Designing for the Dichotomy of Immersion in Location Based Games

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ABSTRACT

The interaction design of mixed reality location based games typically focuses upon the digital content of the mobile screen, as this is characteristically the primary navigational tool players use to traverse the game space. This emphasis on the digital over the physical means the opportunity for player immersion in mixed reality games is often limited to the single (digital) dimension. This research seeks to redress this imbalance, which is caused, in part, by the requirement for the player's attention to be systematically switched between the two worlds, defined in this research as the '*Dichotomy of Immersion*'. Using different design strategies we propose minimising the reliance of the player upon the mobile screen by encouraging greater observation of their physical surroundings. Using a 'research through design' approach for the mixed reality game *PAC-LAN: Zombie Apocalypse*, we illustrate design strategies for increasing immersion in location based games, which we believe will aid designers in enabling players to more readily engage with the physical context of the game and thus facilitate richer game experiences.

Categories and Subject Descriptors

H.5.m. Information interfaces and presentation: Miscellaneous - Design.

General Terms

Design.

Keywords

Location-based games, dichotomy of immersion, minimal-attention interfaces, immersion, legibility of space, physical immersion, digital immersion, mobile games, digital cartography.

1. INTRODUCTION

One of the most common components of a mixed reality Location Based Game (LBG) is a digital map that allows the player to visualise the game space and, in many cases, the location of the virtual game elements within the physical space. As such, the map

element often encourages players to constantly check their current location on a mobile screen in order to navigate the physical space resulting in their attention being divided between the digital representation of the space and the physical space itself. This repeated switch in attention has the potential to interfere with the immersion of the player in the physical context of the game as the virtual component dominates and so the quality of the locative experience may be reduced.

Carrigy et al. [3] stated that immersion is used to describe a state where the player has lost connection with the world outside of the game and results in "the boundaries of the magic circle", in which the game is played, becoming the current 'real world' of the player. In the case of computer games, one of the metrics often used to identify this phenomenon is *presence*, "the subjective experience of being in one environment (there) when physically in another environment (here)" [18]. In such games, "players are actively, rather than passively, engaged in the gameplay experience and therefore the quality of the players' interaction with the game system, through the game mechanics, is a key factor influencing immersion" [3].

Immersion can also be described as the degree of involvement of a player with a particular game and can be considered in relation to three distinct levels: 'engagement', 'engrossment' and 'total immersion' [2]. The engagement level refers to the player overcoming the barriers of basic rules and understanding of the game, whereas the engrossment level refers to game elements influencing the players' emotions through play. Finally, the player only enters total immersion when they become completely absorbed within the game space and no longer engaged with operational aspects of the game.

Mixed reality LBGs are enacted simultaneously in both the digital as well as the physical space, thus presenting a challenge for achieving immersion as the player's attention is inherently divided between both the digital and the physical. Immersion should therefore be considered in both worlds: with '*physical immersion*' referring to that when players are immersed in the physical world; and '*digital immersion*' referring to that when players are immersed in the virtual world, which in most cases is presented through the screen of the mobile device. Rather than immersion types being viewed as two distinct states, they should be viewed as the ends of an immersion continuum. At any one time, a player in an LBG may be considered to be somewhere along this continuum, but being attracted by each pole (the digital and the physical) simultaneously, thus preventing total immersion at either extreme. This fluctuation in the player's attention between

the physical and the digital is what we refer to herein as the 'Dichotomy of Immersion' in LBGs.

The majority of previous designs of LBGs only address 'digital immersion' through the use of sound (Riot 1831! [16], Savannah [1], Viking Ghost Hunt, REXplorer, Visby Under, Frequency 1550 [3]), undermining the importance of the physical space that LBGs are played in. However, the requirement to navigate through physical space will prevent total digital immersion, and hence it is equally important to address physical immersion. In doing so, players are encouraged to become more aware of their physical surroundings, and less reliant upon the on-screen digital artefacts.

This research therefore suggests techniques such as the introduction of additional elements into the physical space in order to facilitate in-game navigation, and an interaction design in which the map acts as a reference to physical elements within the game arena as opposed to a direct navigation device. The introduction of these elements may be considered as facilitating what Lynch referred to as the "legibility of the space" [12].

Lynch argues that when navigating familiar surroundings, people use their own mental mappings of physical spaces to orient themselves and that each individual has their own distinct image of how a particular place appears. This image is built upon their past experiences and current perception of that space, and it is this newly formed image that is "used to interpret information and guide to action" [12]. Enabling clear mental mappings of the environment counters the effect of disorientation provided through the unfamiliarity of a new space that can often introduce fear. According to Lynch [12], each image is constructed using three major components: 'identity' (recognition of physical elements), 'structure' (relationship of physical elements to other physical elements) and 'meaning' (practical interpretation to each observer). Therefore, in order for a new space to be easily navigable, it has to have clearly defined physical elements that are easily recognised by people. These elements, in connection to other physical elements, can form a story and lay the foundation for the story to be remembered by individuals navigating the space.

If we consider this notion of spatial legibility in terms of video games that operate on a spatial level, such as Pac-Man (Namco, 1980), the game area is clearly defined as a maze identified by solid lines representing the walls. As such, the player knows exactly what the limitations of the playable area are and there is no movement beyond these hard boundaries. The on-screen representations of the game elements therefore make this space legible in such a way that players can readily deploy different tactics for winning the game. LBGs are inherently open-world games, and even where there are natural boundaries and inaccessible areas (e.g. buildings, lakes, fences etc.) there are generally no physical elements that help identify the bounds and nature of the playable area. This is because LBGs are played in the physical spaces that are already legible and have features that often already facilitate the traversal of such spaces (e.g. defined footpaths). As such, any game elements that are added must not be counter-intuitive to existing perceptions of the traversal of the space. These elements should therefore be unique in their appearance and stand out from all other physical features within the space. However, the positioning of physical elements to act as bridges between the real world and the game world is often deemed impractical or limited in terms of scalability, and as such the vast majority of LBGs are only identified digitally on the mobile phone screen.

This paper therefore argues that in order to achieve greater immersion in LBGs the attention of the player must also be allowed to focus on the physical space as well as the digital space, which will require new design strategies. As there are no such strategies readily available we adopted a 'research through design' approach [6] to allow exploration and reflection on this challenge through the design of a particular game. Gaver states that the exploration and experimentation of a particular design can lead to a better understanding of the underlying design processes involved to provide insights that can be utilised more generally [9]. Therefore PAC-LAN: Zombie Apocalypse explores space legibility as a means to achieve greater physical immersion in LBGs. This game builds upon an earlier LBG PAC-LAN (2006) [14] that unconsciously addressed this issue.

Zhang et al. [19] demonstrated that the overall players' engagement level with the environment in LBG's could be increased through the use of deliberate design features and game mechanics [19]. One such mechanic employed by Zhang et al. [19] is the introduction of ambiguity into the game, through the use of "obliquity", which emphasises the "player space" over the "game space" in LBGs and thus encouraging interaction with the physical surroundings [19]. PAC-LAN: Zombie Apocalypse will address the issue of spatial legibility using ambiguity as a mechanic, with the specific goal of trying to minimise the player's interaction with the mobile screen, which is intended to therefore increase their interaction with their physical surroundings. This approach should therefore re-balance the two ends of the immersion continuum without disregarding the mobile UI as an important feature of an LBG game.

The following sections briefly describe the original PAC-LAN game and then the new PAC-LAN: Zombie Apocalypse game design along with the features adopted for immersion and how these are manifested in the rules of the game. This is followed by an in-depth analysis of the rationale behind these design elements before presenting empirical evaluation of these strategies and finally drawing conclusions upon the implications of this research.

2. GAME DESIGN

The original PAC-LAN game was created to consider the possibilities arising from the combination of mobile devices and Radio-Frequency Identification (RFID) technology to create new entertainment experiences [14]. Pac-Man was chosen as it allowed a comparison with other games of that time that used this theme, namely Pac Manhattan and Human Pac-Man [14]. At the time of development, hardware limitations meant that RFID rather than GPS technology was used as the method of determining location by requiring players to tag physical objects at known locations. It is worth noting that this particular version of RFID went on to be standardised as Near Field Communication (NFC). PAC-LAN: Zombie Apocalypse is built using the Android platform to allow the game to be widely distributed 'in the wild', as Android is found on the greatest number of handsets with on-board NFC readers. As per the original PAC-LAN game, the NFC game pills are created from Frisbees (yellow and red), to physically embody the 'pills' that Pac-Man collects during the original arcade game. These pills include straps so they can be easily attached to the physical environment (e.g. lamp post, downpipes, trees) and an NFC tag programmed with an ID, allowing access to the name and location of that pill via the game system.

The following sections describe the game as a function of its rules utilising the classification of rules existing on three levels [17], which are: 'operational', 'constitutive', and 'implicit'. The operational rules are the guidelines players need to play the game,

while the constitutive rules are the more formal and mathematical structures "that exist below the surface of the rules presented to players" [17]. Lastly, the implicit rules deal appropriate game behaviour to players and are thus unwritten rules that are highly dependent on the social context within which the game is played.

2.1 Operational rules

The game consists of five players, each of which is provided with a character costume (individual character hat), identified by a specific NFC token (attached to the hat) as well as an Android mobile device running the game application. One player takes the role of PAC-LAN, whose purpose is to tag all of the pills in order to earn points; and the remaining four players take the role of the Zombies, whose purpose is to 'infect' the PAC-LAN player by tagging their NFC token. As with the arcade version, there are a number of special 'power pills' located within the game arena which, when tagged by PAC-LAN, enable the player to 'infect' the Zombies by tagging the NFC token on their costume, forcing them to return to the starting location of the game to 're-spawn'. All of the main interactions within the game, such as tagging pills or characters, occur physically and do not require any interaction with the interface of the mobile screen.

Before a game commences the game space needs to be set up which involves positioning the pills both physically in the landscape and digitally on the map. There are 3 types of pills in the game:

1. The base pill – where all players start the game and where players 're-spawn' after being captured (Zombies only) or if their 'roaming time' expires (all players).

2. Check-in pills – update the last tagged location of all active players as well as replenishing their 'roaming time'.

3. Power pills – give PAC-LAN the ability to 'infect' Zombies. They also replenish the 'roaming time' and extra time for 'infecting' zombies. These pills are only distinguished on the PAC-LAN's UI as for Zombies they function the same as check-in pills.
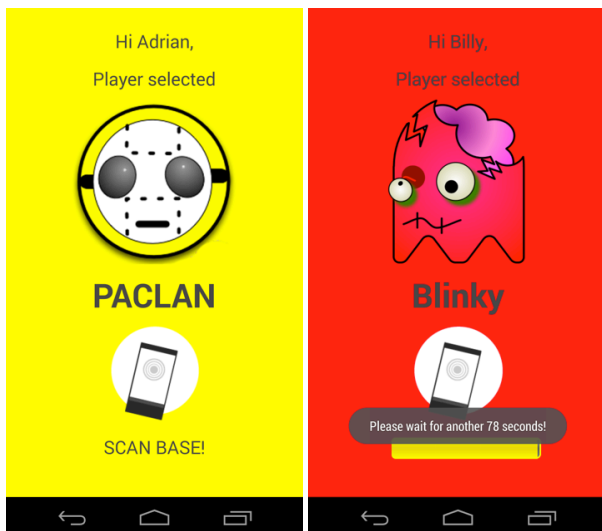
**Figure 1. a) PAC-LAN entering the game (left);
b) Zombie entering the game with a countdown for 'waiting time' (right)**

Once the physical game space has been successfully set up and the players are equipped with their chosen costume, each player is then required to tag the base pill to start their game. Compared to the PAC-LAN player, who begins play immediately after tagging the base, each Zombie player has a predefined waiting time, displayed as a progress bar before they become active within the game. This gives the PAC-LAN player time to exit the immediate vicinity of the Zombies (Figure 1a and 1b) before they can be 'infected'. The Zombie players have the option of considering which player is the fastest and slowest, and account for this when selecting which Zombie character they will play. The Zombies are named Blinky, Pinky, Inky and Clyde after the original ghosts from the Pac-Man arcade game, and have to wait for 100s, 80s, 60s and 40s respectively before they can actively view the map and play the game.

The game UI displays a map depicting the location of all pills, paths and buildings, and a decreasing progress bar ('roaming time') that represents the maximum time that a player can take between tagging pills before being forced to return to the base. During this 'return period' the player is inactive and so no interactions with the UI or physical anchors are allowed until the base is scanned again.

When a player tags a pill, the 'roaming bar' is replenished and the UI refreshed by showing the location of the last pill tagged by each active player, as well as changing the colour of the pill to grey to indicate it is no longer worth any points. Each player's interactions with the pills are visible only on their individual UIs. The player can return and 're-tag' a 'grey' pill to replenish their 'roaming time' and to update the last tagged location of all other active players, though they will not receive any more points for that pill.

There are also deliberate design features that obscure parts or the whole of the UI at different times during the game, in order to encourage the player to be less dependant upon the screen. The 'Fog of War' (FoW - shown in Figure 3) is controlled by the 'roaming time' and incrementally covers the screen at predefined times reducing the visible portion of the map until the player tags the next pill. Another such design element is 'Screen Blanking', which occurs 5 seconds after the user's last interaction with the screen. Both these elements are described in more depth in sections 3.2 and 3.3 respectively.

The game is finished when either PAC-LAN tags all the pills or is tagged by one of the Zombies and the winner is calculated based on the total points gained during the game. When the game finishes, the mobile application displays a leader board showing all five players and their scores.

2.2 Constitutive Rules

1. Points are gained by the physical act of tagging both pills and players.

2. Points for tagging a pill can only be received once by each player.

3. A fixed number of points are allocated per type of pill whereas a percentage system based on the total number of game pills is used for tagging players. This feature allows the game to be balanced irrespective of the number of pills used to define the particular game arena.

4. PAC-LAN receives 100 points from tagging a 'check-in pill' and 200 points for a 'power pill', whereas Zombies earn 50 points per pill, as a 'power pill' and a 'check-in pill' are effectively the same.

5. Similar to the original arcade game, Zombies are in 'infect mode' until PAC-LAN tags a 'power pill'. When PAC-LAN is in 'infect mode' he/she can 'infect' Zombie each of which is worth 25% of all potential pill points available for PAC-LAN. When this happens, the 'infected' Zombie's mobile phone turns off the map and informs them that they must re-tag the 'base pill' in order to re-join the game. Additionally, when PAC-LAN is in 'infect' mode, the player can see a set of 'blood drops' for all Zombies on the player's map, in order to aid their capture. These 'blood drops' represent the last five GPS known locations of all Zombies after their last allowed action. The 'blood drops' are deliberately not showing the current location so as to again discourage reliance on the screen. (Section 3.4). This feature is related to game balance as discussed in section 3.

6. If a Zombie 'infects' PAC-LAN, they receive 75% of all potential pill points available for the Zombies in the game and the game is ended for all players.

7. The FoW covers the screen at 4 different stages of the roaming time, 60%, 45%, 30% and 15%, until the screen is fully covered. Whilst PAC-LAN is in 'infect mode' no FoW is performed.

8. When 'infect mode' has ended for the PAC-LAN player, the system automatically updates the player's 'roaming time' as if a 'check-in pill' was tagged. As such, a 'power pill' effectively doubles the time for which PAC-LAN can navigate the map before his roaming time expires.

2.3 Implicit Rules

Within all games there are some 'hidden' rules that, even if not necessarily written down, every player is expected to abide by; for example those related to "etiquette and good sportsmanship" [17]. As with any other game we expect that *PAC-LAN: Zombie Apocalypse* will develop rules that fall into this category but they are beyond the scope of this research. However, some specific examples are apparent such as the physical pills being located at a height that is accessible by all players and that players should not exchange costumes or phones during the game.

3. DESIGNING FOR IMMERSION

The following section reflects upon the overall design rationale of individual elements added with a view to enabling a deeper sense of immersion within the game.

3.1 Map Design

Monmonier suggests that "a single map is but one of an infinitely large number of maps that might be produced for the same situation or same data" [13]. In order to avoid hindering the user's understanding by displaying all possible elements, all maps must necessarily be selective with regards to the information that is displayed, with decisions as to what to show based upon the purpose of the map and the medium in which it will be presented (paper, screen etc.) [11,13]. For the majority of LBGs the role of the map is to aid players in their navigation of the game space by following their location on screen, exploring their surroundings, and finding digital game artefacts that are not visible in the real world (e.g. collectable virtual 'coins'). Whilst useful as a gameplay mechanic, it has been suggested that the map may act to break the player's attention from their physical surroundings [4], which may have a negative impact upon their immersion into the game. Typically, developers use a commercial mapping provider such as Google to supply their maps in LBGs. This is likely a result of the ease with which such maps can be incorporated into an application, arguably at the expense of a rigorous design

process [7]. One exception to this would be *Ingress* (Google, 2014), which had a custom animated map from a '3D' viewpoint.

The ubiquitous use of generic maps as backdrops for a variety of web and mobile applications has led to a great deal of discussion and criticism in the cartographic literature relating to the idea that their prevalence has produced a global "blandscape", creating a sense of "unauthoredness" and apparent 'homogenisation' of the landscape through the lack of detail and high level of generalisation [11]. It is worthy of note that, following this perceived 'stagnation' of map production, video games have been described as "the bold future of cartography" [8]. Games such as Grand Theft Auto V (Rockstar Games, 2014) and Elder Scrolls V: Skyrim (Bethesda Game Studios, 2011) comprise not only detailed 3-dimensional 'open world' maps to explore within the game, but also accompanying paper maps to aid navigation. Skyrim, for example, comes with a foldout stylised map on textured faux-parchment, as well as a 660-page guide, which includes 220 pages of maps, representing the work of many digital cartographers [8]. It seems only fitting therefore, that LBGs, a game genre that relies heavily upon maps, should engage more fully with cartographic design, rather than relying upon generic commercial products. It is hoped that this research serves to stimulate conversation relating to this within the LBG community.

Map design revolves around the need to satisfy a particular communication goal [7]. In the case of web mapping services such as Google Maps, this purpose is primarily a road atlas, an assertion that may be verified by their appearance, and the route-planning heritage of the web applications from which they are derived [5,11]. It could be seen as inappropriate, therefore, that these maps are often used for a wide range of purposes without due attention being paid to their suitability for a given application (in this case an LBG). In *PAC-LAN: Zombie Apocalypse* the primary function of the map (referred to as 'Pac-Map' herein) is to indicate the locations of the physical game elements to the players. Additional design goals for the map were: to be in-keeping with the theme of the game through the use of a suitable aesthetic; to perform well within the context of the game (i.e. outdoors); and to encourage users to glance at the map and navigate in a 'head-up' manner, using their surroundings, as opposed to navigating in a 'head-down' manner, looking at the map throughout their journey as is typically the case when navigating using a mobile phone.

The Pac-Map was created using data that were derived from OpenStreetMap (http://www.openstreetmap.org/), using PostGIS (http://postgis.net/), and were rendered on-demand into 256x256 pixel 'tiles' using Mapnik (http://mapnik.org/). These 'tiles' are requested from the server by the Android application, which mosaics them into a seamless base game map. Rendered tiles are cached on the server for efficiency. Using "real" mapping data and on-demand rendering allows the game to be played anywhere, whilst maintaining an aesthetic for the game that reflects the style and appearance of the original Pac-Man arcade game. This may be seen as a significant improvement upon both the non-stylised, static image-based map used in the original *PAC-LAN* game [15] and upon a generic mapping products (Google Maps or similar) that are not well suited to supporting gameplay and do not provide a gaming aesthetic. In order to achieve a map that reflects the classic Pac-Man game, all labels and POI's have been omitted, and features have been generalised such that boundaries are only comprised of vertices that are oriented North-South or East-West, and are rounded to the nearest 10m. This simultaneously acts to reflect the characteristics of the Pac-Man 'maze' from the original game and to generalise features on the map, which acts to

introduce spatial ambiguity into the dataset. It is intended that this ambiguity will help discourage over-reliance upon the map during gameplay by making it less representative of the true nature of a player's surroundings, and so encourage 'head-up' navigation [10].
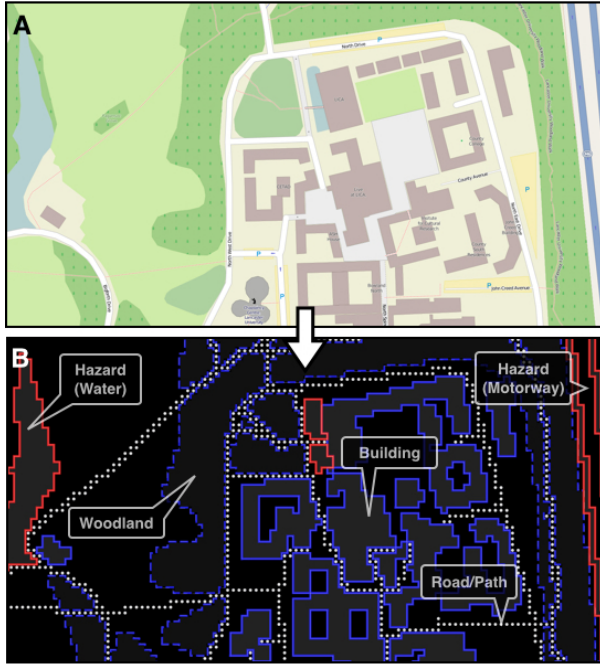

Figure 2. A comparison between the original *OpenStreetMap* (A), and the *Pac-Map* (B)

Trees and buildings are drawn in the same blue as the Pac-Man maze, and a complementary red has been used to mark out hazards as shown in Figure 2B. Whilst effective in the evocation of the game itself, the dark palette employed by this map has the potential to be susceptible to screen glare in bright sunlight. In order to combat this, the lines in the map are chunky, with fine white lines drawn into the blue and red in order to increase their contrast with the black background. 'Pathways' (roads, footpaths, cycle tracks etc.) have been marked with chunky white dots (Figure 2B), providing a high contrast with the dark background, whilst reflecting the 'pellets' within the maze in the original game. The Pac-Map is compared with the source-data in Figure 2A, in order to illustrate the effect of this process.

3.2 The Fog of War

The 'Fog of War' (FoW) shown in Figure 3 is a game design feature controlled by the 'roaming time'. It consists of incrementally obscuring the map with a white 'fog', thus making it less easy to read. There are four different levels of 'fog', with each level obscuring a greater area of the map as it incrementally 'creeps in' from the edge of the screen towards the centre. To further aid the player's awareness of the passing of the 'roaming time', each level of the FoW is associated with a haptic feedback, with handset vibrations informing the player of their remaining 'roaming time' without the requirement to check the screen.

3.3 The Screen Blanking

Similar to the FoW, 'Screen Blanking' is designed to discourage over reliance of the player on the mobile screen. It consists of turning the whole mobile UI into a black screen after 5 seconds from the last action the user performed. There are two types of actions that make the screen fully visible again: either the player tags a pill or player, or explicitly requests access to visualise the game interface by tapping the mobile screen. The latter action displays the UI in its current form, and so does not remove the FoW. It is important to note that the Screen Blanking and the FoW work simultaneously and are not mutually exclusive.

3.4 The Blood Drops

The 'Blood Drops' are a design feature used to lessen the level of uncertainty of the location of the Zombie characters whilst PAC-LAN is in 'infect mode', and so give a slight advantage to PAC-LAN in their attempt to 'infect' a Zombie. As soon as the PAC-LAN player tags a 'power pill', 'infect mode' is therefore activated. At this point, a 'virtual' trail of *blood drops*, as shown in Figure 4, is displayed on PAC-LAN's UI, which shows five GPS positions recorded after each Zombie last tagged a pill. Given that the PAC-LAN player does not know how long ago the Zombies last tagged a pill, this information indicates their initial direction of travel from their last tagged pill, but does not give away their location with any certainty. In this way, the 'Blood Drops' may be considered as a 'clue', as opposed to robust locational information, and as such acts to balance the game by giving PAC-LAN a temporary slight advantage, without making it too easy and therefore unfair to the Zombie players.
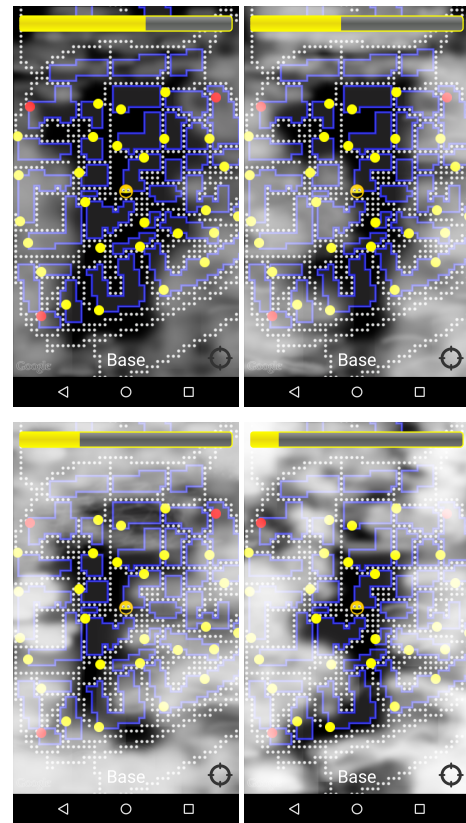

Figure 3. The four different levels of the Fog of War covering the screen.

3.5 The Game User Interface Design

The User Interface, shown in Figure 4, displays all the game elements: the players (in this case PAC-LAN and Blinky), the pills, textual location information and remaining 'capturing time' information. As previously mentioned, the roaming UI has a yellow bar and does not normally display the 'Blood Drops' for the Zombie.
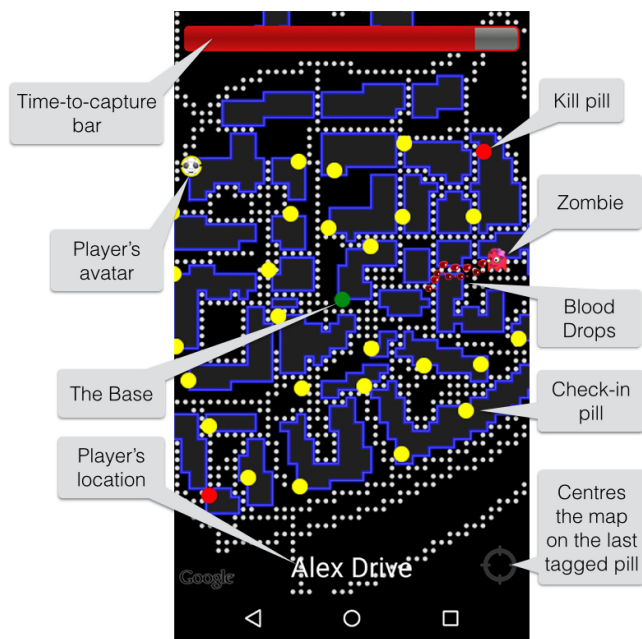
Figure 4. PAC-LAN's User Interface (capturing UI)

A very simple yet intuitive colour scheme was chosen for the pills, and was shared between the physical game elements and their counterparts on the map (shown in Figure 4 and Figure 5). Since yellow Frisbees have been used to identify the 'check-in' pills in the physical game, yellow circles are used on the map. Similarly, red circles identify the 'power pills' to match the red Frisbees. A yellow bar is used to show the 'roaming time' available for all players which changes colour to red when PAC-LAN enters 'capture mode'. To display the last tagged location of the player only the user-defined name of the place is used. The researchers chose to include this information in order to create a link between the physical element and its digital representation (the same way streets and places have names).

Figure 5. Physical pills: a) 'check-in pill'; b) 'power pill'

4. ANALYSIS

Thus far, two preliminary studies have been undertaken: one to evaluate if the game is playable and balanced (Study 1); and one that specifically assesses the design of the 'Pac-Map' in terms of aesthetics, performance in the context of a mixed-reality LBG (outdoors) and the promotion of 'head-up' navigation (Study 2). This approach was used because of the number and variety of design features included in the game would make their individual evaluation impractical within a single exercise. In both studies, the participants were somewhat familiar with the space within which the game area was constructed, but had no prior knowledge to the whereabouts of the physical game components. Both studies took place in the same geographical space so that variations in the quality of coverage of the *OpenStreetMap* database would not influence the evaluation of the map. Informal semi-structured interviews were carried out and recorded at the end of each game in order to ascertain the perceptions of the players. An in game ethnography was also performed by the researchers to allow observation of different particularities of individual aspects of the studies.

4.1 Study 1

4.1.1 Background

Study 1 was run on the 14th of May 2014 between 11am and 2pm at Lancaster University with seven participants. Two different games were played with some players acting as the Zombie characters as well as PAC-LAN across different games. The main purpose of this study was to test the game 'in the wild', in order to gain a better understanding of the playability of the game as well as to ensure the game was still balanced in relation to the player roles.

4.1.2 Findings

During the trial players were encouraged to engage in open conversations with each other to discuss and analyse different tactics and approaches to the game as well as own understanding of the rules. The feedback indicated that the players enjoyed playing the game and that all of them seem to have understood the rules and mechanics when briefly presented prior to gameplay.

Overall, the players thought the game was well designed and had enough elements to actively keep one playing: "*The features of the game kept you thinking and guessing what to do next*". The participants that played both as a Zombie character and the PAC-LAN character believed the game was balanced between the two roles.

One of the players mentioned that the 'Screen Blanking' was misleading and was easily confused with the screen lock capability of the device. However, when this feature was explained, the player understood its importance but suggested that instead of a plain black screen a better use of the space would be to display their individual game avatar thus allowing the player to recognize the feature as part of the game.

When designing the map there was an emphasis on removing the clutter from the map to avoid player distractions. According to the discussions at the end of the trial, the map was perceived as a better alternative than a standard Google Map, with players mentioning that it was simple enough to understand and "*more than sufficient to quickly know what to do next*". Three players pointed out that the characters and pills could be larger. Although the map was not designed for navigation, some players requested the ability to determine direction, either by using a navigational arrow or rotating the map. Audio feedback was also suggested as an enhancement to the current haptic feedback.

4.2 Study 2

4.2.1 Background

The second study took place on the 5th of February 2015 with 8 different participants in order to investigate the creation of a map to promote 'head-up' navigation in LBGs. This assessment comprised the comparison of the 'Pac-Map' against three other

maps that were created using slight variations upon each of the same set of design goals: 'Sketchy Map' (Figure 6a), the 'RPG Map' (Figure 6b) and the 'Anti-Glare Map' (Figure 6c), all of which were rendered using the same software and the same *OpenStreetMap* database.
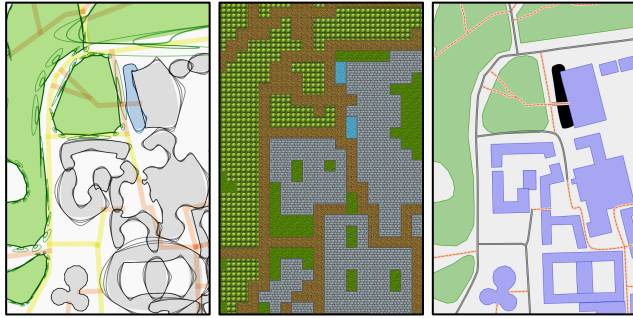

Figure 6. a) Sketchy Map; b) RPG Map; c) Anti-Glare Map;

The 'Sketchy Map' is rendered using a combination of polygon smoothing, line simplification and image compositing techniques in order to give a 'hand-drawn' appearance to map features. Aside from being aesthetically pleasing, this approach introduces spatial ambiguity in to the map in a different way to the Pac-Map, and so allows the comparison of these alternative approaches, in order that their effectiveness may be assessed. The 'RPG Map', is constructed using 20m tiles taken from a custom tile-set similar to those used in the classic Role Playing Games (RPG's) of the 1980's and 1990's. This gives the map a gaming aesthetic whilst introducing spatial ambiguity by generalising all features to the nearest 20m. Whilst this approach to introducing spatial ambiguity is similar to that of the Pac-Map, it has a much greater level of feature generalisation, and so a greater level of spatial ambiguity. In this way, this map will allow a comparison of the effect of different levels of spatial ambiguity in the maps. Finally, the 'Anti-Glare Map' includes no spatial ambiguity whatsoever, and instead is characterised by a triadic colour scheme in order to maximise the contrast between all map features. In doing so, this map minimises the interaction time through being clear and easily readable, thus requiring less interaction than other maps due to ease of use, rather than spatial ambiguity. In this way, this map may act as a 'control' in the analysis, providing an alternative approach to the promotion of 'head-up' navigation. A more detailed discussion of the maps is given in Huck et al. [10].

All 8 players were asked to play a short custom-built LBG that required them to navigate between 20 physical objects (the PAC-LAN game pills) with 5 objects per map type. The initial map was chosen at random and then changed for another randomly selected map after every fifth anchor was correctly tagged, in order to allow the assessment of each map. The LBG tracked players' progress using GPS and required them to hold down the volume rocker in order to view the map (similar to the 'Screen Blanking' design element in the main game). In order to avoid the confusion reported during the first study, the screen displayed the message "*Press and hold the volume rocker to see the map*". This mechanic also means that players' interactions with the map are both logged alongside GPS-derived location for later analysis. Following play, all eight players were also given a semi-structured questionnaire and interview about how each map influenced their level of interaction with the screen and their surroundings.

4.2.2 Findings
Based upon the data collected within this study it was concluded that the 'Pac-Map' was the most suitable of the four maps for the

promotion of 'head-up' navigation in the game. The combination of the gaming aesthetic and moderate level of spatial ambiguity promoted the notion of gameplay whilst encouraging the player to validate what they see on the map against the physical landscape. The players considered navigation using the 'Anti-Glare Map' (no spatial ambiguity) and 'RPG Map' (more spatial ambiguity) to be "*too easy*" and "*too hard*" respectively, with the clarity of the former negating the need to validate locations against players' physical surroundings; and the latter being so difficult to use that players frequently became lost, distracting attention away from gameplay and so having a negative impact upon immersion.

The 'Sketchy Map', on the other hand, was found in both the questionnaires and interviews to be considered by players as similar in quality to the 'Pac-Map', and indeed was favoured by several of the players. Under scrutiny of the automatically collected data, however, the 'Sketchy Map' was found to attract a much greater level of interaction than the 'Pac-Map', indicating that it was less successful in its goal of promoting head-up navigation. These findings are important to this work because they contribute to the validation of the design rationale for the map interface used for *PAC-LAN: Zombie Apocalypse*. This design rationale includes the promotion of game immersion through the use of an appropriate map aesthetic, the promotion of 'head-up' navigation through the introduction of spatial ambiguity into map features, and a good level of performance when viewed on-screen whilst outdoors. This analysis has demonstrated that variation in each of these elements reduces the utility of the map in the facilitation of LBG immersion through the promotion of 'head-up' navigation. A full discussion of these synthesised results appears in Huck et al. [10].

5. Conclusions and Future Work
This paper has introduced the concept of the '*Dichotomy of Immersion*', in which the attention of the player is repeatedly shifted between the digital and the physical elements of a mixed-reality LBG. At any one time, a player's interactions are heavily influenced by one of these two elements, which act to prevent the attainment of immersion within all elements of the game. In many LBGs designed thus far, the effect of the '*Dichotomy of Immersion*' is that the digital game elements dominate the attention of players, at the expense of the physical. In order to address this issue, two possible approaches were proposed: the de-emphasis of the digital game elements, by the adoption of deliberate design features that discourage screen interactions; and the augmentation of the physical space with objects that provide a link to the digital world. These approaches have been explored using a 'research through design' methodology in order to design *PAC-LAN: Zombie Apocalypse*: a LBG that explores how different design features can minimise the number of interactions between the player and the mobile device, encouraging engagement with the physical surroundings instead.

This paper has focussed upon the first of the above approaches: the design of the digital game elements, specifically the mobile interface. A number of design features were introduced, and some preliminary results were presented in order to demonstrate the effectiveness of those features. Firstly, results were presented from a study that examined the quality of *PAC-LAN: Zombie Apocalypse* as an engaging mixed-reality LBG. Having played the game, users reported that the rules were clearly defined and easy to follow, and that the game mechanics encouraged play. This preliminary study demonstrated that the game was playable and enjoyable, and so would be a suitable platform for research into the issues discussed in this paper.

Secondly, results were presented relating to the specific evaluation of the 'Pac-Map', which was designed to promote game immersion through the use of an appropriate aesthetic, the encouragement of 'head-up' navigation through the introduction of spatial ambiguity into map features, and a good level of performance when viewed on-screen outdoors. The map was user-tested against three other maps that were designed using small variations upon the above design goals, and was found to be the users' preferred map both for use in an LBG, and in context of the design goals.

Future work will address the second of the above identified approaches to dealing with the '*Dichotomy of Immersion*': the augmentation of the physical space with objects that provide a link to the digital world, once again based upon *PAC-LAN: Zombie Apocalypse*. Whilst this is done to a certain extent by using physical game pills, new ideas will be explored, such as the use of additional physical elements within the game space, and how variations in size, colour, shape or location of the pills might affect game play. Furthermore, as technology evolves in the areas of the Internet of Things and Smart cities, pre-existing street-furniture or other physical elements such as benches or streetlights could be incorporated into gameplay and influence the legibility of a space. In this way, any physical space could potentially be transformed into different games without the requirement to augment the space prior to play.

The contribution of this paper is therefore a design strategy for the creation of more immersive LBGs. It provides a number of design features that act to minimise the number of interactions between the player and the mobile interface. It is intended that the design strategies demonstrated here will be employed by others in the design of future LBGs, and that an understanding of the '*Dichotomy of Immersion*' will lead to the creation of a new generation of LBGs that provide richer locative experiences.

6. ACKNOWLEDGMENTS

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