Games for passengers – Accounting for motion in location-based applications

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ABSTRACT
Passengers pay attention to the landscape as they move through the environment. We suggest a new type of applications, which adds to that experience. It consider their motion and velocity, which make the time available for interaction with individual geographical objects very limited, at the same time as they cannot control it. Applications, in this case a game, could utilize audio and gesture interfaces, as well as digital maps to provide for experiences that are sequentially mapped onto the landscape. An initial user feed back trial made visible interactional and experiential challenges in passengering.

Categories and Subject Descriptors
H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems - Artificial, augmented, and virtual realities; H.5.2 [Information Interfaces and Presentation]: User interfaces; K.8 [Personal Computing]: Games.

General Terms
Design, Human Factors

Keywords
Pervasive game, movement, velocity, backseat playground, passengers, mobile devices, audio, location based.

1. INTRODUCTION
In this paper we discuss a new type of applications, namely location-based applications for passengers. Potential examples include games, tourist guides, situated learning, and interactive storytelling, which in various ways link the content to the geographical location. Such applications draw upon passengers' engagement with the surrounding landscape. The key to such applications is to establish a link between the passenger and the continuously changing scenery that swiftly passes by outside the windows of the vehicle. Objects and places along the road have to be referred to in such a way that the user understands the intended linkage and finds it a believable and meaningful part of the experience. A critical design challenge is to account for the specificities of passengering. First, users often travel at high speed which greatly limits the time available to engage with geographical objects. Second, passengers are not involved in maneuvering the vehicle [5]. It follows that they are not able to control their motion or adapt it to their interaction with e.g. location-based applications. The purpose of this paper is to discuss how these practicalities might affect experiences and interaction in mobile location-based applications.

Designing for passengers is motivated by the sheer size of the social activity of traveling. Transportation is today a significant part of many people's lives. Statistics show that people in the US, on average, spent twenty-four minutes for commuting each day in 2001, and those who used public transportation had to add another sixteen minutes [10]. People over sixty-five years of age spent as much as an hour per day in their vehicles, and children younger than five years spend three quarters of an hour a day in a vehicle. In the UK, passengers conduct on average 228 trips by car, adding up to approximately 82 hours of travel per person and year [7]. Children younger than five years travel in a vehicle as much as 45 minutes per day. Passengers have to sit still, and are not involved in controlling the vehicle. This frees them up to enjoy the journey by looking out of the windows, reading, or daydreaming. However, this period of physical inactivity is sometimes considered boring [14], which makes transit a commonly used context for mobile games [1]. The possibility to incorporate the dynamic and vivid context of road travel into a mobile experience is therefore a promising alternative.

Furthermore, the increased use of mobile devices makes users' motion within physical space an emerging issue in interaction design. A number of applications have been suggested such as support for navigation [15] as well as location-dependent games [3, 8]. However, our focus on passengers sets such applications apart from most current mobile applications, which are preliminary designs for use by pedestrians or car drivers [12]. Our particular focus is on 'mobile mixed reality games' for passengers. We report a field study of the game 'Backseat Playground' [9]. With the help of digital map data, the application dynamically presents sequential stories and game challenges as the player travels through the landscape. The player acts as a manager of field agents, and uses a set of tools to take part in the unfolding of a crime story, where the actual location of the vehicle is of importance. We will discuss how motion influenced the ways in which the passengers interpreted and experienced

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local geographical objects as part of the game; how it influenced their visual attention to the surrounding geographical layout, and how it influenced their apprehension of the game story per se.

In general, the motion of a passenger is a tricky but resourceful parameter for design. The players are required to develop complex techniques where pointing and looking are done in parallel to enable interaction at specific locations. Still, the audio design did not enable visual identification of all types of geographical objects when the passenger was moving with high speed. At the same time, the motion seems to evoke something of an experiential paradox. The motion makes it hard to make the geography more transparent to the swiftly passing player, but easy to cheat about it. Finally, the velocity of the vehicle seems to affect the ways in which players experience the narrative itself.

2. RELATED WORK

Our research is related to the emergent area of location-based games. There are a wide range of projects which explore the prospect of location-based games [3, 8]. 'Feeding Yoshi' [3] makes use of wireless networks around a city to create a game-environment. Secured wireless networks represent virtual creatures called Yoshis. The player's mission is to locate and feed them by growing and retrieving fruit from plantations represented by unsecured wireless networks. This game is played via the interface of a mobile device using traditional graphical user interfaces, with buttons and stylus as interaction mechanisms. 'Can you see me now?' [8] is a chasing game where online participants compete with mobile participants on the street. It utilizes traditional graphical user interfaces, but the participants can also collaborate by communicating via a real-time audio channel while moving through the city streets. All these games are designed for use by pedestrians in urban settings. However, the evaluation of Feeding Yoshi showed that it was also played in cars, buses, trams and trains, and even when bicycling. This more extensive movement made it possible to discover new hotspots. But the speed of the vehicles also made it difficult to connect to the access points encountered. Accordingly, the players had to stop or slow down when they were near useful access points to 'feed Yoshis'.

The research discussed above deals with pedestrian-use contexts, and hence accounts for slow and manageable motion in physical space. However, it does not explicitly explore the implications of motion as a design parameter when designing applications for mobile spatial interaction, except as a topic for spatial navigation. Furthermore, the situation for pedestrians differs from passengering in several ways. Passengers are not involved in maneuvering their body or their vehicle [5], whereas the pedestrian must to some degree be occupied with the activity of walking. Pedestrians' interaction with a mobile device often becomes supplementary to the task of handling the physical movement. It follows that passengers are not able to control their movement, either as a way to spatially interact with their mobile device or with the geographical environment. Finally, since they often travel at higher speeds than pedestrians the time available for them to engage with geographical objects is much more limited.

Leshed [12] analyze the experience of available GPS systems to support car drivers' navigation. They noticed that people actively tried to annotate the landscape to create an experiences, e.g. of familiarity, and that it sometimes added to their understanding of the geography even though it most time decreased their engagement. Road Rager [7] is a game prototype specifically developed for passengers in vehicles. It focuses on the interaction with other passengers in oncoming vehicles as part of the game-play. Even though speed is an essential feature of this game, the available research does not specifically address how motion affects passengers' interaction and experiences.

3. PASSENGERING AND INTERACTION DESIGN

Early studies in architecture [2, 13, 16] points to the effects of motion on how people visually interact with a passing landscape, as well as how they experience it. Here it is argued that passengers' visual focus of attention is adapted to the speed of the vehicle, which makes individual objects only visible for a very short time. At high speeds the visual attention tends to be directed forward, while passengers pay more attention out of the side-windows at slower speeds. A viewer is more likely to attend to nearby objects in the immediate environment, and apparently 'moving' objects, than to distant stationary ones.

Passengers' motion also affects the experience of individual geographic objects [13]. When people walk through a city they have time to interpret what they see. Vehicle passengers do not have the same opportunities, given their much higher speed. Additionally, the swift motion also makes the view change from one moment to the next, which generates various sequential experiences [2]. The experience of a single object is influenced by where the passengers have already been and what was experienced at those locations. A uniform and predictable series of objects often contributes to a sense of fatigue and boredom during a journey, while spatial change and contrast in the surrounding landscape often contributes to a gratifying experience. Architecture research also considers how to design for interaction and experiences during rapid motion. Lynch [13] promoted the idea of designing roadside architecture to make the local context transparent for the highly mobile modern visitor (see also [12]). Bold signs and the form of the architecture should be used to reflect local life from distant viewpoints. This would give the people passing by enough time to read the signs and understand the local life. Venturi [16] agreed on the effect of high speed, but instead saw it as an opportunity to transform the boundaries of local culture. The speed of the vehicles erases the ordinary local meaning of individual geographical objects, which are then transformed into something completely different through large-scale roadside architecture, e.g. the signs in Las Vegas that are reminiscent of an exotic Roman culture. In sum, we learn that motion affects visual interaction and the experience of geographical objects, and that it is critical to account for it in design.

4. A GAME FOR PASSENGERING

In this section we describe the game implementation and how it is influenced by the theoretical perspectives on passengering outlined above.

4.1 Accounting for Motion in Design

The game is designed to account for players' motion through the landscape. This means that the interaction with the mobile device must be adapted to the interaction with the landscape where individual objects pass by very quickly. Previous research has shown that even minimal graphical interaction diverts passengers' attention from the outside environment onto the computer screen [6]. Furthermore, the passengers have no means of controlling their velocity and direction, in order to make time to visually attend to both the landscape and a screen. Therefore, the suggested design is largely sound based. It gives the player the ability to listen to fictive activities taking place in the surrounding, while at the same time looking out through the windows.

We argue that a passenger game should both make the landscape more transparent [13, 12], as well as transform it [16]. First, the application can be designed to communicate local information about geographical objects over a distance and during a very short time span of interaction. Here we draw upon digital maps based on commonly known classification schemes of geographical objects such as houses, public buildings, mansions, churches, sports grounds, lakes and fields. That data enables us to present the roadside objects in somewhat greater detail than is normally available to the passenger [12]. Second, the game allows us to transform local meanings of objects. Furthermore, the velocity of the passenger causes the experience of an individual geographical object to be influenced by passengers' previous encounters i.e., it is part of a sequential experience. Accordingly, we argue that the application should be designed to fit into a series of encounters with geographical objects, rather than just to an individual location. The challenge is to generate a game-play and game narratives that fit together with the order of the upcoming geographical objects. Therefore, the game engine pause the progression of a storyline until a requested geographical object emerges. As a player's intended route is unknown to the game, the sequence of physical objects that appear is highly arbitrary, and a specific object might take time to become visible. It is therefore possible that a single story line, with specific local objects, would not provide sufficient sequential experiences. Therefore, the prototype is implemented with six concurrent and interconnected storylines (see Figure 1). Each storyline includes a set of story events, which accepts a different set of objects to execute, that advance the narrative. Furthermore, the choice of objects changes over time. When the game starts, an event might only accept an infrequent object, such as a church. It might also accept a more commonly occurring object, such as for example ordinary private houses, if no church appears for a set period of time.

4.2 Implementation

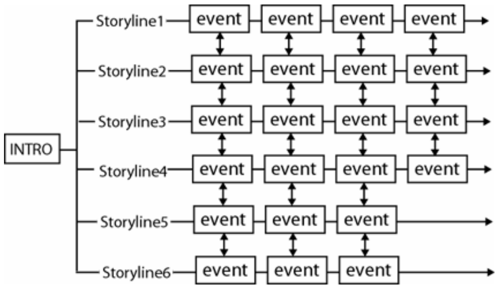

Figure 1. Overview of narrative structure

The players' device consists of handheld hardware in the form of a directional microphone (see Figure 2) and a pair of headphones. The directional microphone metaphor is used in order to superimpose an aural landscape onto the outside view. For this task it contains a Pocket PC and an advanced module containing magnetometers and gyros, capable of sensing the users' gestures. The display of the Pocket PC is used to present a number of virtual tools, e.g. a walkie-talkie and a phone. The phone and walkie-talkie provide audio conversations through synthetic voice generation with in-game characters. The player responds by making selections on a list presented on the screen.

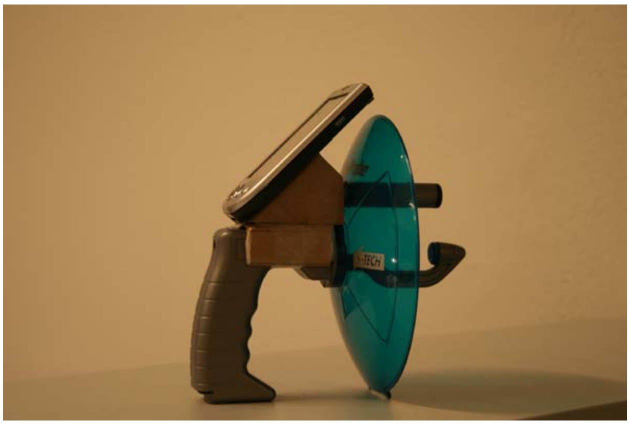

Figure 2: Handset

The backend of the game consists of a laptop, which hosts the server, a GPS receiver, and a local wireless LAN. The server contains commonly available digital maps, game scripts, sound effects, several voice libraries for speech synthesis of the in-game characters, as well as story and map engines [9]. A soundscape is automatically generated as the passenger moves through the landscape using the information provided by the maps and the motion data provided by the GPS. This is done by first filtering the maps for suitable information, which is then translated into geographical encounters potentially occurring along the road. The encounters are then provided to the game engine which compiles story events with local geographical references. The player interacts with the soundscape by pointing the directional microphone at audio augmented objects.

4.3 There's a dead body beside the road

The general narrative within which the storylines evolves is basically a crime story with a supernatural twist. The passenger play a field agent manager assigned to solve what initially looks like a simple robbery. In the following we will present a single storyline, called 'the dead body' as it might be experienced during game-play.

Dave is sitting in the back seat of his parents' car on the way to visit relatives in a rural area. He looks at a field and a power line that appears in the distance. The calm moment is suddenly interrupted by a crackling sound from the walkie-talkie in his hand. A male voice says: 'Agent Bravo to agent Alfa. I just saw your car passing by. We're on the other side of the golf course searching for the robbers. Over!' He looks up and indeed sees a golf course on the field just behind a barn. He decides to select the directional microphone and starts pointing the device towards the surrounding landscape to listen for suspicious sounds. Suddenly the deafening sound of a gunshot pierces the calm. He quickly switches to the walkie-talkie in order to contact the nearby team of agents over the radio. As the agents seek to determine the location of the shooting, David continues to use his directional microphone. Now he can hear voices from one of the buildings on his right saying 'we're out of ammunition, let's get out of here!". He quickly decides to call in his team of field agents and tells them to storm the building. He does that by making a selection on his menu on the screen. Moments later he hears agent Bravo's voice over the walkie talkie, telling him that they have found a dead body inside the building.

5. METHOD AND SETTING

Our game was put to an initial user feed back study in a field trial, where the subjects use the prototype for a limited period of time in its intended setting. It was carried out on a 25 km test route on the island of Lidingö in Stockholm. Each test consisted of about thirty minutes of game play followed by interviews and questionnaires. In total, ten players – three girls and seven boys – participated in pairs. Each test run was carried out with two participants at a time, to enable us to observe the interaction between the players to gain further insight into how the game was perceived and played.

We then conducted interaction analysis [11] based on a combination of methodological techniques i.e. video recordings, interviews and questionnaires. Two video cameras were used to capture the players' physical interaction with the game. The video material was viewed several times to identify specific interaction styles. A loosely structured interview was performed in conjunction with the trial to give more detailed answers. All interviews were recorded and later transcribed. Finally, the test participants were handed a simple questionnaire.

6. ANALYSIS

6.1 Sounds do not overcome size

In the following we will discuss how the passengers experienced individual geographical objects, when interacting with the directional microphone, and how the size of the objects seems to play a role. The questionnaire reveals that the majority of the players gave positive feedback on how fictitious content was combined with the meanings of locations, as expressed in the digital map data. Additionally, all players answered that it felt as the game took place outside the car. However, the questionnaire also reveals that the players struggled with the visibility of geographical objects, as part of game events.

Here, the interview provides more details on the complex experiences of passing individual objects. We asked the players whether they identified the geographical origins of the sounds. Two boys, Michael and Daniel, said that they knew them 'to some extent'. For example, they linked the sound of a submarine to the surface of the water they had seen. They also linked sounds of a tennis game to a tennis hall. Other players linked the sounds of boats to the view of the sea. They connected various sounds to map objects such as a golf course, houses and a road junction.

The objects they reported were only a minority of all those that were executed during the field trials. Furthermore, the objects they recalled seemed to be rather large, as compared to non-reported objects. The prevalence of large geographical object can be explained either by insufficiencies in mapping the digital to the local due to deficiencies in the precision of the gyro, or due to the way the sounds are presented. They could also have failed to actually see the geographical objects, since these might have been occluded by other objects in the landscape. But then they would instead recall other geographical objects than those referred to in the digital map data. It could also be explained by the motion of the user vis-à-vis the object, providing only limited time to identify and then remember it. Geographical objects such as forests, golf courses and enclosed pastures, allowed for more time to identify and interact with them. Thus, similar to what Lynch and Venturi [13, 16] argued regarding architectural roadside objects, it seems that size matters also in the case of passengers interacting with audio augmented objects. Although, some game experiences occurred as a combination of visual sightings and audio effects, it seems that the soundscape did not foreground smaller objects for visual identification.

6.2 Imaginary visual experiences

The interviews reveal another interesting aspect of how the landscape was experienced. The difficulties in recalling what they had seen led them to remember what they have seen inaccurately, such as in the following two interview transcripts:

Researcher: Where, more precisely? Which church are you talking about?

Michael: Mmmmm, don't know.

Researcher: What did it look like?

Michael: Like an ordinary church [Daniel: Yes]

Researcher: You actually did see the church?

Michael: No [Daniel: No]

Michael talks about a church he has seen. He even describes it as 'ordinary' and Daniel agrees. Upon further questioning they both reconsider and claim that they have not seen the church. Interestingly, the interviews with Steve and Bob reveal a similar confusion as to what they have actually seen:

Steve: We heard the robbers a couple of times talking about 40 000. What was it? 40 000 dollars? [Bob: 40 000 dollars]

Researcher: Okay. Where were they?

Bob: We had just turned into a road by then.

Steve: It was in a church, wasn't it? They were in a church.

Bob: Yeah, later on. But we had just made a turn.

Researcher: How did you see that it was a church? How do you know that they were in a church? [Bob: First, we heard…]

Researcher: Bob, how do you know that it was a church. I wasn't there you know.

[Bob: I guess you said so.] Steve: How was it? ...this leader, the one who is our main boss said that they had…

Researcher: She said so, but did you see it yourself? [Steve: no]

Researcher: Okay, you didn't see it.

Steve: Or wait! I heard it. Yes, I could hear the bells.

They recalled overhearing a conversation between burglars. When asked where it occurred they first referred to a junction, where the car made a turn, and then to a church. They claim that the conversation could be heard 'in a church', which was the location given to the sound effect by the game engine. Upon further questioning it turns out that the reference was not to a sighting of the church, but to the sound effect of church bells. In both those cases, they talk about the objects as if they had seen them, whereas after further discussion it turns out that they had not.

It follows then that the design of the system did not support them well enough to make the church itself noticeable. The system failed to overcome the interactional challenges posed by the motion of the passenger, which make it hard to single out specific geographical objects and link them to the game events. However, the cursory experience might also explain why they thought they had seen the church.

6.3 Sequential experiences

The passengers' motion brings them to many different places during a game session. The game is designed to account for that motion and provide a serial location-dependent narrative. We will discuss how the players experienced such series of events as they were de facto executed by the game engine. The game execution varied between all trial runs, even though the evaluation took place along the same route. This was due to variations in velocity, game play and occasional system errors.

In all, the questionnaire reveals that all test subjects responded average or better to the question whether they thought the different events were 'connected' during the game session. However, the video recordings and the interviews give more details as to how the velocity of the vehicle affects the players' alignment of game events into sequences.

In the following we will discuss the 'dead body' scenario (see previous description), which is a script including two geographical events triggered in sequence. Several sound effects trigger at various locations, with the intention of referring to two separate geographical locations. First, it refers to the location of a house from which a gunshot is heard from afar, and then from the same house but at closer distance when some burglars' conversation is heard. Second, we also referred to the location of friendly field agents in the vicinity of a field. The intention was to provide clues in a sequence, to lead the player to take appropriate actions regarding the orders to the field agents. The script was triggered during all test sessions, however it played out at diverse geographical locations.

The interviews reveal that the players in four out of five cars connected the gunshot heard during the first event with the dead body found during the next event. However, none of these players refer to the action as relating to a specific house. It is possible that the intended building was not visible during some of the game sessions, or that the device failed to support their investigation.

The players in the fifth car never mention any relation between the two events, but rather talked about them as separate occurrences. They instead interpreted the gunshot as if they themselves were the target. Furthermore, these players linked the second event to a house that they had seen outside the window of the car. A close look at the video recordings of the game-play (Table 1) reveals that variations in the motion of the cars might have influenced those variations in the interpretations of game events.

Table 1: Excerpt from the dead body script in the 5th car

Time	*System output*	*Road context*	*Visual focus*
07:49	Agent:" We´re on the other side of sports ground"	Car is standing still at red light.	Look towards sports ground
07:55	Gunshot	Standing still.	Look towards screen
08:01	Choices		Looks at the screen

In the transcript in table 1, the 5th car is driving past a sports ground and stops at a red light. The first event is triggered and a walkie-talkie call from a field agent is heard (07:49). The players immediately look in the direction the agent is referring to. The gunshot is heard (07:55), as the car is still halted at the red light.

Thus, the car is actually standing still when the event is executed. In the other trials, the car was moving when the script triggered. We suggest that the variations in speed might have influenced their interpretation of the game narrative. The players in the fifth car interpreted the gunshot as being directed towards themselves. It is not so surprising that the players did not link the gunshot to the dead body found moments later. A possible interpretation is that a player that is standing still might feel more exposed and vulnerable than if the car is moving at high speed. In this way, motion might contribute to a feeling of confidence.

6.4 Spatial interaction

In this section we will discuss the ways in which the players interact with the devices and the landscape, as well as how they focus their visual attention.

The questionnaire reveals that directional sounds could be easily located by most players. Only two players rated this as difficult. The questionnaire gives the impression that they could balance interaction and visual focus between the digital devices and the geographical objects passing by. However, there is not much in the questionnaire that reveals the ways in which they actually managed to focus both on game and environment.

The video recordings provide more detailed insights into these activities. All the recordings have been studied a number of times. We then identified different ways in which their interaction and visual focus were balanced. In the following we will present transcribed vignettes of such recurring player techniques. We are specifically interested in the use of the directional microphone, since it requires the most specific interaction with the geography. The person holding the game device will be referred to as the player, and the other person will be referred to as the co-player.

Vignette 1. Co-aligned interaction: The passengers occasionally displayed an interaction technique where they kept their gaze and the device co-aligned throughout a play sequence.

Table 2: Co-alignment

Time	*Road context*	*Hand movements*	*Visual focus*
01:34	Driving along the road.	Holding the device facing forward.	Looking at the device.
01:36		Sweeps the device to the left, holding it high up.	Continually locking in the direction of the device.
01:37		Stopping far left and sweeping back right.	Still looking in the direction of the device.
01:41		Stopping as device points towards co-player.	Look at the co-player.

Table 2 provides a transcription of Sophia's actions as she investigates the landscape with the directional microphone. She initiates a careful sweep to the left, while looking in the direction of the device (01.36). She stops the motion and starts sweeping back right, when the device is aligned with her shoulder. As Sophia reaches the right shoulder she is aiming straight at her co-player Olivia (01.41). This causes both players to laugh. The device is held at face level during the entire period. The direction of gaze and pointing are aligned throughout the back-and-forth sweeps. We refer to this interaction method as co-aligned interaction (see Figure 3).

Figure 3: Sophia points and looks in same direction

Vignette 2. Aural precedence: The next transcript displays how the player searches the landscape by first scanning with the device to find an interesting sound, and only thereafter moving the gaze to look at the object.

Table 3. Aural precedence

Time	*System*	*Road*	*Hand*	*Visual focus*
04:37	None	Driving along the road	Sweeps device to the right.	Head and gaze forward.
04:39	Male voice		Stops the device at 3 o'clock	
04:41				Turns head and gaze to device.
04:42		Car slows down.		Leans down to take a better look at house outside on the right.

In table 3, Daniel scans the surroundings for sounds by moving the directional microphone in a sweeping motion from left to right (04.37) (see Figure 4). He halts the device and listens briefly when an interesting sound appears (04.41). He turns his gaze, that until now has been directed straight forward, in the direction of the sound (see Figure 5). As the car slows down due to a traffic situation, (04.42) Daniel leans forward and takes an additional look at the building towards which the game device is pointing. In this case, the player relies almost entirely on the aural cues from the system in order to find game events. Alignment of visual attention and hand movement occurs only later. We refer to this technique as aural precedence. Furthermore, we note that he leans forward to get a better view when the velocity of the car decreases. The lower velocity allows him to take time to align his body to take a more prolonged look at a specific object. Thus, varying velocity changes conditions for player's interaction with the surroundings.

Figure 4. Player listening to a sound (04:39)

Figure 5. Player looking for origin of the sound (04:41)

Vignette 3. Visual precedence: As above but players' investigation is initiated by visual cues.

Vignette 4. Intermittent alignment: We also identified a more complex combination of interaction techniques. In this example the pointing and looking are actively conducted in parallel, with intermittently occurring alignment

Table 4. Intermittent alignment

Time	*System*	*Hand movement*	*Visual focus*
14:13		Begin sweeping the device forward	Locking straight forward
14:15		Continuant sweep towards left	
14:16			Locking left
14:17	TV, owl	Holding the device to the left	
14:24			Locking forward left
14:25		Sweeping device slowly to the right	

In table 4, Daniel moves the device from side to side in the car (14.13). He stops briefly when he detects interesting sounds, which come from a TV-set as well as from an owl (14.17). Occasionally he looks in the direction of the microphone to establish the origin of a sound (14:24).

As he scans with the device in one direction, his eyes search the surroundings continuously in other directions. When he spots something interesting he interrupts the sweeping motion with the device and aims directly at the object. The visual orientation and the aural orientation are now co-aligned. We suggest that by scanning one side with the device and one with the eyes the player manages to cover more ground compared to solely using one of these strategies. It differs from all discussed techniques in the more limited time when gesture and gaze are aligned. The variation of the temporality of alignment has not been quantified, but is empirically observable in the video data.

Summing up, the video analysis gives much more detailed insights into how they interact with a passing landscape than the questionnaire. We identified four ways in which they combined hand movements and gaze to generate a combined experience. Co-alignment was quite rare, and in many cases their search for relevant geographical objects in the environment was dominated either by their gaze or by their listening. However, intermittent alignment occurred as a combination. They used their gaze and hearing to search in various directions, and only co-aligned them for short periods. This seems to be the most effective method for investigating the landscape. However, it diverges somewhat from the design intention, which was to link visual objects to digitally generated sounds, in order to create a merged experience. Intermittent alignment increases the area that can be investigated, given the limited time at each location, but decreases the time for investigation of a specific geographical object.

7. DISCUSSION

The field trial shows that the players' motion affected their interaction with, and experience of, the physical landscape in various ways.

Audio space does not overcome size: Passengers moving quickly trough a landscape struggle with smaller objects. Our particular audio design did not make small objects more salient.

Create beliefs about what has been seen: The system occasionally made the passengers believe that they had seen objects which had not been sighted. We argue that this was possibly due to the motion of the car, which gives them little time to get a good view of individual geographical objects. They then confused the soundscape with the actual view of the road setting.

Possibilities for sequential narratives: A critical challenge, given the players' motion, is to fit a temporally unfolding game, with its associated location dependent narratives, to an unpredictable travel path. Here, the results are promising since the players made sense of the different episodes as being part of an overall narrative. However, the players occasionally had difficulties associating fictive content to several sequentially appearing locations, such as hearing a gunshot at one location and then associating that event to a sound appearing somewhat later.

Experiencing vulnerability and resistance: The motion influenced the passengers' emotional experiences. We suggest that a lower speed created a sense of vulnerability, which had consequences for game play. When the vehicle was standing still during an intense moment in the game, the players' interpretation of the event differed from that of moving players. It appeared as if lack of speed made the player feel more vulnerable than if the car was rolling. High speed might contribute to a feeling of confidence where the player felt more like an observer, while standing still would suddenly turn the player into a victim.

Search and identification minimize temporal co-alignment: The application was intended to support co-alignment, which would make the most of an encounter with an object. But the actual use differed. Instead, by splitting the visual focus and the hand movement they managed to cover more ground in the search for game events, in combination with a moment where an individual object is investigated. We conclude that high speed causes shorter moments of alignment, but that alignment was still attained as soon as either an object or a sound caught the players' attention.

Variations in motion influence interaction: Previous research investigates how passengers adapt their gaze to their velocity [2]. In this case, we investigated how they combined their look with their gestures to control the directional microphone, and how that depends on their velocity. We initially expected a greater interest in spatial details, and hence a prolonged orientation aligned towards individual objects such as is displayed in simultaneous orientation. This behaviour also occurred rather frequently as soon as the car slowed down. Accordingly, the players adapted their visual focus of attention very much in accordance with the velocity. Intermittent alignment seems to occur at higher speeds, whereas co-alignment is used when the car is moving slowly.

Balancing transparency and transformation: The design of passenger applications can benefit of the balance between transparency and transformation when adding new experiences to the road. But that balance needs also be considered in design. First, it seems like the cursory experience of the landscape makes it difficult to visually identify objects, but easy to cheat the passenger. It might be difficult to change that balance to improve identification, at the same time as preserving the potential to trick the player. Second, new techniques might increase the precision in mapping digital content to the geography. But then the passenger has to put even more effort into identification work, which gives less time for the experience of individual objects.

Challenge and immersion through motion: Immersion is a central concept with game theory. It can occur when difficult sensory-motorical and mental tasks is combined [4]. In all, the players struggle to keep up with things, leading them to invent new interaction strategies to cope with the situation, although missing out on many details. This could in some cases be interpreted as a failure. But from a game design perspective it is not necessarily negative, since these types of applications should provide interesting challenges, rather than solving problems as effectively as possible. Furthermore, almost all the players responded that they felt as if the game was going on outside the window. Several players also struggled with distinguishing between what they actually had seen and what they believed they had seen. We argue that this, taken together, shows that the game provided a very immersive experience.

8. CONCLUSION

We suggest a new type of applications, where passengers interact and experience a passing geographical environment. It could turn the journey into an augmented experience and make the passing view more transparent or more fictitious. Designing such applications acquires accounting for their uncontrollable movement, as well as for a very short interaction span at any location. We provided an example of how this could be done through providing a user interface with audio and gesture interaction, as well as links to digital maps to provide more location information. Our initial feed back study shows that it is a promising area not least for game design. At the same time, it was evident that passengering is a challenging use context.

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