Abstract Feature Representation as a Cartographic Device for Mixed-Reality Location-Based Games

J. J. Huck [1], P. Coulton [1], A. Gradinar [1] and D. Whyatt [2].

[1] Imagination Lancaster, LICA, Lancaster University
[2] Lancaster Environment Centre, Lancaster University

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Summary

This paper presents a number of cartographic design solutions to the creation of a map for the mixed-reality location-based game '*Pac-Lan: Zombie Apocalypse*'. The research-purpose of this game is to explore ways in which players may be encouraged to become less reliant upon the device screen during gameplay, and so more fully engaged with the physical environment in which the game is played. In this paper we specifically consider approaches to designing the game-map in such a way as to discourage players from becoming solely reliant upon it for navigation, and instead interact more with their surroundings during gameplay. This paper therefore considers four maps as potential solutions for '*Pac-Lan: Zombie Apocalypse*', which serve explore the use of abstract feature representation as a cartographic device to encourage player engagement with the landscape. A description of the design rationale for each of the maps is presented here, along with some preliminary findings from user evaluation of the maps against a defined set of design goals.

KEYWORDS: Cartography, Location Based Games, Feature Abstraction, Mixed-Reality Spaces, Landscape Legibility.

1. Introduction

This paper presents a *research through design* (Gaver, 2012) approach to the creation of a web-map for the mixed-reality Location-Based Game (LBG) '*Pac-Lan: Zombie Apocalypse*' which operates on the Android mobile platform. Based upon the popular '*Pac-Man*' arcade game (Namco, 1980; Figure 1), this sequel to the original '*Pac-Lan*' (Rashid et al., 2006; Coulton et al. 2006a; Coulton et al., 2006b) is played by up to five players: one of which takes the role of *Pac-Lan*, with the remaining four taking the roles of the 'ghosts' (*Blinky*, *Pinky*, *Inky* and *Clyde*). Players run around a real-life 'maze' defined by the physical landscape (buildings, woodland, water-bodies etc.) and earn points by 'tagging' physical 'pellets'. Frisbees fitted with Near Field Communication (NFC) tags that are attached to street furniture represent the physical 'pellets', and 'tagging' them is simply a matter of physically touching them with their NFC-enabled smartphones upon which the LBG application is running. Similarly, players may also 'capture' each other by 'tagging' them in a similar way, this time using an NFC tag attached to each player's back. The winner of the game is the player with the greatest number of points when the game ends, which is either when the time runs out, when all of the 'pellets' have been 'tagged' by *Pac-Lan*, or when *Pac-Lan* is captured by a ghost.

The research purpose of '*Pac-Lan: Zombie Apocalypse*' is to explore the legibility of mixed-reality spaces, specifically through the concept of the '*Dichotomy of Immersion*'. Where *immersion* refers to the degree of involvement that a player has with a computer game (Brown, 2004), the *Dichotomy of Immersion* describes the peculiar situation created in LBG's whereby a player's attention is constantly divided between the physical world within which the game is being played (the physical world), and the screen of their mobile device (the digital world). The split of attention between the physical and digital game components is usually dominated by interaction with the screen at the expense of interaction with the landscape, which can limit engagement with (and therefore immersion into) the LBG (Zhang et al, 2012), as well as contribute to the low uptake of LBG's by members of the public (Lund et al, 2012). It is hoped, therefore, that addressing this imbalance in this research will

contribute towards the development of more engaging LBG's, with a higher level of uptake.

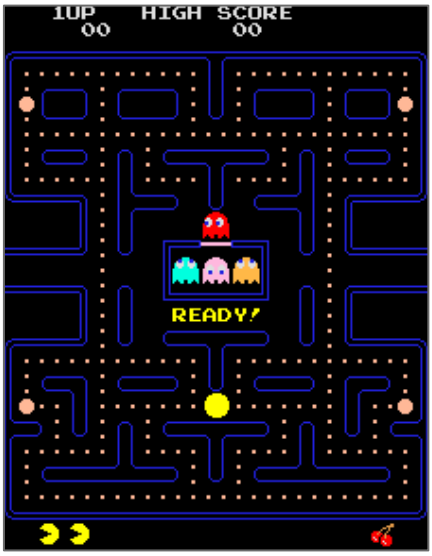

Figure 1: Screenshot of a classic version of Pac-Man (Namco, 1980). *Reproduced from http://en.wikipedia.org/wiki/File:Pac-man.png*.

The game-map is a central and essential component of any LBG and so has been one of the major areas of focus within this research. In order to discourage user interaction with (and reliance upon) the mobile screen, the map must be designed in such a way as 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 users navigate using a mobile phone. Instead of simply using a Google Map or similar as a game-map, a number of bespoke cartographic designs have therefore been developed in order to facilitate greater immersion into the physical game. It is the design of these game-map that will be addressed within this paper, specifically in the context of the use of abstract feature representation as a cartographic device.

2. Design Solutions

The game-map for '*Pac-Lan: Zombie Apocalypse*' has three design goals: to promote immersion into the game through the use of a suitable aesthetic; to perform well within the context of a mixed-reality LBG (i.e. outdoors); and to encourage players to navigate 'head-up' rather than 'head-down' during gameplay. The latter of these design goals is the most important given the context of the wider '*Pac-Lan*' research aims, and in this paper it will be approached by the use of abstract feature representation as a cartographic device. It is hypothesised that a small amount of abstraction in map features may encourage players to 'look up' more and verify what they see on the map against their physical surroundings, thus increasing their engagement with their physical surroundings. This is in contrast with the use of a more traditional (precise) map, which will not require validation against the landscape; or a map that is 'too abstract', which may be too difficult to read quickly whilst playing, thus increasing interaction with the screen at the expense of the landscape.

As already discussed, this paper will consider four potential solutions to the above design goals, along with some preliminary findings relating to user evaluation of the maps. The maps have been all created using data from OpenStreetMap (http://www.openstreetmap.org/), or derived from it within PostGIS (http://postgis.net/), and have been rendered using Mapnik (http://mapnik.org/). For the purpose of comparison, all maps are shown at the same standard orientation (north at the top), zoom level (17, equivalent to a geographic scale of 1:4514) and extent (showing part of the Lancaster University campus). This view is also shown as drawn in OpenStreetMap in Figure 2 for the purposes

of comparison. None of the figures include a legend, north arrow, scale bar or similar, as such features are not typically provided in LBG's or other mobile applications. In-keeping with the above design goals, all of the maps are very limited in the number of features that they contain, with only 4 or 5 feature classes typically included to facilitate easy reading. For the same reason, augmentations such as labels and points of interest have also been omitted from all of the map designs.

Figure 2: The 'standard' *Mapnik*-rendered *OpenStreetMap* map style.

2.1 The 'Anti-Glare Map'

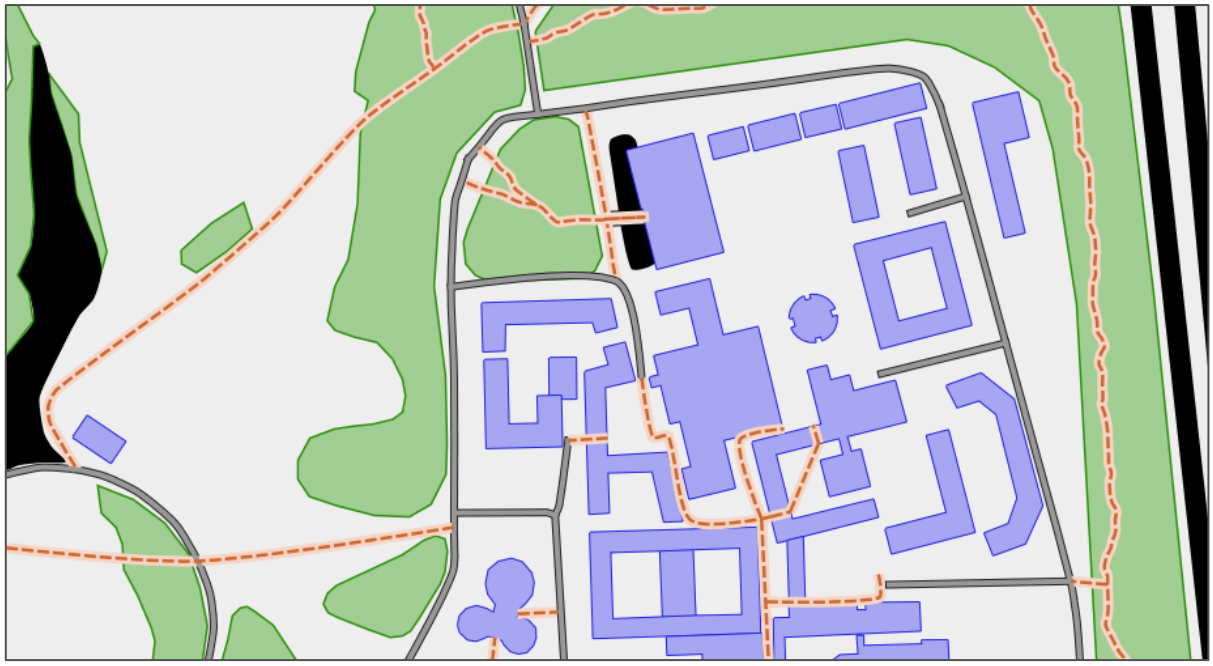

Figure 4: The *Anti-Glare Map.*

The first map to be presented is the *Anti-Glare Map* is intended primarily to perform well outdoors, and investigate the alternate hypothesis that a clear and precise map may be more successful than an

abstract map in encouraging 'head-up' play as players will be able to digest spatial information more quickly. As such, the *Anti-Glare Map* does not exhibit any level of abstract feature representation, and so will act as a 'control' in this investigation with regard to the effectiveness of this technique. The *Anti-Glare Map* utilises a triadic colour scheme in order to gain a high degree of contrast between features whilst maintaining colour harmony. Features are divided into five classes: 'building', 'road', 'footpath', 'trees' and 'hazard', and a light-grey background was chosen because lighter background colours are typically less susceptible to screen glare. Hazards are filled with black, accenting them in comparison to the background and other features, whereas the other features (those using the triadic colour scheme) all include an accent using a darker shade of the same colour. This accent is used to outline all of the features except footpaths in order to make them 'pop' out from the light background, and is used as a dashed centreline for the footpaths, in order to create a contrast between the footpaths and the roads.

2.2 The 'Pac-Map'

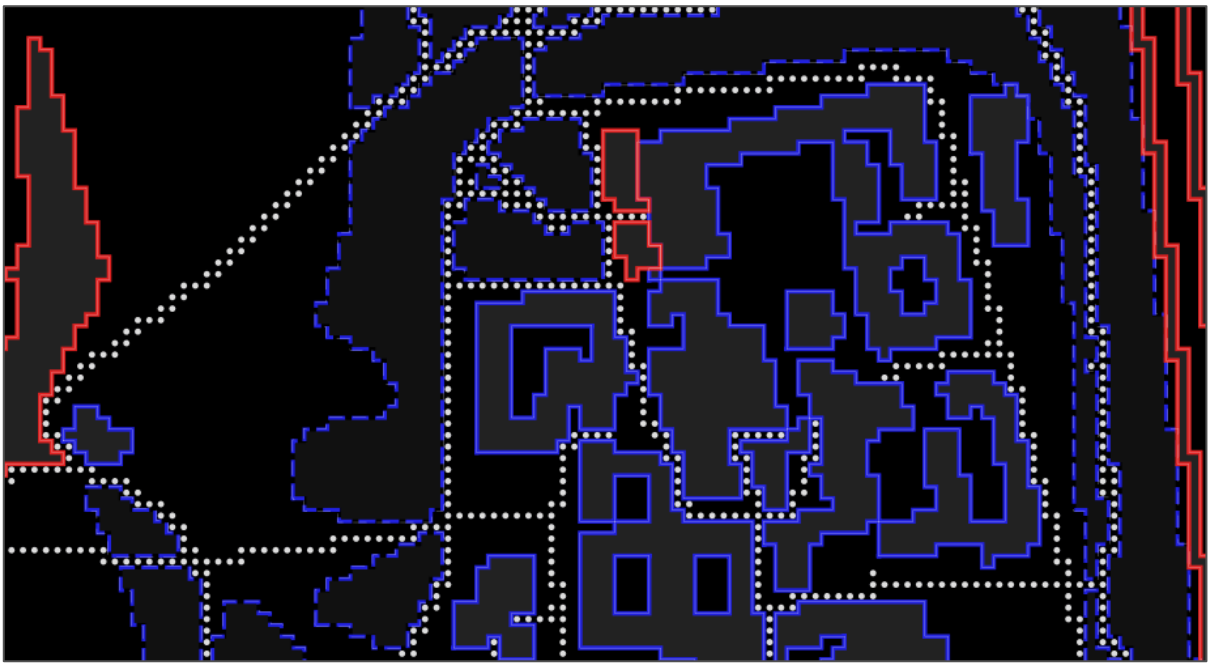

Figure 3: The *Pac-Map*.

The *Pac-Map* (Figure 3) is designed primarily to match the aesthetic of the classic Pac-Man arcade game (Namco, 1980; Figure 1). Abstract feature representation has been achieved in this map by generalising all nodes to the nearest 10m, and forcing vertices to be oriented either north-south or east-west: resulting in abstract features that also contribute to the game aesthetic. There are only 4 feature classes included in the map: 'building', 'path', 'trees' and 'hazard', all of which are rendered using styles directly inspired by the Pac-Man game (Figure 1). 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. In order to ensure that the dark palette employed by this map performs well outdoors, the lines in the map are thick, with very fine white lines drawn into the blue and red in order to increase their contrast with the black background. Pathways (including roads and footpaths) have been marked out with white dots, once again to gain contrast with the dark background, whilst also reflecting the 'pellets' that Pac-Man collects from within the maze in the original game.

2.3 The 'RPG Map'

Figure 5: The *RPG Map*

The *RPG Map* is inspired by the 'classic' Role Playing Games (RPG's) of the 1980's and 1990's. The data has been abstracted into a grid of 20m cells, each of which can only contain one of five feature classes: 'building', 'road', 'water', 'trees' or 'hazard'. Cells were then dissolved into contiguous areas of each data type, and coloured using tiled textures collected from freely available online sources. The use of a coarse 20m grid gives this map a greater level of abstract feature representation than the *Pac-Map*, therefore making it more difficult to rely upon for navigation, in order to investigate the effect that this has upon the players' interactions during gameplay. The coarse grid, RPG-style textures and playful features (e.g. the use of a 'lava' texture to denote hazards) lend a definite 'game aesthetic' to the map, but in less-specific manner to the *Pac-Map*, permitting exploration as to the effect of this upon players' perceived level of immersion.

2.4 The 'Sketchy Map'

'Sketchiness' as a device for enhancing the aesthetic or narrative qualities of cartographic outputs has been explored previously by Wood et al. (2012), and has also been employed by Griffen et al. (2014) as a visual variable in maps. In this case, however, 'sketchiness' is used as an alternate approach to abstract feature representation, acting to obscure the precise position and shape of geographic features. The 'hand-drawn' or 'sketchy' effect on the polygons has been achieved by a combination of polygon smoothing, line smoothing, multiple-overlay and image composite operations in order to give the impression that they have been drawn using felt-tip pens (akin to the approach first suggested by Ashton, 2012). Conversely, the line features were simplified using the Visvalingam-Whyatt line generalisation algorithm (Visvalingam and Whyatt, 1993), and overlaid using transparency and image composite operations in order to give the appearance of having been drawn using highlighter pens. This approach will allow the comparison of abstract feature representation arising from 'sketchiness' against the grid-based approaches used in the *Pac-Map* and the *RPG-Map* as a device for the encouragement of 'head-up' gameplay. The main difference with this approach is that the level of abstraction varies from feature to feature as opposed to being uniform across the dataset as is the case in the grid-based approaches, which may prove more disorientating for users. The 'hand-drawn' aesthetic promotes a 'playful' feel to the map, but without specifically evoking a 'game', permitting further investigation into the effect of the map aesthetic upon game immersion.

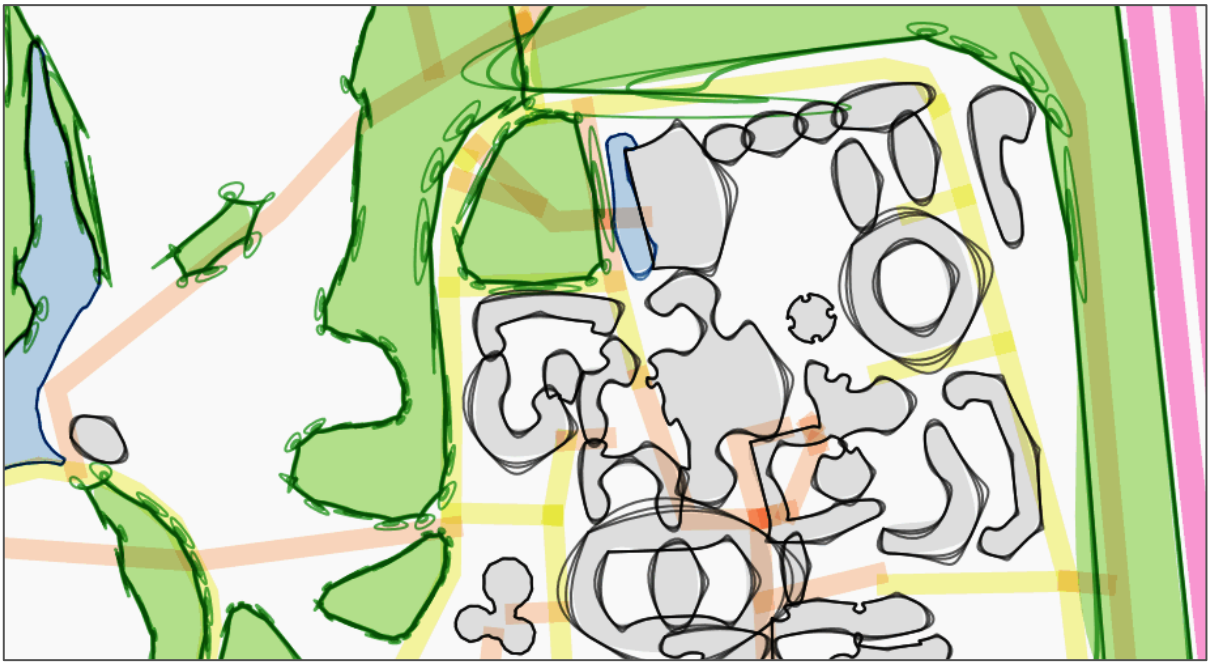

Figure 6: The *Sketchy Map*

3. Methodology

For the purpose of assessing the four proposed design solutions, a for-purpose Android-based LBG has been developed that is less complex than the full '*Pac-Lan: Zombie Apocalypse*' game, and so allows a more detailed exploration of the maps without distractions arising from other game elements. This LBG requires users to navigate between (and physically 'tag') 20 NFC-enabled 'pellets' (Fig 7a) that have been placed around an area of student accommodation at Lancaster University. Only one 'pellet' is displayed at once on the on-screen map, which disappears when tagged as the map re-centres onto the next 'pellet' (screenshot in Figure 7b). The map style changes after every fifth 'pellet' and a pseudorandom number generator determines both the order of the maps, and the order in which the 'pellets' must be 'tagged'. In order to view the map, users must hold down the volume button on the mobile device, and the map is hidden from view as soon as this button is released. In this way, it is possible to keep a log of the amount of time during which each map is viewed, in addition to the location and movements of each player using the on-board GPS receiver in the mobile device. Following gameplay, each player was given a semi-structured questionnaire and is interviewed in order to gain feedback relating to the quality of each map against the above design goals.

4. Preliminary Results

Whilst still in the process of data collection, we are able to demonstrate results from the first 8 players as preliminary findings. The quantitative data collected in the log files confirms that, as expected, players spent the least amount of time looking at the (least abstract) *Anti-Glare Map* (c. 31% of the time), and the most amount of time spent looking at the (most abstract) *RPG Map* (c. 47% of the time). Of the remaining two maps, more time was spent looking at the *Sketchy Map* (c. 44% of the time), with its variations in level of abstraction from feature to feature, in comparison with the uniformly abstract *Pac-Map* (c. 38% of the time). Whilst these findings are interesting (albeit expected), the amount of time spent looking at the map is unlikely to be inversely correlated to the level of engagement with the landscape. As such it is the qualitative data relating to the players' perceptions of the impact that the maps had upon their engagement with their surroundings that is therefore of more interest to this research.

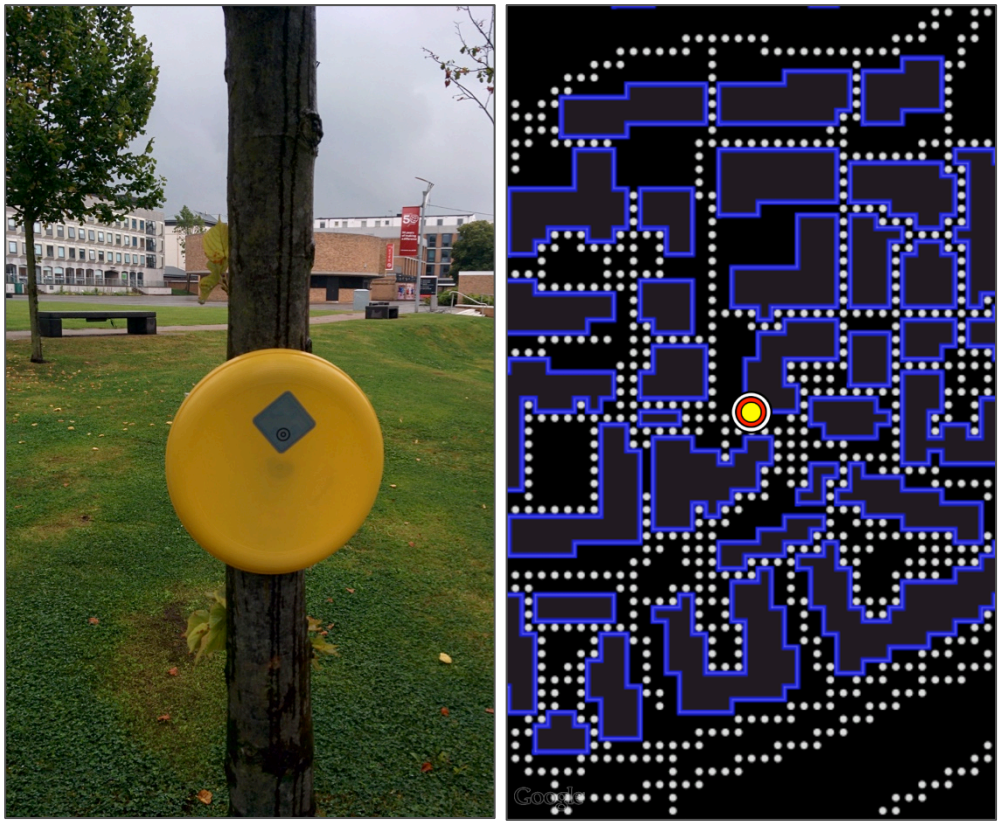

Figure 7: a: A physical 'pellet' for players to 'tag', complete with NFC tag. **b:** A screenshot of the LBG used to evaluate the maps, displaying the *Pac-Map* (covering the actual test area) and location of the next 'pellet' to tag.

Through a simple vote within the questionnaire, players identified the *Pac-Map* and *Sketchy Map* as being equally the "*most suitable map for use in an LBG*", whereas the *RPG-Map* was considered to be the best for generating engagement with the environment. The reasons for the latter, however, were very clear in the associated comments, with the *RPG Map* being unanimously considered to be "*very difficult*", and "*frustrating*" to use, with one player even suggesting that it was "*totally unusable*". This, along with a complaint that the map suffered from screen glare, is a clear suggestion that the *RPG-Map* is 'too abstract', and therefore not well suited to an RPG. These comments were interestingly contrasted with those relating to the *Anti-Glare Map,* which was described as "*too easy*" by two users, and caused one user to feel they "*spent too much time looking at the map because it was easy to [navigate with]*". These preliminary findings lend support to the hypothesis that a map exhibiting abstract feature representation can lead users to engage more with their surroundings, and that too great a level of abstraction can become counter-productive in this regard.

Of the remaining maps, the *Pac-Map* seemed to be considered as more well balanced: "*I could tell what things were represented but still looked up*"; and as an attractive or well-suited map design: "*Nice feel*", "*It's like the original Pac-Man*". Similarly, the *Sketchy Map* was considered as "*pleasing on the eye*" and "*more fun*", as well as "*showed just enough to navigate but required you to look around*" and "*challenging enough to keep it interesting*". These comments suggest that both were well received by users and fulfilled their desired purpose well, again lending support to the above hypothesis.

When the quantitative findings are also considered, however, the *Pac-Map* appears to have performed best across the three principal design goals: to promote immersion into the game through the use of a suitable aesthetic; to perform well within the context of a mixed-reality LBG (i.e. outdoors); and to encourage players to navigate 'head-up' rather than 'head-down' when playing a LBG.

5. Conclusion

The consensus from the preliminary user feedback suggests that the *Pac-Map* was the most effective with regard to the intended design goals, and was even described as "*the best suited to a game*" by one user. Overall the data from this preliminary analysis seem to suggest that using abstract feature representation may indeed be a suitable approach to the creation of maps for the promotion of immersion within LBG's, and that the application of 'too much' abstraction will start to degrade the quality of the map for this purpose. Whist it is clear that further user testing and analysis is required before any firm conclusions may be drawn, it would appear that maps produced in this manner can discourage players from navigating 'head-down'; forcing them to engage with the landscape in order to find their next target.

This *research through* design project has begun to explore the design of a map that will encourage immersion into a mixed-reality LBG through the promotion of 'head-up' navigation. Each of the design options presented in this abstract will continue to be evaluated by users in order to assess them against the above design goals so that more firm conclusions may be drawn from this work. It is intended that the resulting design knowledge will aid other cartographers in the design of maps for mixed reality LBG's, and contribute towards increased uptake of LBG's within the gaming ecosystem.

6. Biography

Jonny Huck is a 4th year part-time PhD student researching Geographical Information Science jointly with Imagination Lancaster and the Lancaster Environment Centre at Lancaster University. His interests include web mapping, the representation of 'place' in GIS, cartography, and the application of new technologies to spatial analysis.

Dr Paul Coulton is a Senior Lecturer in Design within Imagination Lancaster. His research interests are primarily around experience design, game design, and design fictions. His research often encompasses an 'in the wild' evaluation methodology, utilising 'app stores' and social networks as experimental platforms

Adrian Gradinar is a 2nd year PhD student at Lancaster University, researching around The Internet of Things within the Digital Public Space, especially how digital information can be integrated with familiar objects. He is also interested in how digital games could be interconnected with the physicality of the surrounding world.

Dr Duncan Whyatt is a Senior Lecturer in GIS within the Lancaster Environment Centre, Lancaster University. His research interests span social and environmental applications of GIS, with specialisms in air pollution.

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