Matyas. 2006. Geogames - Designing Location-based Games from Classic Board Games. *IEEE Intelligent Systems* 21, 5 (Sep/Okt 2006), 40–46. <https://doi.org/10.1109/MIS.2006.93>
- [28] Kiley Sobel, Arpita Bhattacharya, Alexis Hiniker, Jin Ha Lee, Julie A Kientz, and Jason C Yip. 2017. It wasn't really about the Pokémon: Parents' Perspectives on a Location-Based Mobile Game. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 1483–1496.
- [29] Veronica Sundstedt. 2010. Gazing at Games: Using Eye Tracking to Control Virtual Characters. In *ACM SIGGRAPH 2010 Courses (SIGGRAPH '10)*. ACM, New York, NY, USA, Article 5, 160 pages. <https://doi.org/10.1145/1837101.1837106>
- [30] Tobii. 2019. Tobii Gaming. <https://gaming.tobii.com/games/> visited on 2019-02-11.
- [31] Jayson Turner, Eduardo Velloso, Hans Gellersen, and Veronica Sundstedt. 2014. EyePlay: Applications for Gaze in Games. In *Proceedings of the First ACM SIGCHI Annual Symposium on Computer-human Interaction in Play (CHI PLAY '14)*. ACM, New York, NY, USA, 465–468. <https://doi.org/10.1145/2658537.2659016>
- [32] Hidde van der Meulen, Andrew L. Kun, and Orit Shaer. 2017. What Are We Missing?: Adding Eye-Tracking to the HoloLens to Improve Gaze Estimation Accuracy. In *Proceedings of the 2017 ACM International Conference on Interactive Surfaces and Spaces (ISS '17)*. ACM, New York, NY, USA, 396–400. <https://doi.org/10.1145/3132272.3132278>
- [33] Eduardo Velloso and Marcus Carter. 2016. The Emergence of EyePlay: A Survey of Eye Interaction in Games. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '16)*. ACM, New York, NY, USA, 171–185. <https://doi.org/10.1145/2967934.2968084>