Walking the GPS Line : Insights on the use of shape walking as a game mechanic

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ABSTRACT
In this paper we describe an experiment to investigate and ascertain the feasibility of utilizing GPS tracking as a control mechanism in a mobile game. The interaction mechanism tested was that of walking shapes and we examine the user response to this novel form of game mechanic. We discuss the difficulty in developing a good cognitive model of how GPS works and problems with orientation and feedback. We reflect on the skills needed to map virtual shapes into physical spaces and to cope with the facets of GPS. We highlight the importance of the use of physical landmarks and we discuss whether future designs might be able to teach these skills and to incorporate the indeterminate nature of GPS into the game play itself.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]:, H.5.1 [Multimedia Information Systems]: *Artificial, augmented, and virtual realities.*

General Terms
Design, Experimentation, Human Factors

Keywords
Location based, Games, Interaction

1. INTRODUCTION
Pervasive electronic gaming, a genre of interactive entertainment that integrates elements of the physical and virtual world into their interaction experience has seen increased industry and research interest over recent years, concordant with a proliferation of wirelessly interconnected mobile devices appearing in the consumer market.

As a sub-genre of pervasive gaming, 'location-based' games utilize the position, movement and orientation of players in the real world to create the interaction with the virtual world of the game. In order to facilitate location identification and tracking, it has usually been necessary for additional hardware such as short range proximity detectors or wireless networking infrastructure to be installed within the real world – a solution that is not ideal, particularly if the game world covers a large expanse of 'real world' space (Harris, 2004). Thus, portable location identification technologies such as satellite tracking (utilizing the global position system - GPS) might be a more appropriate solution.

As a proof-of-principle model, the present project was conducted to investigate and ascertain the feasibility of utilizing GPS tracking as a control mechanism in a mobile game, without the need for supplementary ground-based hardware support (and thus in doing so be entirely portable).

2. RELATED WORK
2.1 Uses of location tracking in a mobile gaming context
Despite the availability of cellular network location identification since the early nineties, and GPS location tracking since the mid seventies, research into the potential use of location-based technologies in a mobile gaming context appears to have gained pace only over the last five years. While commercial attempts to exploit location based and other mobile phone specific technologies do currently exist (Glofun's 'Raygun', It's Alive!'s 'Botfighters' and Groundspeak's 'Geo-Caching remain the most successful to date), examples of the potential of such games remain predominantly within the research lab.

A summary of some of their projects alongside projects developed by other commercial and research groups are presented in table 1.

A common factor across many of these projects is that the tracking of players is often not achieved using GPS alone, but is augmented using additional hardware such as proximity sensors (e.g. 'Pirates!'), DRM (e.g. 'Human Pacman') and the mobile cellular networks (e.g. 'Botfighters'). Furthermore, those projects that have exclusively used GPS ('eg. 'Road Rager', 'Savannah', 'Can you see me now?') use it only as a location identification mechanism: i.e., while establishing the position of the players is important in terms of the mechanics of the game, the players themselves do not use their position to directly *control* the game.

Table 1. Examples of Recent Location Based Gaming Projects

Game	Developer	Availability	Locative Technologies Used
Raygun	Glofun	Commercial -US Only	GPS
Botfighters	It's Alive!	Commercial – Sweden / Ireland / Finland / Russia	GSM Mobile Network /SMS
CitiTag	Vogiazou et al (2004)	Non-Commercial – UK	GPS / Wi-Fi
Uncle Roy all Around You	Benford et al (2004)	Non-Commercial – UK	Mobile Networks: Audio / SMS
Savannah	Facer et al (2004)	Non-Commercial – UK	GPS / Wi-Fi
Can you see me now?	Iddon et al (2002)	Non-Commercial – Europe	GPS / Wi-Fi
Human Pacman	Cheok et al (2003)	Non-Commercial – Singapore	GPS / Wi-Fi
Geocaching	Groundspeak	Commercial – Worldwide	GPS
Pirates!	Bjork et al (2001)	Non-Commercial - Sweden	WLAN
'Real' Tournament	Mitchell et al (2003)	Non-Commercial – U.K.	GPS / Wi-Fi
'Road Rager'	Brunnberg (2004)	Non-Commercial – Sweden	GPS

2.2 Uses of location tracking technology as a control mechanism

While attempts to utilize the position, orientation and movement of a player to control a game have been attempted both commercially (e.g. Sony's 'Eyetoy' device), and in a research context (e.g. the 'Active Floor' – Headon et al, 2002 and the 'Lumetila' floor sensor project, Leikas et al, 2000), none have succeeded in creating a location-based control mechanic that is truly portable. Augmented / trans-reality projects such as Human Pacman (Cheok et al, 2003), Real Tournament (Mitchell et al, 2003) and Pirates! (Bjork et al, 2001) suffer a similar problem in that, despite utilizing wireless networking to track players, they still require additional infrastructural hardware such as proximity sensors and WLAN beacons to be positioned within their game worlds in order to work.

From the perspective of total portability, the requirement of additional hardware to be present within the physical world is not a desirable solution – not simply for issues of cost, but as in doing so, the size and scope of the game space is limited by the amount of infrastructure that is available. A truly portable location based game should be playable anywhere within the physical world, and insofar as creating a portable location-based game experience that is controlled and driven entirely by the movement of the player, a successful solution has yet to be presented.

3. iMagick Game concept

Conceptually similar to 'The Songs of North' (Lankoski et al, 2004), 'iMagick' is a fantasy role playing game where the player assumes the guise of a wizard, competing in a virtual world for supremacy over other players / wizards. Dominance over other players is achieved through the successful casting of spells.

The Spells within 'iMagick' are represented by simple geometric shapes that are mapped (virtually – through GPS co-ordinates) onto the physical world (see figure 11). Once located, a spell can be activated to create a competitive advantage over other players. In order to activate a spell, the player must accurately trace the shape of the spell by walking the complete length of its path perimeter in the real world - tracked by a GPS receiver attached to the game device.

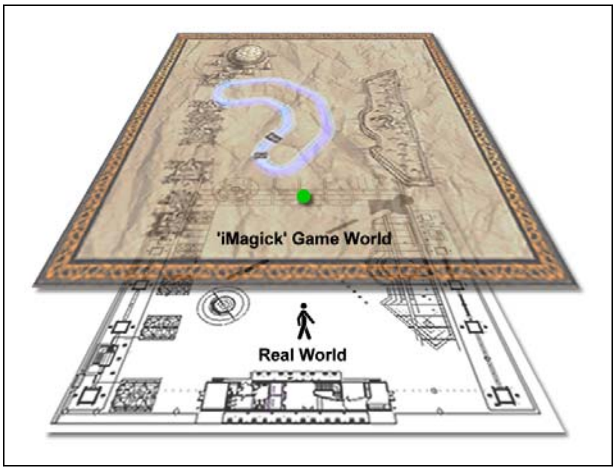

Figure 1. The correspondence of the physical and virtual worlds in 'iMagick'

3.1 Aim of the prototype game

The broad aim of the game prototype is simple: accurately navigate a 'spell' shape's perimeter path from a defined start point to a defined end point without deviating so far from the correct path often enough that all of the players lives are lost (resulting in failure and the end of the game). In order to trace out the spell, the player must accurately 'walk' the spell in open space using the game device screen as a navigational reference (the current location of the device in terms of its physical GPS co-ordinates is represented on the screen as a green tracer dot – see figure 12). A useful metaphor for describing the game is that of a 'wire loop' game - where players must attempt to guide a loop along a serpentine length of electrically charged wire without allowing the two to touch.

The Mobile Bristol toolkit (Hull et al 2004) was used to map each of the shapes to an open pedestrian square and implement the following logic

> Each user has three lives to successfully walk from the start to the end point keeping the tracer dot inside the shape boundary. The shape boundary was 3 meters wide and the start and end points were 6 meters square and 5 meters apart. On the start point the user hears the prompt "By the power of the water spirits, I call thee forth"

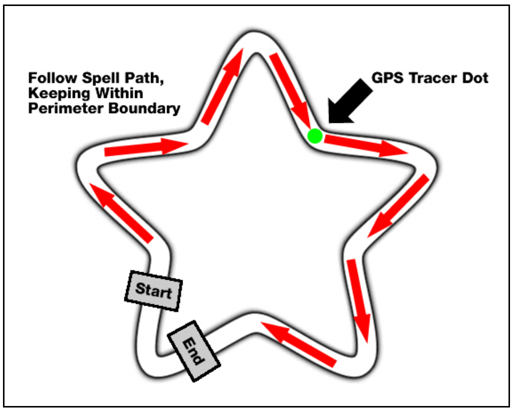

Figure 2. Conceptual mock up of the game

When the tracer dot is within the shape boundary a ticking clock sound is heard

If the GPS tracer dot moves just outside the path a warning buzzer will sound. The warning boundary was 1 meter wide

If the GPS tracer dot moves significantly outside the path a life would be lost signaled by a prompt such as "The powers are leaving you". The outer boundary was 3 meters wide.

If the user successfully walks the spell they hear the prompt that they have summoned a powerful spirit

3.2 Development of the three 'spell' shapes

In order to examine the effect of disorientation and other elements that might affect task difficulty, three different spells were developed with increasing levels of angles.

To be deemed suitable, the shapes used to represent the spells had to fulfil the following criteria:

Any potential spell shape must have some association with the fantasy / magical genre in keeping with the look and feel / consistency of the game

Any potential spell shape must fit within a real world space of no more than 200 square metres, without being obscured by obstacles on the ground (Millennium square contains several fixed benches that could reduce its usable surface area).

Any potential spell shape must have no two points that are so close to each other that poorer than average GPS accuracy might compromise the spell navigation and game logic (not accounting for instances of random GPS 'drift').

Any potential spell shape must possess a complete boundary path that does not cross over itself at any point.

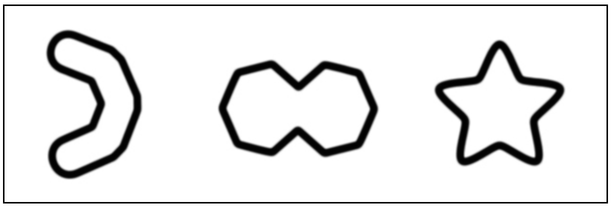

Figure 3. The shapes used in the game - Moon, Analemma and Star

The three shapes identified for use as spells in the present prototype (in ascendant order of difficulty) were: crescent moon, analemma and pentagram star (see figure 3). The level of difficulty was defined as a product of both the number and degree of angles contained within the shape that required the player to re-orientate themself and make a movement tangent decision.

4. USER TRIALS

Ten participants took part in our experiment. The purpose of the experiment was to examine user response to a novel control mechanism (i.e. themselves), in comparison to a 'traditional' game control interaction. To achieve this, participants were instructed to attempt to complete the game both by:

'Walking' the spell boundary path in open space - the user being tracked in the virtual world through their GPS position in the real world.

'Tapping' the spell boundary path directly onto the screen of the game device using their finger (utilizing the touch screen interface of the Pocket PC).

In this paper we will focus on the insights gained from the walking task only. A wider discussion and comparison of walking compared to tapping has been written in Bevan (2005). Four sources were used to gage response

Video capture of task with participants being encouraged to "think aloud"

Subjective responses to a questionnaire, delivered post-hoc

Verbal responses elicited from post-study informal interview

Performance data provided by system logging

4.1 Walking interaction.

Participants were presented with the iPAQ / GPS receiver and were instructed on the basic objectives and operation of the game. Once satisfied, the participant was then led into Millennium Square where the GPS receiver was activated and the first spell 'mediascape' loaded. The start and end points of the spell were confirmed prior to the first spell attempt.

Figure 4. "Walkingthe shape" using the game device as a reference.

Once a GPS 'fix' was achieved (typical latency: 30 seconds), the participant was instructed to navigate themselves to the designated start point, and then to attempt to follow the spell path as accurately as they could until they reached the end point. In the event of failure (all lives lost), the participant was instructed to return to the start point and restart the spell.

Participants were afforded a maximum of 5 attempts per spell, but could spend as long as they wished on any given attempt. However, after a period of approximately 10 minutes, participants were encouraged to abandon the current spell attempt and move to a different spell. Participants were encouraged to attempt all three spells at least once.

During the spell navigation task, participants were encouraged by the experimenter to think aloud, and to discuss problems or other issues they encountered during the challenge (recorded via wireless microphone). In order to facilitate the 'co-operative evaluation' protocol, and to attend to any technical problems quickly, the experimenter supervised each participant at a distance of around 3 feet.

The total duration of the 'walking' interaction phase was approximately 20 minutes.

5. RESULTS & DISCUSSION

Only five of the participants were able to successfully complete any of the spells. A summary of how each participant performed is shown in Table 2.

Participant		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gender		F	M	F	F	M	F	M	M	M	M
Used Gps before?		N	Y	N	N	Y	N	N	N	N	N
Moon	Completed	N	N	N	N	Y	N	N	Y	Y	Y
	Attempts	3	2	2	1	1	2	2	1	1	1
	Time					9			5	5	3
Analemma	Completed	N	Y	N	Y	Y	N	N	Y	Y	Y
	Attempts	3	1	0	1	1	0		1	1	1
	Time	0	10		9	9			5	5	3
Star	Completed	N	N	N	N	Y	N	N	Y	Y	Y
	Attempts	3		1	1	1	1	1	1	1	1
	Time	0				9			5	5	3

Despite the difficulty of the task and the low success rate the participants reported that they enjoyed the act of "spell casting". They enjoyed the novelty of walking as an interaction and the concept of the iMagick game. In the remainder of the paper we will concentrate on the many difficulties and issues that were exposed but it is important to bear in mind that despite these issues the act of walking to cast spells was still compelling.

Participants were often confused by the game feedback. The use of sound to help signal success and being on "track" were inadequate and could have been much more powerful. Any future design should concentrate on effective audio feedback as a priority.

By far the most significant issues were to do with GPS and orientation.

5.1 GPS Issues

The problems with GPS location tracking are well documented. Bendas et al (2002) observed, reasonable reliability and a low feedback latency are crucial factors in the success of any location-based game. Conventional GPS receivers are not particularly well equipped at dealing with the signal attenuation and multipath reflection errors that occur in urban environments (Agarwal et al, 2002) and so developers of location-based games need to reach an acceptable accuracy/portability trade-off solution (Benford et al, 2003).

GPS has an inherent accuracy margin-of-error of between 10 and 20 metres from 'truth' and (to further complicate issues) a highly variable error rate / size over time. When GPS location identification 'drift' occurs, there is a rapid and uncontrollable movement from one location to another, and this movement can be anywhere from as little as 1 to as much as 50 metres or more.

The effect of GPS inaccuracy and 'drift' is largely unavoidable and thus often highly salient issue in any location-based game that uses the technology to track its players (Benford et al, 2003). As 'iMagick' required both a high degree and stability of accuracy to complete the game, this issue was particularly apparent and as such was the most salient issue arising from analysis of the field trial / interview transcripts (139 instances). During the testing of 'imagick', the effect of GPS inaccuracy / drift appeared to manifest itself in three distinct flavours, with different effects upon the participants:

5.1.1 Tracer Movement whilst the Participant was Static

Even during periods of high accuracy, the GPS tracer dot / avatar was generally not entirely static when the participant was standing still. While this issue was not generally noted by the participants if the tracking accuracy was being reasonably predictable during prior periods of movement, if the tracking was generally being highly erratic, the problem became a notable source of confusion and frustration:

Participant: *Yeah…because it just moves, even If I don't move…like this, it's now going like this <makes circular hand movement> <laughs> And I'm not actually, er, it was just here…and now it's just moving by itself…off, off the map again…*

In the event of a large or prolonged period of erratic behaviour, the typical reaction of the participant was to stand still in the hope that the erratic movement would stop or at least settle down. However, the loss of correspondence between the real and virtual world incurred by the previous erratic behaviour was instead compounded by the effect of the tracer continuing to move while the participant was static:

Participant: *I kind of like the idea of…confidently striding out and that's good…but it's hard to trust something that you know…I'm definitely standing still and that should also definitely stand still…otherwise there's no correspondence between…that's when that blue dot becomes something else other than me…*

This participant, in common with several others, built up a model that the dot was a representation of themselves and that it should move and stay still when they do. In reality GPS will always be slightly behind the real position depending on the algorithms and filtering used. Perhaps a better model would be to associate the tracer dot with a balloon that is tethered to you on a piece of elastic. As you move the balloon should more or less follow you but if you turn sharply or there is a sudden gust of wind the balloon can be blown about wildly. This model may have helped those participants change their expectations for the perceived accuracy of how the dot moved in relation to themselves.

5.1.2 Minor GPS Drift

In the event of minor GPS drift, the participants typically blamed themselves, and often assumed that the movement was an issue of scale:

Participant: *Um…I'm just…I'm just finding it very confusing…um…in terms of scale and in terms of how fast it moves to keep up with what you're doing…and I think that's what difficult is…it's very difficult to get a se…a sense of the scale when you don't know how…how it's corresponding with the way you're moving…*

To overcome this, the participants generally altered their tangent and moved to correct the drift (even if this involved a little trial and error). Tolerance for minor episodes of drift (1 – 2 metres) was high, and did not appear to negatively affect the participant's experience of the game:

Participant: *Most of the time I thought it was alright…the occasional time it would jump you somewhere else and…you'd appear somewhere else but…I just made an estimate…I mean, I kind of saw where it had jumped to and made an estimation as to how…which way…based on the way I was already going …er…a little bit of trial and error…*

5.1.3 Major GPS Drift

Participant's reaction to large drift / jumps (particularly repeated jumps) was a notable rise in confusion and often frustration. They appeared to quickly lose trust in the game, and there was a notable shift in their reasoning, as illustrated by the following quotes:

From feelings of self-doubt:

Participant 1: *I think it, that was what was very difficult though, that's what was so frustrating – was not knowing whether it was your own mistake or whether it was the…system…and not knowing what to do to correct it…It would be way out and you couldn't retrieve it…and that's very frustrating…*

To explicitly blaming the system:

Participant: *Err, I found it very frustrating because I was doing it right and the system was letting me down and that is very frustrating*

Regaining of trust in the game's feedback was vastly reduced, and the participants worst affected appeared reluctant to formulate or explore any form of strategy in order to regain control. In essence, there was a move from confidently asserting the experience as 'the game is telling me something has happened that I know must be wrong', to the more uncertain 'I'm telling the game to do something and it's not doing it!'.

A major problem of nascent models of interaction like location-based games (as Stringer et al, 2001 notes) is, because the technologies employed to facilitate a co-ordinated interaction between a physical and virtual world are largely a novel and uncertain entity to the general populace to begin with. The lack of experience with an inherently error-prone technology like GPS can itself compound issues of confusion and uncertainty, and this was certainly the case with 'iMagick'. In any location-based game, a stable correspondence between the location of the players in the physical and virtual world is crucial to the players sense of certainty that their chosen strategy is valid, thus the effect of losing that connection must be regarded as extremely harmful (Magerkurth et al, 2005). The issue of 'uncertainty' in pervasive games was also highlighted by Benford et al (2003, 2005), with their work on the 'Can you see me now?' project. As found with 'iMagick', they noted that feelings of uncertainty as to the behaviour of tracking feedback was the most salient issue arising from user experience, and highlight the inherent uncertainty of GPS tracking as being the most significant cause of this problem.

Participant:: *Cos, I mean I'm…and now I'm getting a lot of drift because, you know, I'm on it and then it's…I, I've done it…*

Interviewer: *Problems?*

Participant: *Yeah, we're, we're on track…I'm getting clippy-cloppy noises…ha…I think I have to turn now…*

Interviewer: *OK, let me know how you're thinking…*

Participant: *Well…it's fiendishly difficult to cast these spells*

Interviewer: *Oh yes indeed*

Of course difficulty and challenge are an important aspect of games that make successful completion more satisfying.

During the testing of 'iMagick', the effect of the participant's lack of experience with the characteristics of GPS had varying levels of consequence, but some of the negative effects of GPS inaccuracy could have been more actively controlled. For example, it was noted that the rate of error and drift were substantially worse during the morning testing session than in the afternoon (as different configurations of satellites became available). Furthermore, the position of the GPS receiver itself was found to be a factor in drift occurrence, with participants often having to be told to not obscure the receiver with their thumb. As connection between the receiver and the iPAQ was achieved wirelessly, this issue could have been easily avoided by mounting the receiver elsewhere on the participant where it could not be so easily obscured – perhaps on a rucksack or baseball cap.

Despite this, those participants who were lucky enough to begin their experience during times of stable and accurate tracking appeared to develop a model of the technology rapidly, and could subsequently adapt to and resolve drift issues (even major incidences) with little problem. Conversely however, those participants who began their experience during a period of low accuracy and high drift, even when informed of the technical cause of the drift and coerced into what would otherwise be a successful strategy to overcome it, remained highly confused, frustrated and seemingly reluctant to overcome the problem - instead resigning themselves to the conclusion that task completion was impossible:

Participant: *So even, even if I wanted to finish this spell…it wouldn't let me, cos it would move away from it?*

For 'iMagick', the active minimisation of GPS drift was thus particularly crucial in the initial phase of play, where participants attempted to test the system, establish a reasonable walking pace and orientate themselves – a process often incurring trial-and-error based movement strategies. Failure to maintain a reasonable level of movement tracking accuracy at this early stage appeared to render the remainder of the game player's strategy formation flawed, and their reaction to times when the signal *was* stable often did not positively balance out their initial negative experience.

1.1. Problems with Orientation

The second most salient issue to arise from analysis of the field trial transcripts was the issue of orientation:

Participant: *Well…I'm, I'm just trying to aim for that <start point> and…I would assume that when I'm here, and I walk straight on…it would go across…I'm obviously not looking at the map properly…no…oh here I am…no now I'm definitely walking away from it…<laughs> eh?*

Interviewer: *Now you're looking confused*

Participant: *Yeah, I definitely don't know what direction I have to walk to now <laughs> I'll just try any old direction…*

Completion of a spell in 'iMagick' required multiple movement and tangent decisions (particularly notable in the 'star' shaped spell), which in turn required close and continual monitoring of the visual feedback supplied from GPS on the iPAQ screen. In order to provide some level of orientation assistance, the background imagery of the 'iMagick' game was designed to replicate the 'real' landscape of Millennium square (albeit through a suitably fantastical interpretation), yet many participants did not notice this unless explicitly told. Those who did realise the correspondence used it to their advantage and often rotated their iPAQ in order to maintain their orientation to a physical landmark / point of reference:

Interviewer: *I notice you're rotating the iPAQ…*

Participant: *Yeah, I, sort of…it seems easier to…keep on track if you can…keep that <iPAQ map> layout matching the layout of the <millennium square>…*

Participant: *Well, if, er, I don't know, but when I'm, er, reading a map, I always turn the map round as well …So I'm facing in the right direction…because otherwise you can't…it's difficult to, like, go backwards in your head…*

Importantly, those participants who did use the map also reported that navigating a spell would have been significantly more difficult without it:

Participant: *I was originally just following the line and that wasn't work…um, it's, for me, it, for me it was a case of, you follow the line as long as you're staying on it, and if you get off at all, then you follow a landmark…um, cos yeah, I did feel that I could just follow a line…as long as I was actually managing to keep on track…But as soon as got off track, then knowing where the line was didn't really help…Cos I'd, at that point I'd obviously, I'd lost what direction I was going in so I needed to go in the direction of a landmark in order to get back on track…*

Indeed only those participants who used the map were able to complete the spell. The video analysis shows a distinct difference in the behaviour of those who succeeded at the task and those who did not. Successful participants spent the first five minutes orienting themselves, understanding where the landmarks were and the direction and scale of the map compared to the physical landscape. They had a good mental model of where the shape was supposed to be in the physical world. When walking the shape they continuously looked up to check bearing, direction and angle from the real world and they used the feedback on the screen to verify that they were still in the boundaries of the shape. They were less flustered when the tracer dot jumped around as they were confident that they were in the right place and that eventually the tracer dot would come back to them.

Participant: *You have to kind of…turn…before…erm…it looks like you're supposed to, to accommodate for, er, the calculations…because if you actually do it near, actually, where the point is…or wait for it, then it will…sort of, er, be too late, and you'll end up being outwards…*

Participant: *Yeah, I think once you've got used to it, it's not too bad at all…does take a few minutes to get used to … used to orientating yourself using the path, the dot, and the landmarks…together…*

Those who were not successful did not use the physical landmarks or noticeably look up from the screen at all. They became mesmerized by the dot on the screen

Participant : *But once I was on the blue line…everything else was…I was oblivious to everything else*

The appearance of the track and the dot may have been a strong contributing factor to why some participants formed a model that they were trying to push the dot around by following it, much as a joystick on a games console would work

Interviewer: *And you did mention that, um, it was as that point that you realised the blue dot wasn't representing you…*

Participant: *Well that was the thing, it was breaking that link…it did take me a while conceptually because I was doing all sorts of stupid things…I was doing, um, when it went off to the left, I'd try and go to the left to push it back in, you know, in a kind of…a bit like a joystick in a flight sim type of game…*

Without looking up at the real direction participants would seemingly try to "follow" the dot to push it or bring it back.

Participant: *Yeah…it seems to me that it's in the same place as me, when I walk…Oh, I know what I'm doing…idiot…god knows why I thought this, I was trying to walk that way to push that back on there…*

Some of the participants never became confident that they knew where the shapes were, how the dot moved in relation to them or that the task was feasible at all. These participants also acknowledged that they were not confident with maps.

Participant: … *I'm not very good with maps…I know it probably doesn't help*

Additionally, consequent of the limited screen estate afforded by the iPAQ used to deliver the in-game visuals, the game area map was several times larger than could fit on the screen, thus requiring scrolling (albeit automatically). This issue was compounded further by a low screen resolution requiring a zoom level of 50% in order to permit a clear representation of graphic detail. As a result, ground truth that was not in the immediate proximity of the player was often obscured and a single point of reference could not be used consistently.

However, as observed during testing, some participants would rotate their iPAQ to 'line' up points of reference in the real world, and this could be facilitated in future revisions of the game by allowing the game map to rotate on its own axis through use of an electronic compass (a technique successfully employed in ‘Real Tournament’, Mitchell et al, 2003).

5.2 Implications for future designs

We have seen that to be successful at “spell walking” the user needs to be able to develop a conceptual map of the relationship between the virtual “spell shape” and the real world and to use the tracer dot, the landmarks and the map together to work out the angles you need to turn and the distance that you need to walk. The user also needs to realise that their movement leads the tracer dot, the tracer dot is not meant to be followed or pushed. Without a good conceptual model of where the shape is in relationship to the real world it is impossible to “lead” the dot.

We have also seen that participants can learn this mapping and the “art” if spell walking if they realise that they need to look up and locate physical landmarks and relate them to map. The speed of realisation and mastering the art varies tremendously and some participants never got it.

Future design could incorporate some of these findings into the game interface to see whether it might be possible to “teach” these skills and help the user create the right conceptual model. For example a better representation for the tracer dot might be a balloon or “magical artefact” which was virtually tethered to you on an elastic thread. This might break the expectation that the dot should move in exactly the same way as you.

The interface could also make more explicit reference to physical landmarks in the environment and encourage the user to look up rather than continuously look down at the screen. A training level could help teach the user the relative scale of a “spell shape” to the real world. For example by relating the turn points of a practice spell to the physical structures in the environment and encouraging, through audio narration, the user to take note of physical reference points.

Some representation of the strength of the GPS signal might also be helpful. Whilst more sophisticated algorithms might feasibly filter out and reduce the effect of unlikely or impossible movement from drift (Agarwal et al (2002)) it is unlikely that GPS jitter would be eliminated completely. In keeping with the mystical theme GPS strength could be represented as “the winds of change” and users could learn to cast spells when the “winds were favourable” and so understand the uncertainty of GPS at different times of day.

Participant 1: *…but I think from a story point of view it makes a lot more sense with magic, you know, cos whether it’s gonna be a vague, kind of a grey irrational kind of thing…*

A representation of GPS strength would also help with potentially scoring spells so that it was a factor in the degree of difficulty of the spell.

Movement sensing equipment such as an accelerometer, pedometer, compass or gyroscope could also potentially be incorporated into the mobile gaming device thus offering a backup solution during periods of low-accuracy or non-signal (Randell, 2003).

6. CONCLUSION

We have seen that “casting spells” by walking shapes in the environment is “fiendishly tricky”, satisfying if you complete it and a learnable skill. To be successful a user needs to be able to form a cognitive map of the virtual shape on the physical world and use the physical landmarks in the environment to guide the direction. Looking up frequently from the screen to see where you are in relation to the physical world is a critical part of the interaction which unsuccessful participants did not do.

Despite its many idiosyncrasies, the utilisation of GPS as a control mechanism in a game appeared not only quite feasible, but actually made for a novel and somewhat enjoyable experience:

Participant: *I thought the fact that it was…fairly challenging, but I could do it was a lot of fun, which, I dunno…it’s…the whole thing is quite new cos I’ve never done anything like it before, and, so…I mean, I dunno…not surprised as such but I didn’t really know what was going to happen at all…um…so, in a way, all of it was a bit…original I thought*

Participant: *Yeah, I think it’s a really engaging idea…I, I, I really liked the idea of it, I really wanted to be able to do it…um…yeah.*

Importantly, this was found to be true despite an often highly salient distrust of the technology:

Participant: *I didn’t trust the blue dot…but that never made me think that the idea of casting a spell was bad…I think it’s a wicked idea, I think it’s really cool…*

Thus, while more sophisticated efforts to improve the accuracy of the technology would have clear benefits to easing the aspects of frustration that GPS inaccuracy incurred during testing, it is not yet clear whether it might not benefit the game experience more to instead capitalize on those inaccuracies as a core aspect of the game.

7. ACKNOWLEDGMENTS

We would like to acknowledge Fluffy Logic for the iMagick game design and graphics. Kirsten Cater, Pieter Diepebmaat, Ben Clayton, Tom Melamed, Stuart Martin, Constance Fleuriot and the rest of the Mobile Bristol team for help developing the prototype and running the tests.

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