Experiences with AR Plots: A Travel Time Augmented Reality Game

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Abstract

Digital games have the potential for changing attitudes towards social issues such as climate change and sustainability. These games don't have to be based on fixed computing and with the rise of smart phone, they can make use of a range of sensor and augmented reality technologies. This paper presents the experience of developing AR Plots, a prototype locative game with an augmented reality interface. It is a game designed to fit in with the fractured nature of travel time on public transport. This paper discusses technical challenges, usability issues and game design approaches used to work within these constraints.

Introduction

This paper outlines the early stage results of developing a location-based game with an *augmented reality* (AR) interface. The game is intended to be played on local, intra-city bus trips and carry a message about climate change and sustainability. This is part of a wider project to examine how technology can instrumentally affect people's attitudes towards climate change and sustainability issues. It builds on work carried out in mobile computing and travel time use.

AR Plots – The Game Prototype

In AR Plots the players grow plants alongside bus routes, watering their own and friend's plots. Virtual gardens grow up by bus stops and traffic lights. When the bus stops for a length of time, empty plots are created that they or other players can plant in. A player can plant a seed in a plot and then 'owns' it with their plant. Plants need watering, however the amount of water they have is limited. Plants only bear fruit or flowers if other players also water them. A simple one-click 'check in' mechanism is used for the players to water their own or other's plant. The persistent game world is run from a web server using PHP and a MySQL database. Augmented reality is the basis for the graphical interface and is being prototyped and tested on Android smart phones, using a background service and the Layar AR browser [1]. There is a wide range of different commuter journeys on many public transport types. There are also many different types of bus journey. This game is being designed to work on Bristol, UK, based buses intended for a commuter audience (www.firstgroup.com/ukbus/southwest/bristol).

Layar – An Augmented Reality Browser

Layar is an application for Android and Apple iOS based phones that overlays virtual points of interest on the phone screen by using a combination of the phone's camera, compass and GPS. The browser retrieves data in the form of layers, which are content collections that serve geo-located points of interest (POIs) in the vicinity of the user and overlays these POIs on the live camera view. Layers are created and maintained by third party developers or content providers. Each POI in a layer contains icons and actions that layer users can use to interact with the POI. The primary focus of Layar is to enable provision of geo-located content as an augmented reality layer on phone's camera view and facilitate various interaction patterns with the POIs in the layers. The interactions, encoded as actions in layer definitions, include launching web pages, video or audio streams, placing calls and sending emails.

Technical Requirements and Architecture

To achieve the above-mentioned aims of the game a number of requirements and constraints arise in system design.

Technical Requirements and Constraints

The foremost requirement is awareness of the location and movement of the user. This requirement is easily met by targeting the game play for modern smart phones with GPS sensors. Moreover, not only the location but also the orientation of the mobile device - in its own plane and in earth's magnetic field - needs to be known in order to present the augmented reality view to the user. This is possible in modern mobile devices with orientation sensors. Obviously an AR view requires presentation of the real world onto the device's screen and this can be achieved with the built in camera of the device. The game play is collaborative in the sense that a user is able to view and interact with digital artefacts created in the virtual world by other users. This requires central processing of user interaction with the game (and consequent effects) and updating all users with the latest state of all artefacts in the system. This aspect enforces the requirement of communication between the user devices and the central processing server and is met in the form of 3G data connectivity in user devices.

In addition to these hardware and communication oriented requirements, specific requirements in the mobile device software are also apparent. Because the game interaction intends to present an AR view of the user's current location a software platform is required that can combine the user's location information, orientation of the device, detect movement and stoppages, and allow the user to interact with digital artefacts in the augmented reality world/view. Layar Browser aids in meeting a majority of these requirements.

The use of Layar leverages several benefits that include availability on significant share of current smart phones (43.4% in second quarter of 2011 [2]), support for interactive presentation of augmented reality, 3D modelling of the real world landmarks and feasibility for quick prototyping interactive augmented reality applications and services. A few shortcomings of Layar (frequently changing interfaces and addition of new features that are not backward compatible) can be attributed to its early stage in terms of software maturity. One of our requirements is not addressable by Layar i.e. triggers for detecting stoppages and movements from user devices to the central, game processing server. To satisfy this requirement, we have developed a background application that monitors the device movement via GPS and sends triggers at appropriate situations to the central server where the triggers are used to create empty pots in the virtual world. Figures 1 and 2 show the system architecture used to develop the game.

The game design and interaction faced a number of constraints due to limitations in software and hardware platform as far as interactive AR gaming is concerned. The GPS accuracy is variable and effects placements of digital artefacts in the virtual world and also the detection of stoppages and movements of the device. Different device screen sizes affect the quality of interactive experience of users, a higher resolution and larger screen naturally offers a better, more immersive experience with a greater field of view. Moreover, Layar limits the actions that can be performed by interacting with the digital objects in the augmented reality view i.e. actions are predefined on the central server and cannot be modified dynamically based on user/device situation or location. We have overcome this limitation by using a feature in Layar which is designed to refresh the client view by re-fetching all digital artefacts available in the central server. While sending this request, we have forced the actions to send back parameters that help us detect the user's location, the latest action he performed and the digital artefact on which the action was performed.

Interface Constraints and Context for Use

To understand the issues for designing a game with Layar as the platform, a PACT analysis framework [3] was used to evaluate the application in the context that the game will be played; on local buses in Bristol. The project is small and is following discount usability [4] and iterative design. Existing Layar content and early stage prototypes were evaluated in live situations with members of the extended project team. This has highlighted a number of key issues that have become important inputs into the design process.

Motion Sickness whilst using an AR Browser

Whilst evaluating Layar on the bus all participants reported a feeling of motion sickness whilst using it. This included those who said that they didn't normally feel motion sick whilst reading or using devices in cars or public transport.

The double-decker bus that was used for testing does have many turns and we purposely tested on the top floor. However it appears to be the camera view that Layar uses to overlay information that brings about the feelings of nausea. The feelings of nausea quickly subside when not using Layar. Motion sickness is still a poorly understood physiological phenomenon but the stimuli that cause it are well documented. It is caused by a mismatch between visual stimuli and the inertial sense received from the vestibular system. These causes are usually isolated to either inertial motion (with visual stability) sickness or visually induced (with no movement) sickness [5, 6].

A number of physical and device factors contribute to motion sickness whilst using an AR application on the bus. The camera feed is not an instantaneous view of what is going on behind the phone and there is a tiny delay after movement. The phone must be held up in front of the face and even with two hands the phone will bob and sway with the bus movement. Rapid movement during transit causes the GPS to constantly update which leads to the onscreen icons not appearing fixed in relation to the background view. By themselves these factors would lead to visually induced motion sickness, but the bus itself is also moving. So attempting to use an AR application on a bus creates the typical stimuli associated with both visually and inertially induced motion sickness. Individuals do have varying susceptibility to these [5], but with the range of conflicting stimuli even those who are not highly susceptible feel the effects.

Social Issues of Camera Use

Another observation was that when the phone is held up, people in front of the camera are very aware of being photographed or filmed. When using Layar the phone is physically moved around to seek information in the environment and bystanders inevitably end up in the camera field of vision. It is clear that smart phones, with in-built cameras are being used, and the live camera view is visible when the phone is pointed away. This means that bystanders are very aware that they have or will appear on screen in the camera view.

The pointing of cameras, and capturing people on-screen, raises two interrelated issues of privacy [7] and the claiming of personal social space [8]. When using a camera in a public space, the user can be seen to be claiming a particular, indeterminate space in front of the lens. Those in front of it are now in a one way, non-negotiated relationship, with the camera holder. On the street (or any other situation where people are mobile) people may cross the camera's field of vision, but usually there is plenty of opportunity to move quickly out of camera view. On public transport this is not the case, people more or less have to stay in their seat.

This is not a one-way, or naive, relationship though, the users of Layar are just as aware of this as a problem whilst it is happening. They are aware of the social rules being broken and the uneven relationships being created. This makes the users uncomfortable, as well as other people on the bus, creating a very difficult situation for the use of this technology whilst on any forms of public transport and is an unexplored tension between the user of AR Browsers and others in public space.

Device and Interface Issues

There are two specific device issues that came up during testing, the variability of lighting conditions and the relationship between GPS data and the application. Lighting on a bus will be highly variable, based on the internal lighting and the level of sunlight coming in from the outside. The AR Plots game is likely to be played at peak times of public transport use; the morning and evening 'rush hours'. At certain times of the year the sun will be at a low point and will have a large effect on screen readability and will cause white out, or extreme contrast in the camera feed. Even outside of these times of day and year there will be problems with lighting affecting the experience.

As noted earlier (Section Technical Requirements and Architecture), there is a lag between movement and updating of the GPS data, so the application does not show an entirely accurate representation of where the user is. The variability of the bus speed and irregular starts and stops means that the users' location can not be corrected for statistically. So whilst viewing the Layar application the content often jumps around, or disappears completely, as connectivity or GPS location is lost or updated. This leads to a disrupted and broken experience, and the relationship between the on screen icons and the background camera view is not stable enough to make any associations between location and distance.

The Aesthetics of Augmented Reality

The term augmented reality raises expectations about what the final product would be. There is also a big difference between the technologies, applications and contexts of the use for AR browsers and glyph based AR. AR browsers show an overlay of icons on a live camera feed. In ideal conditions this gives the illusion that those icons are fixed to the location they represent. Close-up objects, for example passengers, bus walls or nearby buildings, tend to interrupt the experience of the application either being an augmentation or informational overlay of reality. There is no connection between the outside world and the information being displayed on screen.

The experience of using Layar has more in common to a Head-Up Display (HUD) traditionally used in aircraft, especially for military use. The visual vernacular and the informational design approach of the HUD have also been carried across from military applications into computer games as there is a very close relationship between these military technologies and the computer games industry [9]. As a gaming interface the concept of a HUD also seems to fit as a better description of the experience and has a better association for those taking part in the tests.

Game Design Recommendations

Our original design directions intended the game to be both seamful and ambient, fitting in with our current understanding of travel time use and technological constraints. These have been refined via the feedback from the live testing of Layar.

Seamful Design

Chalmers sets out a design strategy for dealing with ubiquitous computing applications that he calls *Seamful Design* [10]. This involves designing to fit the inevitable problems such as sensor unreliability and connectivity loss into the game's design rather than assuming that the technical infrastructure is robust and reliable.

This approach allows us to deal with the technical and device constraints described above rather than try to overcome them. For example, the creation of plots for players to plant in does not have to be dynamic, and the exact location of these plots does not have to be geographically accurate, except to be on either side of the bus.

Ambience

Ambient games run in the background and don't require constant attention [11] and are the game equivalent of ambient music and intended to require minimal attention and interaction. As games they should continue to function without player attention and should not punish the player for inactivity or inattention. Our original design goals was to design a game that does not take over the travel experience, but works with the fractured and distracting nature of public transport. Previous research has shown that people on public transport tend not to focus on one task for the duration, and will probably engage in a number of activities on a journey [12, 13]. They will also use a variety of Information and Communication Technologies (ICTs) to improve their experience, from listening to music to making phone calls, to using the internet. So the intention was to create a game that gently complements the journey, and associated activities, rather than dominating it.

This design direction is reinforced by the findings that extended use of AR on a bus will create motion sickness in players. So a design constraint is to create a game that is only interacted with occasionally via the AR interface and functions in the background, persistently and lambently. We also want the player to always be in control of their interactions with the game and not have the game interrupt their journey, so we will not be making use of alerts.

Dynamic Generation of Locations

The game dynamically generates empty plots in places where the bus stops, and these will be maintained through planting and water. So places along the bus route such as bus stops and traffic lights will become game gardens. We have made this decision because of GPS lag, motion related sickness in the AR and the fact that the bus can speed by Layar locations making them difficult to interact with. When the bus is stopped, or moving slowly, the player can easily interact with the on-screen icons.

The plots will be generated on either side of the bus so that there is always a plot outside the window that the player is seated nearest. This leads to a reduced need to point the phone camera at people to see plants that might located at the other side of the bus, as there should always be something to interact with on the player's own side of the bus. This means less embarrassment for both the player and other passengers. Ideally this makes the action of choosing a seat on the bus part of the gameplay.

Simple Interaction mechanic

The game interaction is designed to be simple as the game is intended to be ambient, and not distract from other activities on the bus, or simply the enjoyment of the journey. The system is also limited in the types and amount of interaction that can be achieved via Layar. So we will use an interaction that is similar to the 'check-in' mechanic used in location based services such as Foursquare (www.foursquare.com) or Gowalla (www.gowalla.com) and other treasure-hunt style pervasive games [14]. The AR interface will present the user with icons or objects that can be interacted with a 'one-click' manner. The player's only decision will be to interact or not. For empty plots the player may plant or not, for existing plants, the player can water or not. Players will also be extremely limited in the number of times they can interact with their own and other players' plants; only one or two interactions over each journey. This is to slow the game down, making it extend over many journeys and not become a journey dominating experience.

Conclusion

Discount usability techniques and early stage testing have delivered a variety of insights, which have impacted on the game design. The contextual issues of motion sickness, embarrassment around camera use, usability problems and application aesthetics can be addressed through simple, seamful and ambient design. Even though we were aware of these design philosophies the findings presented in this paper have helped to reiterate the usefulness of these approaches for locative games.

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Figures

Figure 1 - System architecture

System design and interaction between Layar browser and server, game server and the Android background application.

Figure 2 - In-game snapshot

In-game snapshot showcasing two plants in various stages of growth.

Figure 3 - In-game snapshot

Geographic distribution of plants along a bus route.