

# Believable environments – Generating interactive storytelling in vast location-based pervasive games

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## ABSTRACT

Generating content into vast areas is a relevant challenge in the field of location-based pervasive games. In this paper, we present a game prototype that enables children travelling in the back seat of a car to enjoy a narrated experience where gameplay combines with the experience of traveling through the road network. The prototype is designed to provide what we refer to as a believable environment. We propose four design characteristics to persuasively include a journey within a pervasive game. First, the story should refer to geographical objects with their everyday meanings. Second, the game's scale needs to cover vast areas. Third, the application should provide sequential storytelling to make it fit with the journey experience, and finally it should provide interaction support where players can engage in gameplay and interact with the computer in various ways at the same time as they are looking out of the car window. We describe how these requirements have been implemented in the prototype and present an initial performance test.

## Categories and Subject Descriptors

J. 7 [Computer applications]: Computers in other systems - Consumer products

## General Terms Design, Human Factors

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**Keywords** Pervasive game, believable environment, interactive storytelling, prototype performance test, backseat playground, location based, audio centric.

## 1. INTRODUCTION

In recent years, location based experiences and location-based pervasive games, where a user's bodily and spatial movement in the physical world is a key element, has increasingly become a research focus. However, available applications depend on either constant manual work to make the game fit new geographical areas or lack location-based experience beyond navigation support for chasing other players. Furthermore, there is an issue of generating content if pervasive and location based games are scaled up beyond limited experimental setups, which has dominated research so far.

In this paper we investigate the possibility of enriching pervasive games by providing more narrated elements in the game, as well as scaling the game environment through integration with increasingly available geographical information systems. Recent advances within interactive storytelling are promising [7,15,17]. First, these engines can extend the scope of pervasive games beyond simple chasing games, to include more complex interaction. Second, these engines could possibly handle the interaction as it occurs through the players' movements through the landscape, as an addition to the more active choices pursued within the narrative experience. Furthermore, GIS data is becoming more widely available and accurate. Available map objects can

be used for reasons other than supporting navigation. They can be used to link the pervasive narrative game with the surrounding environment. We have implemented a narrative-based game, called Backseat Playground, on a platform consisting of a PDA, a gyro and a GPS receiver, as well as a server running on a lap top that connects to the game device over WiFi. The application provides audio centric interaction, which includes telephone and walkie-talkie interaction as well as a directional microphone to investigate the soundscape surrounding the car. The player acts as a manager for field agents. The technologies are utilised to unfold a crime story with supernatural twists, where the actual location of the car is of importance. The game characters reference geographical objects in the vicinity, and the player investigates what is happening with the directional microphone and interacts with other characters over the phone or the walkie-talkie. A journey along a road involves a continuous flow of impressions of situations where changing scenes, the sense of motion and contingent encounters provide for a very special sensation [1]. It is a sequential experience, resembling a dramatic play of space and motion, i.e. the highway experience. We suggest that it is possible to engage children more deeply in that journey experience. Today, and in the foreseeable future, travelling by car is for many families an important part of their mobile life. It is a largely mundane activity involving daily commuting, trips to the weekend house or longer journeys when going on vacation. Children traveling in the car often engage in different means of amusement in order to pass the time. They might read, talk or play mobile games. But current mobile games are often portable versions of classic computer games where the focus is on the interface and screen. Thus, gaming becomes a complete alternative that does not draw on the positive aspects of being on the road. This form of traditional computer game obscures the highway experience, rather than exploiting the journey for play and learning. The research is also of interest for the study of interactive storytelling, since it reconsiders the

role of the stage set and introduces what we will refer to as “the believability of the environment.” Researchers have been struggling to build interactive storytelling engines since the 1980s [7, p 134] However, the disappointing results have been explained by the difficulties in balancing interactivity and the demand for linearity in stories to provide dramatic effects, as well as difficulties in generating believable characters. New forms of stage sets, such as the landscape as seen from the backseat of a car, could prove to be an area where interactive storytelling makes sense.

## 2. RELATED WORK

This paper is related to commercial applications and research prototypes in the areas of *location-based games* and *location based storytelling*. On the other hand, a number of industrial and academic research projects explore the idea of using geographical locations as a resource in a computer generated gameplay. The possibility is exploited by the industry, e.g. in *Botfighters* from *It's Alive* [3]. *Botfighters* is a commercially available SMS game, which depends on network positioning and therefore scales easily. The players can track opponents, get their location, move and then fight them using phone cell positioning. But the game does not adapt to the differences between the locations. It will present the same tasks and context and background stories at a graveyard as on a motorway. *Backseat gaming* is a mobile augmented reality game that makes use of changing scenery and the sense of motion during traveling. The real world passing by the vehicle acts as the world where the game takes place, and the gameplay and the narratives have clear connections to the roadside objects seen from the windows of the vehicle. This game is highly situated, and depends on the designer visiting the stretch of road, to make up special stories for each location [4]. The research prototype *Treasure*, is played between two teams who run around in the physical environment to chase virtual coins [2]. The coins are placed in the vicinity of WiFi access points, which are selected by the game provider. Thus, the game scales through the inclusion of more access points. The game is

simple, and the content does not change from place to place. “*Can you see me now?*” [10] is a mixed reality chasing game where online participants compete or collaborate with mobile participants on the street. Both games are played via a traditional screen-based GUI. The participants can also collaborate by communicating via a real-time audio channel while moving through the city streets. The game can be played where there is availability of high bandwidth networking and digital maps.

In summary, these location-based pervasive games incorporate geography for navigational challenges, i.e. chasing, and manual work is often utilized to enrich map data and change the game’s scale.

The *Journey* [11] is a simple commercial mobile service, which consists of a linear murder mystery story, where the player switches pages by walking e.g. 50 meters in any direction. But there are a number of more advanced research applications, which to a greater extent incorporate a player’s presence at a geographical location as part of a story. *Hopstory* is an interactive storytelling research application, which depends on infrastructure to provide location-based audio stories. Users are offered individual stories when they come into the proximity of objects. The static stories are played in the order in which the user arrives at specific places. Thus, the user will experience something like an anthology presented in random order [16]. *M-views* is a similar application, which provides media clips dependent on how the user moves through a geographical area. The researchers stress the non-linearity as a specific feature of the story telling [8]. The *Geist* concept is designed for location-based storytelling provided as an augmented reality experience with see-through displays [12, 14]. In particular, the researchers aim to enrich the experience of visiting a historical site of tourist interest. The focus of the project has been to provide a scalable video solution, which includes positioning through video recognition. The scalability problem emerged when attempting to use such systems in other than geographically con-

defined areas. The application is not only meant to provide historical information, but also to provide fiction. Therefore, the application has tools for authors to put together fact and stories for specific locations. Interestingly, they also identified the possibility to include the user’s movements between locations as a form of interaction with the story. They formulate the requirement that “[t]he engine has to ensure that the story keeps unfolding wherever the user goes.” [14] However, the end solution, as presented in the concept papers, seems to lack an engine that provides a story that holds together over the specific “stages”.

Thus, several location-based storytelling applications provide narratives rich in detailed references to the specific locations where they are being told. However, it would be difficult to generate content for larger geographical areas. First, they depend on manual design labor to invent stories at specific sites. Second, they do not interact with the users’ journeys. The experience becomes a random collection of visits to locations with embedded stories, which in terms of a reading experience could be described as an anthology, rather than a novel.

### 3. JOURNEYS AND STORIES

Children travel in the back seats of cars for various reasons. They go on routine trips back and forth to schools, or to pursue their leisure activities. They go with their families to shopping centres or to visit relatives and friends. They also follow their parents on longer trips on vacations and weekends. Sitting in the back seat, they have very limited control of where the car is moving, and there is no demand on them to take part in the maneuvering. They can therefore spend the journey time looking out of the car windows or doing something else. The experience of looking out at the passing landscape has been studied by architects such as Kevin Lynch and his colleagues [1]. They described the journey as a visual sequential experience that resembles a dramatic play of space and motion. In the early 1960s they believed that road construction could be further developed if it was informed by their detailed

studies of road users' experiences. Based on their findings, road design should be seen as a work of art like cinema or dance. However, the critical challenge when designing for the journey experience is to account for the specific path by which the road network is crossed, which in turn creates a very situated experience. This poses a design problem at any specific road section. Lynch and his colleagues argued that: "...the audience enters and leaves from different points, or may be proceeding from end to beginning rather than vice versa." [1, p 53] It follows that it is difficult to design to provide dramatic visual effects, e.g. by escalation and relief, when the designer cannot know in what order it will be experienced. The issue of providing for multiple readings of a designed experience is also a topic in the emerging field of interactive storytelling. It is a research area that has come into focus in the area of computer games, where better stories could provide interesting experiences [13, 6]. It is defined as the "...real-time generation of narrative action that takes into account the consequences of user intervention, by 're-generating' the story as the environment is modified by the user's intervention." [6] Research has aimed to resolve the tension between interactivity and the traditional demand of linearity in a plot, to provide dramatic effects such as conflicts and resolutions. Furthermore, the focus has been on providing believable characters with depth and complexity, e.g. emotional behaviours [7]. Although, it is too early to say that interactive storytelling has settled the issue of how to balance linearity and user control, the available systems are sufficiently developed that we can expand the area of research.

We propose an addition to the ways in which efforts are made to increase the dramatic range of available storytelling systems. We argue for research into the design of the story's "environment", or in other words, the stage set of the story [7]. New forms of environments for interactive storytelling could be an aspect that would make interactive storytelling more convincing. In the following we will refer to this approach as inves-

tigating what makes a "believable environment". However, this does not mean taking another step in the direction Crawford refers to as the "environmental approach", which just suggests that more props and larger environments are better. We argue that taking the environmental approach seriously means to design and investigate new types of stage sets with greater complexity than computer generated environments. A first step is to explore the use of new mixed reality interfaces, which include individual geographical locations in the story such as in systems like Geist [12,14] or Cavazza et al's projects [6]. We suggest that an additional step towards understanding the characteristics of a believable environment is to utilize a complete journey, or traveled path, as the stage for an interactive story. Children appreciate references to roadside objects in computer generated narratives [4]. The challenge is to develop a narrative engine that utilizes the movement of the vehicle, and the path of the journey, to form a sequential story rather than a random anthology. The concept of a journey through a computer-generated environment has been used in several interactive storytelling systems to enforce linearity [7]. But then the journey is a pre-designed backdrop which determines the unfolding of the story. There is a major difference between such a use of a journey to provide narrative rigor in a computer game, and using a journey as it unfolds in real time through a physical landscape

#### **4. BELIEVABLE ENVIRONMENTS**

The rationale for the Backseat Playground application is to meet four challenges, to draw upon a journey as a believable environment in location-based interactive storytelling.

##### **Geographical objects with everyday meaning.**

In order to create a believable environment it would be favourable to draw upon the environment as an intrinsic part of a computer-generated story. Some game/story objects should refer to physical objects with their everyday meanings retained. By the 'everyday meaning' of a geographical object, we mean its publicly understandable interpretation. By linking the

game intrinsically to such objects, the game will provide possibilities for designing linkages between gameplay, narratives and environment. **Scalability over vast areas.** Children in the back seat travel over large distances on family trips as well as when commuting. Thus, the game must be available over very large geographical areas. In order to allow widespread use of location-based pervasive games, we will explore cost-effective scalable solutions that enable widespread gaming over any territory with associated digital mapping data.

**Sequential storytelling.** A believable narrative game, in this particular context, should fit with the journey through the environment, i.e. the journey as it unfolds when a car moves through the road network should be a meaningful part of the story a posteriori. Thus, the narrative game engine should provide a temporally continuing story that fits with the dynamically appearing locations in the environment.

For traffic safety reasons, players should not interact with the driver as part of the game. Sudden orders shouted to the driver in excitement could be dangerous and must be avoided. Thus, the player should not be allowed to interact through mobility. Thus, it should be clear to the player that she has nothing to gain from changing the driver's direction.

**Blended focus of attention.** Belief in story environments could break if the player exclusively interacts with either the computer or the landscape. Therefore we need to develop user interaction support which provide for a "blended focus of attention" [5], which occurs when the players engage in gameplay and interact with the computer in various ways, e.g. make gestures or listen to sounds, at the same time as they are looking out of the windscreen. The support for visually focusing out of the windscreen at the same time as interacting with the computer, resembles the requirements for developing car driver support [9]. Following these European guidelines we suggest an audio centric approach to enable the passenger, in this case, to look out

at the environment at the same time as she interacts with the computer.

## 5. THE BACKSEAT PLAYGROUND

The prototype implemented to study the design of believable environments consists of *hardware*, as well as architectural modules such as a *story world*; a *narrative logic*; a *game event manager*; means for *user interaction* and a *GIS module*.

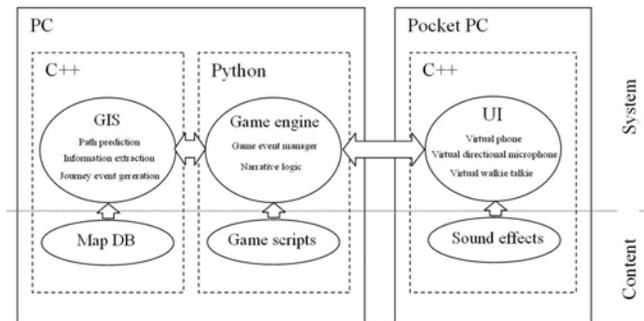


Figure 1: System architecture



Figure 2: Devices

### 5.1 Hardware

The backseat playground prototype consists of a server running on a laptop, a client (a pocket pc), a gyro, a pair of headphones, a Bluetooth GPS receiver, a wireless access point and a 12V - 220V power converter. The player is equipped with a casing containing a directional microphone, the pocket PC and the headphones, while the rest of the devices are installed at suitable places in the car.

The casing of the directional microphone has been equipped with a Microstrain 3DM GX1 sensor module carrying accelerometers, gyros and magnetometers for sensing orientation and motion in all 3-dimensions. The data from the sensor module is transmitted from the directional

microphone to the Pocket PC device by a small Bluetooth module.

The Pocket PC provides both a visual interface through its display, as well as aural interface through the connected headphones. It uses wireless LAN to communicate with the server. The Bluetooth GPS can be connected to either the Pocket PC or the Laptop. The GPS signal will be relayed over the wireless LAN in either case.

### **5.2 User interaction**

The user interaction is audio centric in order to demand and support a visual focus on the surroundings rather than on a device.

The user interaction is built up around the idea of having a set of virtual devices: a mobile cell phone, a walkie-talkie and a directional microphone. The cell phone and walkie-talkie both provide means for the players to keep in contact with the game characters. Both devices use text-to-speech synthesis (TTS), with a number of voices, together with a sound-effect system, to create lifelike incoming phone calls and walkie-talkie calls. The virtual user interface of each of the device is displayed on the pocket pc when the device is active. After a call, an options menu can be displayed on the screen in order to let the user respond by selecting between different messages. The directional microphone enables us to map sounds to geographical location, e.g. sound-effects like howling wolves to a forest, humming to power cables or conversations, generated by TTS, to a house. The player tunes into sounds at different virtual locations by pointing the microphone. The appropriate direction to the sound is identified based on data from the direction sensors together with the GPS location, which then triggers the sound system.

### **5.3 Story world**

The story is a crime mystery with a supernatural twist. The player is positioned as a detective in a special crime unit, charged with the task of overseeing operations to investigate a series of seemingly related crimes, and ultimately to uncover the workings of an organised crime gang. After being introduced to the story with a radio report of a museum robbery, the player is introduced to

his or her partner Helena, who is located at police HQ. Helena and the player build a relationship of trust and cooperation. Whilst the player communicates with agents in the field via walkie-talkie, the relationship with Helena is reinforced by being conducted over the mobile phone. But all is not as it seems, Boss Ulf is aggressive and grumpy; reports of wolves are met with derision and anger, and relations between him and Helena become strained as the case develops. So what about the dog hairs in Ulf's office? What of the mysterious deaths of the criminals involved in the thefts of valuable occult related artifacts from local museums. Things take a turn for the worse when agents track and shoot a rogue wolf only to discover that they have shot a person. By affecting the moods and relationships between player and in-game characters, the player's actions unfold a dark adventure. The player decides whether to strengthen her colleague's fight against these dark happenings, or to betray her partners and help unleash occult forces on the unsuspecting neighbourhood. One thing is for certain, Ulf is not who he seems, and the player has to decide whether she wants to know more.

### **5.4 Narrative logic**

The narrative logic is implemented as a set of story scripts, which each contain a separate part relating to the story world. The user interacts with the narrative through active choices, as well as by moving through the geographical landscape. However, in the choice of providing linearity or user control [17] the implemented narrative logic tends towards providing linear stories. The logic not only interacts with the users' movements and selections, but also maintains a well-paced unfolding of the script. For example, it keeps track of the tempo between events in the scripts. Lack of available geographical objects could lead to tedious lingering. The requirements for pacing affect the selection of geographical objects for the narrative. First, the logic sets the scripts to trigger on additional types of roadside objects the longer the time that passes without a match. In this way a script can initially be set to only respond to preferred object triggers. If time

passes without the script being triggered, it will also accept less appropriate objects. Second, it can also decide to trigger events with no local reference at all. Furthermore, the narrative logic interfaces the game event manager by rating the scripts own desire to execute at any specific moment of time as well as keeping track of their current state in the narrative plot. This is done by selecting a value from 0 to 100%.

The test implementation consists of two story scripts. We will, in the following, describe one path through the “wolf encounter” story script’s tree structure:

1. The first part of the Wolf encounter script is a local event and can be triggered at geographical objects such as forests, woods, marshes and nature reserves. When the car approaches such an object it triggers a 3D-sound of a howling wolf. The player can then use the directional microphone to track the sound.
2. If the player manages to point towards the sound, it will increase, and the script will proceed down the tree structure. Two optional messages will appear on the screen of the pocket pc. The player can choose to report the event to Helena at the head office or to ignore the sound.
3. The game event handler will then execute (see section 5.6). If the player has chosen to report the sound to Helena, the Wolf encounter script will be set to generate a phone call from Helena.
4. After 120 seconds the Wolf encounter script will once again highly rate its desire to execute, which will prompt the application to forward the phone call from Helena. The player will now see a phone on the screen of the pocket pc, perceive the sound of a phone ringing and get the option to answer or reject. If the player answers she will hear Helena reporting back about the wolf sounds.
5. The previous step will be repeated once again, but this time with a phone call from Ulf. After the phone call the Wolf encounter script will once again be set to run a local event on the

objects forest, wood, marsh and nature reserve, but also on urban areas.

6. A walkie-talkie will appear on the pocket pc screen if the player identifies the direction towards the sound. She will hear two walkie-talkie calls in a row from one of the field agents reporting about the progress of the wolf hunt in the vicinity.
7. The script will proceed with two different continuations depending on the player’s current location. In a built-up area the field agent will report back that the wolf has been shot but no body found, and that blood samples have been sent for analysis. If the player is in the countryside, the agent will report that a human body has been found instead of a wolf. The story script will then run phone calls both from Helena and Ulf equal to step five.

### 5.5 GIS module

We use widely available GIS location data as a basis for the generation of a fictitious world to be constructed in the physical environment. GIS mapping data [7] includes layers of physical objects such as road networks, street signs, buildings and topographic features which can be linked to the game database. The map is processed in a GIS server module in order to predict which objects will occur on the journey, as well as their order and pacing during the upcoming movement through the landscape. The map process converts the 2-dimensional GIS data into a linear series of geographical event that are interpreted by the game event manager. These steps include *prediction of the player’s paths*, *extraction of visually available information*, and *production of journey events* through mapping information onto the predicted paths. The outcome is a list of journey event objects sorted as they will occur along the path ahead. The list will be the module’s input into the event manager.

**Path prediction:** The first step in matching the narrative to the surrounding geography is to predict the vehicle’s path. We make this prognosis based on available route options ahead of the vehicle, i.e. in the current direction of the vehicle.

The algorithm starts by searching for a road ahead of the current GPS location, by identifying one of the road boundaries. When a path is identified, the algorithm follows it forward until an intersection is reached and the road branches. From there onwards, the two different road boundaries will be followed until another branching occurs etc. The path finding algorithm will stop after either one of two threshold values is reached. First, it will stop when it reaches a set distance, which is 1000 meters in this implementation. Second, it will also stop when it reaches two branch levels of the path. These values can be dynamically updated to adjust for speed, for example, to allow for a variable window of future events.

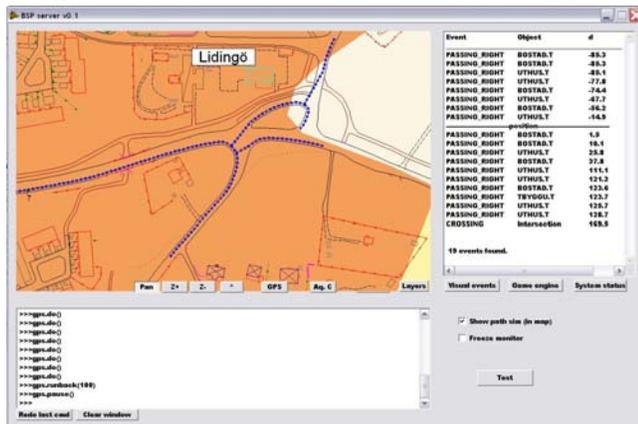


Figure 4. Server functionality for path prediction (left) and list of generated journey events (right).

In the test implementation, only data on the path to the first branch is communicated to the game event manager. However, the path prediction continuously occurs up to two branch levels ahead in the GIS module, which allows quicker completion of upcoming requested data to the game event manager. The algorithm depends on reliable GIS data. Failures will occur e.g. if a gap occurs in the roadside boundaries. To reduce the effects of such problems, the path prediction algorithm will restart and begin a new search for a suitable road on encountering such an error. In the meantime, the system continues running non-location-based game events.

**Extraction of visually available information:** GIS data contains point objects, line objects and area objects. The different objects are sorted into

different map layers, i.e. files in the database, and are marked with different categories of the map supplier's choice. In order to provide an experience where the visual geography has meaning in the narrative, as seen by the player, we need to select the objects available in the map layers that could possibly be seen from the road. Abstract objects, e.g. political borders, are not considered useful. However, some of the visually available objects are only implicitly available in the map information. We then extract such objects, e.g. intersections, by means of algorithms customized for that specific object.

The process of selecting layers and processing map information for implicit information is dependent on categories and layering provided by the map manufacturer. In this prototype we use map data from two different manufacturers. Altogether we use about 50 different categories of objects and only one algorithm for implicit information extraction.

**Mapping objects to journey experience:** The next step is to combine predicted paths, with the extracted geographical objects, to generate what we define as a *journey event* list. A journey event is a prediction of an important visual event occurring along the path of the journey involving a geographical object. In the current prototype we have so far defined three different events: passing right, passing left and crossing. Passing right is defined as the closest point where the distance to the object goes from decreasing to increasing and the object is to the right of the car. Passing left is the same only with the object left of the car. Crossing is the point where the predicted path intersects a map object.

To further distinguish the visibility of the objects we also predict their distance and direction, as well as their frequency of appearance. We assume that unique objects, close by, in the middle of the field of vision, are more important than other objects.

## 5.6 Game event manager

The event manager handles the progression of the game and makes sure that different parts of the story are triggered to ensure a meaningful un-

folding, as well as an interesting pacing of the narrative. The game event manager first receives a list of roadside objects from the GIS module, and then asks each story script to rate its current priority to execute according to its perspective of the world. It receives each story script's internal rating value, rated from 0-100%, and filters out the story script with the highest rating at that moment in time. If the rating is high enough it triggers the story script to proceed with its plot. The game event manager additionally makes its own rating based on a holistic perspective of the world. It is important that story scripts are executed in a suitable order in relation to each other. For example, two murder scripts should not be triggered directly after each other. Further, in order to ensure a rich user experience it is important that the story events are triggered at a satisfying pace. To this end the rating value at which the story scripts are triggered decreases over time.

## 6. INITIAL PERFORMANCE TEST

We have conducted an initial performance test on the island of Lidingö to get feedback on the technical performance. The test was conducted on a route of ten kilometers. A person unacquainted with the project was asked to draw a path on a map of Lidingö, to ensure that the test track was not particularly favorable (see figure 5). We then traveled along that route once, at the speed limit. We started at the westmost point of the route, and video recorded the journey. We traveled for 1 minute and 16 seconds at a speed of around 45 km/h, during which time the server predicted the path and generated lists of geographical events, before the computer crashed. We returned to the starting point and traveled again for 1 minute and 24 seconds when it happened again. We returned half way back and traveled for another 53 seconds before another failure. The three crashes appeared very close to each other and therefore it is likely that there were problems with the path prediction algorithm or map data (see section on path prediction). The test continued onwards and the system ran smoothly for 7 minutes and 25 seconds before it stopped again. No game event

was triggered during that time, since no relevant geographical objects were listed. We traveled through built-up areas, which do not contain geographical features that match the two available test scripts.

The application was restarted and ran for another 4 minutes and 3 seconds. During that sequence, several game events occurred:

0'00	Restart of application
0'57 – 1'11	Sound - Wolves howling
Interaction: Directional microphone directed out to the right whereupon the sound level increases.	
1'08	Screen – A text presenting two options appear on the screen.
Interaction – Select option to send message to Helena	
2'06	Sound - Incoming phone call
Interaction - Answer call by pressing the green phone icon.	
2'10 – 2'19	Sound - Female voice says "How strange. I didn't think we had wolves in Lidingö. I'll ask around to see if anyone heard anything."
2'20 – 2'22	Sound - Wolves howling
2'23	Interaction - Toggling through screen, which provides notes as to what has happened so far.
3'16	Sound - Incoming phone call
Interaction - Answer call by pressing the green phone icon.	
3'18 – 3'33	Sound – Male voice says "Benjamin, what is all this nonsense about wolves. I am sure it is just a large dog. You must be mistaken." Wolves howling.
4'03	System failure

**Figure 6. List of events during test.**

Directly after leaving the urban area, we encountered woods. The application then successfully triggered the wolf script (see figure 6), and generated a howling sound that was positioned by the system in the wooded area. When the player chose to use the directional microphone, and succeeded in directing it towards the location of the wolf sound, a chain of events was triggered. First, the game provided the player with the alternative to send a message to Helena, the player's partner back at base. The choices were to tell Helena about the wolves or to ignore the sound. Helena then responded with a phone call taking the player's concern serious. However, the police chief Ulf made a call shortly after criticising the player's judgment, before the application halted. Thus, the application worked smoothly supporting interaction both through the movements of the vehicle, and the interaction with the player. It managed to predict the paths ahead of the vehicle and extract information, such as the existence of

wooded areas. It then provided the game event manager with the geographical event lists, which triggered the wolf script. Furthermore, it responded to the user input when the player used the directional microphone as well as when making selections on the screen.

When the application was restarted, another occasion of the wolf script was quickly generated since we were now surrounded by woodlands. This time, we declined to investigate the wolf sounds with the directional microphone. This triggered another branch in the narrative, where the field agents contacted the player over the walkie-talkie to request further investigation. Again, the application worked according to expectations.

Summing up, the application manages to generate a story that combines references to the geographical context with user interaction. However, the technical performance of the application needs to be developed further to make it more stable and to make the story a richer experience.

## 7. DISCUSSION

We return to the discussion of the characteristics of believable environments and how our implementation meets these requirements, as well as how the actual prototype performed during the initial test.

**Everyday meaning:** We suggest that some referenced geographical objects should preserve their everyday meanings in the story. First, this implies that the GIS module should list reference objects that are easily recognised by the player. The GIS data available provides many classes of objects such as houses, fences, antennas, and woods. These classes of objects have a meaning understood by the player. Additionally, the same objects must also have meaning as part of a narrative in the game. Here, the implementation shows the prototype managed to find GIS data in the vicinity and link it to stories, which were then presented to the user. Furthermore, instead of just describing the objects with their geographical coordinates, we provided a framework in which the objects were defined in a user centric approach, by generating journey events. This adds

to the perspective of objects as having everyday meaning, i.e. objects as encountered during travels.

**Scalability:** A believable narrative environment should surround the location of the player. It follows that the data should be available along the whole road network and have enough density to provide story experience almost anywhere. The implementation covers an area of around 35 square kilometers (around 41 000 inhabitants), which is per se much larger than other similar narrative environments (see related works). The prototype utilizes two different forms of GIS data. The database provided by the City Council is used for path prediction, whereas the national GIS database from Lantmäteriet is used to generate additional geographical objects. A critical feature to ensure scalability, is to link the story to geographical objects in databases with vast coverage. Since the data from Lantmäteriet, which we used for linking the story to the locations, is available for the whole of Sweden it further ensures scalability beyond the island of Lidingö, our test area.

The level of detail in available GIS data is more than enough to ensure provision of narratives. The maps supplied by the City Council provide rich details such as fences, staircases, and the form and size of most houses. However their database was rejected in favour of the more meager GIS data from Lantmäteriet. The additional detail was not considered relevant for the test story, and would “slow the computer”.

Finally, it is important to consider whether the objects chosen for the implementation fit with other types of landscapes. Lidingö consists of both rural and urban areas. Although the game is implemented for a large geographical area, it still needs to be understood whether this applies to other geographical areas. Here, a specific challenge is to provide stories where the geographical objects vary little over a long period, such as when traveling through large forested areas.

**Sequential storytelling:** We argue the importance of fitting the story to the journey experience, rather than fitting stories to individual loca-

tions, to create believable environments. First, it follows that the implemented prototype must present a story which relates to the traveled path and the stories being told. The prototype succeeded in generating such story segments which both made sense in their temporal order as well as in their referencing to locations in the story. Second, interactive narratives are generally considered less persuasive than ordinary stories since user control diminishes authorial control over the way in which the story unfolds. In our case, user interaction will create a story that should interact with players' choices, as well as with their movements through the road network. It is possible that a single story line would not provide sufficient interaction to provide a good experience. The event manager has to hold the progression of the story until a requested geographical object emerges, which can break the experience of the story linkage to the environment. Therefore we have implemented a solution that provides for several related linear story lines running in parallel. In the test implementation, only two scripts were implemented. The solution consists of longer story with many related threads, as well as a shorter story with a few threads. Finally, we provide individual sound effects that further add to the feeling of a believable environment. The combination of several stories allows us to pace the storytelling along with the unfolding of the journey. At present, the prototype cannot predict the journey more than around 1000 meters ahead. This can mean that some stories require events or objects that take a long time to appear. To avoid boredom, the availability of other stories is then used to enrich the landscape with additional interesting content. We have also implemented a choice to advance the story by using global content, i.e. story elements that do not reference specific geographical content. The implemented game draws on the crime story genre, where the geography is used to place clues and situate action events. Thus, the genre is chosen to generate a believable environment. However, it is still an open question how this environment could be believable in other genres.

**Blended attention:** We suggest that the player should mix the interaction with the devices and with the physical surrounding to generate a coherent experience. The implemented user interaction is audio centric, where most of game and narrative features are presented as sounds. Additional interaction through movements is integrated with audio in the form of a directional microphone. The intention has been to allow as much visual focus as possible on the landscape. However, for practical reasons the response to the speech is designed as a selection of options from a list display on the screen, rather than as speech recognition. The latter was, at this stage, considered too technically demanding. The audio centric approach differs from a visual design approach based on e.g. see-through displays. The latter are considered lacking in precision, which generates nausea and unsatisfactory user experiences [5]. Audio interaction, on the other hand, is generally less applicable for precise positioning. Humans find it harder to orient the location of a sound source than to orient it visually. In this case, we expect tolerance of the players to limitations in precision in the positioning of sound-effects. Further, we suggest that audio encourages the players to shift their attention to the surrounding environment, even though the game does not change the environment as seen from the car. Sounds are intended to evoke the imagination as to what is happening just behind a bush, inside a house or around the corner. Finally, the combination of vagueness and evocation is well suited to a game generated from GIS data. Even though the data is a rich source for narration, it cannot be compared with the possibilities afforded if the author gets to visit the geographic location. Here, an ambient and vague form of audio interaction could be useful, since the level of detail, and understanding of the location, is not as determined as in situated game design.

## 8. CONCLUSION

We argue that an important step in the development of pervasive games is to both design for vast environments and include narrative-based

content. Pervasive games, designed for vast areas, would then evolve from available chasing tasks and performance types of use contexts. The area of interactive storytelling provides new resources for such an extension, and introduces the concept of “believable environments” as a topic of research. If the focus is on utilizing a section of the landscape, as seen from the back seat of a car when traveling, we suggest a focus on four design characteristics. These are: references to geographical objects with their everyday meanings, scalability over vast areas, sequential story telling and finally support for a blended focus of attention. The paper further contributes a suggested implementation, which introduces concepts for linking a GIS module to a narrative engine. Thus, the ambition has been to add features to available engines rather than developing them according to dominant research directions within interactive storytelling research. It is possible to conclude from the initial performance test that our concept is technically viable. The application provides an innovative and vivid experience. However, there are still issues in making the application stable. Furthermore, the content needs to be expanded to provide for an engaging experience that complements journeys in the back seat. Finally, an important step is to evaluate how players experience being field agent managers tracking and uncovering werewolves around their family car.

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