Coping with uncertainty in a location-based game [*]

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Introduction

Location-based games are a new form of entertainment played out on the city streets. Players equipped with handheld or wearable interfaces move through the city. Sensors capture information about their current context, including their location, and this is used to deliver a gaming experience that changes according to where they are, what they are doing and potentially how they are feeling. In collaborative games this information is also transmitted to other players who may also be on the streets or on-line. The net result is a gaming experience that is interwoven with the player's everyday experience of the city.

Location-based games are an exciting commercial prospect. They build directly on current wireless (but usually disconnected and location independent) games for mobile phones. This market is predicted to reach billions of dollars in the new few years and represents a potentially significant income stream for 3G mobile telephony. Early examples of location-based wireless games including *Bot Fighters!* from Its Alive! [8] and *Battlemachine* from UnwiredFactory [9]. Such games also provide an interesting focus for research, offering an open space in which it is possible to create a wide variety of experiences – both collaborative and competitive – and are also relatively easy and safe to deploy in public. There have been several examples of research projects that mix online and mobile players to different extents. These include Pirates! From the Interactive Institute in Sweden [1], the AR Quake project [3] and Border Guards from the Mixed Reality Systems Laboratory in Japan [2].

This paper describes our experiences of publicly deploying an experimental mobile mixed reality game called Can You See Me Now (CYSMN). This has involved collaboration between a technology research laboratory (the Mixed Reality Laboratory at Nottingham [13] which is a partner in the UK's Equator project [7]) and an artists group (Blast Theory [4]), and has taken the form of an experimental public performance that has been staged at two new media festivals – Shooting Live

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Artists in Sheffield in 2001 and The Dutch Electronic Arts Festival in Rotterdam 2003.

CYSMN is therefore both a public art work (in the form of a game) and a vehicle for research into location-based applications. As an art work, our aim has been to create an engaging experience for the public and to show how location-based wireless technologies can be used to create new kinds of artistic experience. Evidence for our success is given by a positive reaction from the public, press and commissioning bodies leading to further bookings for CYSMN in cities across Europe and also the award of the 2003 Prix Ars Electronica Golden Nica award for interactive art. As a vehicle for research, our aim has been to learn from the practical experience of taking location-based technologies out of the lab and deploying them in the field to be used by large numbers of users in the most realistic and stressful situations that we can feasibly achieve. This builds on the approach of staging public performances as a research method that we have developed since 1996 [12].

We have studied CYSMN using a combination of ethnography, audience feedback and analysis of system logs. One of the key issues to emerge from these studies has been the effect of uncertainty on the experience. This is the focus of this paper. Specifically, we provide: an account of how position and connectivity were subject to uncertainty and how we sought to deal with this; an account of how game players experienced this uncertainty; and a discussion of how game designers might manage uncertainty, as suggested by our experiences.

Can You See Me Now?

CYSMN is a chase game. Up to fifteen *online players* at a time, logged in over the Internet, are chased through a virtual model of a city by three *runners*, professional performers, who are running through the actual city streets equipped with handheld computers, wireless network connections (using 802.11b) and GPS receivers. The online players can move through the model with a fixed maximum speed, can access a map view of the city, can see the positions of the other players and the runners, and can exchange text messages with them. The runners move through the streets, can see the positions of the online players and other runners on a handheld map, can see the players' text messages and can communicate with one another using walkie-talkies. A key feature of the game is that the runners' walkie-talkie communication is streamed to the players over the Internet, providing them with ongoing description of the runners' actions, tactics and experience of the city streets, including reports of traffic conditions, descriptions of local topology and the sound of the physical exertion involved in catching a player.

The online players' experience

An online player's experience begins at the CYSMN webpage where they can explore background information about the game, including instructions on how to play. They enter a name for themselves, followed by the name of someone that they haven't seen for a long time – a person that they are looking for. They then join the queue to play (we restricted the number of simultaneous players). When it is their turn to play, they are dropped into a 3D model of Rotterdam. This model is highly abstract, it shows the layout of the streets and outline models of key buildings, including two wire-frame representations of planned buildings that have yet to be constructed, but does not feature textures or details of dynamic objects such as cars and of course, most of the population. The online player uses the arrow keys to run around this model. They cannot enter solid buildings, move out of the game zone or cross several fences. They need to avoid the runners who chase them. Specifically, if a runner gets to within five virtual meters of an online player, the player is 'seen' and is out of the game (their score is the time elapsed since joining the game).

Online players see themselves represented as running avatars, as are other players and the three runners. Avatars are labelled with players' names and the runners are further highlighted with a red sphere that makes them highly visible, even from a distance. Online players can also select a zoomed out map view of the model which shows the positions of more distant players and runners as well as text labels giving the names of key locations. Finally, they can view and enter text messages and hear the runners' audio. Figure 1 presents an example of an online player's interface, with the player's avatar in the foreground and a runner close by in the background. Figure 2 shows the interface in map mode.

Figure 1: online player's interface – close up view

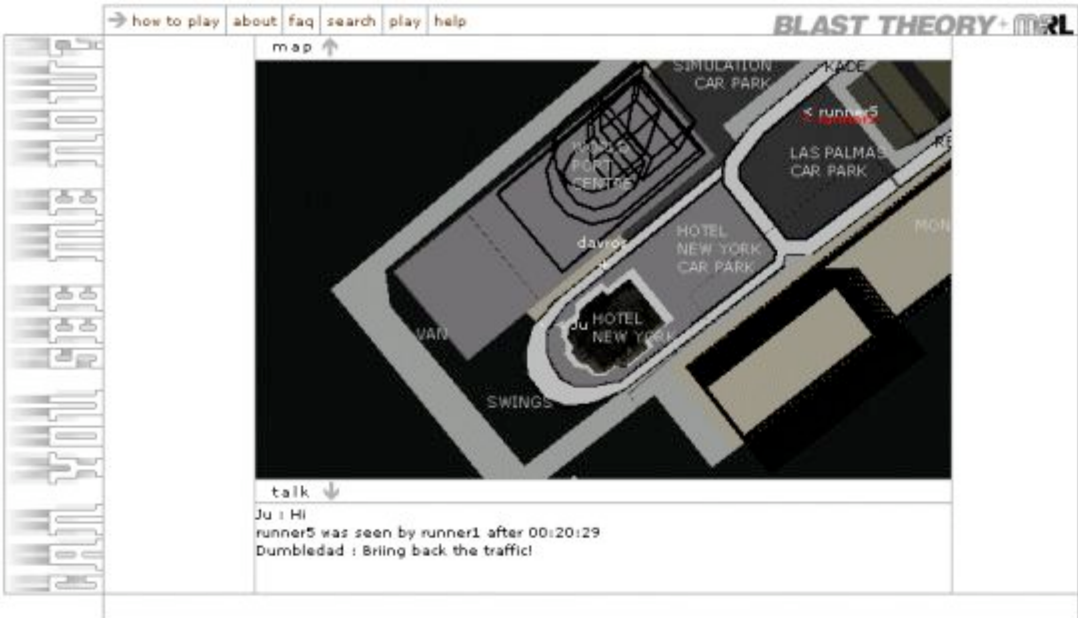

Figure 2: online player's interface – map view

The runners' experience

The runners' interface was delivered on an HP Jornada handheld computer from a server in a nearby building over an 802.11b wireless local area network. A GPS receiver plugged into the serial port of this computer registered the runner's position as they moved through the streets and this was sent back to the server over the wireless network. This equipment was built into a robust outer jacket as shown in figure 3.

Given the small screen size of the iPAQ, the runners' map allowed them to zoom between a global view and a close-up local view centered on their current position as shown in figure 4. Blue arrows show runners, red ones online players and the area at the bottom of the screen shows the most recent text messages from the players. The three pieces of information at the top of the interface in green show the current estimated GPS error as provided by the GPS receiver (left), the strength of the network connection (middle), and the number of online players currently in the game (right). The runners used walkie-talkies with earpieces and a head-mounted microphone. Finally, they carried digital cameras so that they could take a picture of the physical location where each player was caught. These pictures appeared on an archive web site after the event [5,6].

Figure 3: a runner

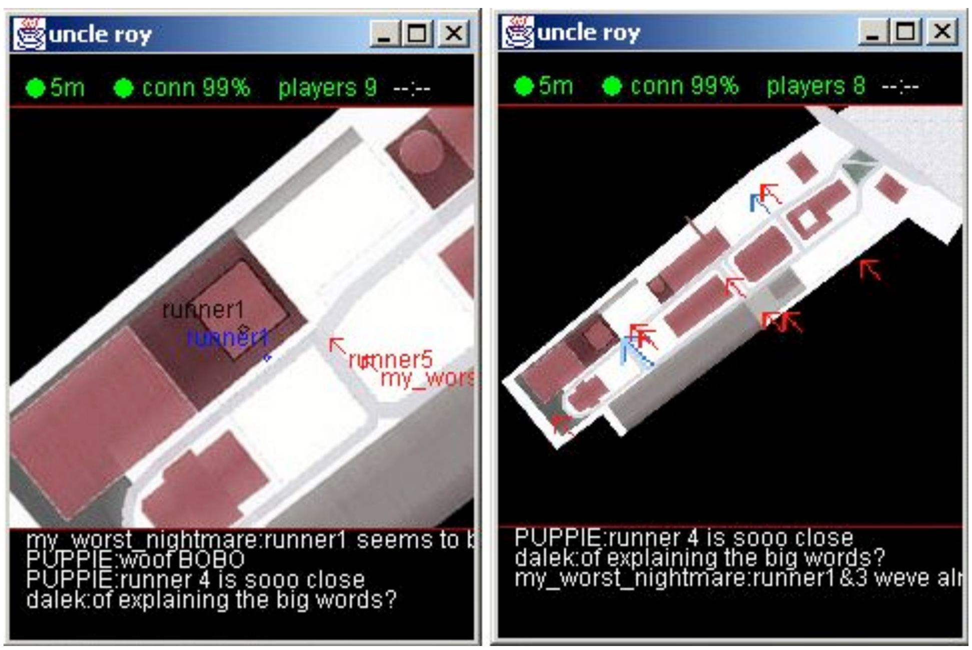

Figure 4: the runner's interface – close up (left) and map view (right)

Deploying CYSMN required the support of an extensive behind the scenes technical crew who were housed in one of the central buildings in the game zone (along with six public terminals for local online players). The control room was home to a technical crew of three who were responsible for running and managing the online server and supporting the runners. This team made use of a variety of monitoring and control interfaces including an overview of the game space, an interface for managing queuing players, an interface for monitoring the state of the wireless network, an interface displaying the status of the runners including current connection status and GPS status and an interface for playing the game. These monitoring interfaces were supplemented by the use of a separate walkie-talkie channel for communication between the control room and the runners. We return to the role of these different interfaces later in the paper.

Causes of uncertainty in CYSMN

There were several sources of uncertainty in CYSMN.

The first and most significant was the uncertainty inherent in GPS. In Sheffield we used standard GPS with Garmin etrex receivers and the game zone spanned a mixture of open urban spaces with a few narrow and built up narrow side streets. Analysis of system logs showed that reported GPS error ranged from 4m to 106m with a mean of 12.4m and a standard deviation of 5.8m. In Rotterdam, we upgraded to differential GPS and used Trimble Lassen LP receivers with Sarantel antennae. The game zone contained a similar mix of open spaces several of which looked out over open water (i.e., with a good view of the sky to one side) and narrower built-up streets towards the centre of the game zone. Analysis of logs showed that in this case, reported error ranged from 1m to 384m, but with a lower average error of 4.4m and a standard deviation of 4.9m. In order to improve accuracy we configured the receivers to ignore satellites that were low in the sky (below 15^{o}), although this meant that it was often more difficult to get a GPS fix. In both environments there were blackspots where multi-path reflections led to particularly high errors and therefore large jumps in reported position.

Our second major uncertainty arose from the use of 802.11b networking. Although we invested considerable effort in deploying 802.11b in both game zones (we deployed an eight meter mast on a roof top supplemented by two omni antennae in Sheffield; and a network of seven wireless access points, four of which were on buildings, one on a lamppost, one in a van and one on a ship, in Rotterdam), coverage of each game zone was only partial. Consequently, runners would move in and out of connectivity, frequently leaving and rejoining the game. Analysis of system logs from Rotterdam revealed three broad categories of packet loss intervals: periods of short loss (less than 5 seconds) that account for 90.6% of loss intervals and were probably due to communication errors; 278 moderate periods of loss (between 5 seconds and 10 minutes) that were probably due to detours out of connectivity or interference; and finally two loss periods of about 15 minutes and one of about 40, probably resulting from more major equipment failures. It should also be noted that the runners speech was transmitted over a separate walkie-talkie channel which on the whole, provided broader coverage across the game zone than the 802.11b network, although was sometimes subject to interference from other walkie-talkie and radio users.

A third source of uncertainty arose from frequent technical failures such as cables working loose and connectors being damaged (our runners were really running and consequently their equipment suffered a battering) as well as soft failures such as batteries running out of charge. These problems would add to GPS and connection problems.

Our fourth source of uncertainty was delay, arising from a combination of network delays across the Internet and the 802.11b network, and processing delays in the game server. Although variable, there was a typical delay of six seconds or more between one participant acting and another participant seeing that action.

The experience of uncertainty in CYSMN

We now consider how the various uncertainties associated with CYSMN were experienced by the players, runners and technical crew. At the time of writing CYSMN has been staged in two different cities: Sheffield in December 2001, where it ran for six hours over two days and received over two hundred on-line plays; and Rotterdam in February 2003, where it ran for twenty hours over five days and received over one thousand on-line plays. The following analysis draws on three sources of data: ethnographic observations of players, runners and technical crew, including capture and transcription of video data; analysis of system logs, including GPS, network traffic, and over three thousand messages of online players chat; and feedback emails from the players. Our discussion briefly summarises some of the key highlights from this analysis.

The players' experiences

Overall, CYSMN was well received and there seems to have been genuine engagement and even tension for the players, especially when the game was working smoothly. These included the players hearing their names over the audio channel and then being chased, struggling to meet up and run with their partners and colleagues without being seen, and also tuning into various aspects of 'life on the streets' including being aware of the runners negotiating traffic, hearing them breathe heavily, hearing other ambient sound (including a mobile disco at one point), and for some players who were in a public area in the game zone in Rotterdam, seeing the runners pass by a window as they came to get them. As one player put it in an email:

> … the start of me becoming totally engaged was when I met up with my partner who was playing in the same room and through fits and starts we found each other and then ran 'hand in hand' in desperate flight across the city. I then had this real feeling of the need to protect her from being caught and we could work cooperatively in keeping an eye out for incoming runners.

However, the game did not always run so smoothly and the effects of uncertainties were sometimes apparent. Players noticed that runners would sometimes suddenly appear and disappear and would jump around (reflecting uncertainty in connectivity and GPS respectively), especially when they were caught as a result, as the following extracts from the text logs show. To quote a selection of players from the text chat logs:

> … hmm the runners seem to jump around a bit
>
> … they seem to appear quite randomly.
>
> … apparently it doesn't matter they boot you from miles away
>
> … sometimes I get seen while the runner is still miles away. do others have this?
>
> … the runner was nowhere near me!!!!!
>
> … Runner 2 just appeared out of nowhere

Or as our previous email correspondent put it:

A couple of times I was caught and I just hadn't seen anything, which is a shame because the adrenalin rush when you see a runner approach and you try to escape is part of the draw in the game.

Online players appeared to sometimes weave accounts of these noticeable effects into the structure of the game, attributing them to power-ups or characteristics associated with the runners. These characteristics include invisibility as we see in this exchange between two players:

Player 1: attention runner1 is cheating by using his invisible coat

Player 2: what's an invisible coat?
Player 1: never mind what the coat is he can pop out of nowhere

blindness …
is runner 1 BLIND?? I closely passed him

laziness …
player 1: they seem to be resting
player 2: not resting lazy

blindness and laziness:
player 1: Runner one is blind
player 2: And lazy too

and even roller skating!
runner 1 you moving very fast sure you're not roller skating?

Runners would sometimes mention the causes of uncertainty, especially GPS, over the public audio channel and some knowledgeable players homed in on this as this selection of quotes suggests:

Runner1 needs a GPS update & 3 maybe she's already on me

Looks like runners without a red circle don't have GPS

Too bad the GPS is so unreliable. I was supposedly seen with no runner in sight

Some speculated that the runners deliberately exploited the characteristics of GPS:
Ah! That's how they hide GPS can't pick you up on the Map if you're inside

And some even recognised its tactical advantages to themselves:

Not only have we a scary looking dark building to hide behind but its also crap GPS. Pray hard to the anti satellite god

It seems that making sense of GPS uncertainty was a core part of the game for players, but that it was experienced in different ways. Sometimes it was a highly noticeable problem, sometimes inexplicable, and sometimes even offered a tactical advantage. However, it should be noted that for much of the time it did not appear to have been a noticeable problem (at least one worthy of comment). We speculate that one reason for this may be that the online players could only directly see the virtual model of the city, and their live connection to the streets was through audio which while it offered a rich source of contextual and atmospheric information, did not invite a direct comparison of reported and actual positions (in the way that embedded video views might have).

Other effects of uncertainty were more hidden from the players. In spite of a few text messages questioning whether the runners were actually present, failure to connect at all seems to have been largely hidden. One reason for this may have been that players could not obtain a global overview of the entire game space and so while they could see that there were no runners in their local area, they could not be sure that there were none present in the game as a whole. Second, the walkie-talkie channel was separate channel from the 802.11b data channel and the runners would often continue to talk over the walkie-talkies even when not connected to the game (in fact, they would deliberately talk more offering richer verbal descriptions of their local environment) creating the illusion that they were still actively participating.

Network delays were also largely invisible, except for when several players consoles shared the same physical space in which case the audio streams could be heard out of synchronisation or (as one player reported) it would appear to each player that their colleagues were lagging behind them (because each player sees their own local movements immediately they make them and before they are received by other players).

The runners' and crew's experiences

The runners and crew were directly aware of the uncertainties inherent in CYSMN. Indeed, they had to constantly battle against them in order to stage an experience for the online players. Our ethnography reveals how providing information about estimated GPS error and connectivity status on the PDA interface, combined with a private walkie-talkie back-channel, supported this. The following fragment of conversation between the control room staff (namely, the 'controller' who is monitoring the overall game state, the 'networker' who is monitoring the network state and 'John' who is specifically responsible for helping the runners out) and runner 4 illustrates this.

> John is outside the control room on runner 4's walkie-talkie trying to resolve a technical problem: Can you confirm runner 4's connectivity.
> Networker: *Looks at network monitor.* Runner 4 is connected.
> Controller on walkie-talkie: OK, we've got that. Can you run the client now runner 4.
> Runner 4 on walkie-talkie: Runner 4, client is connected.
> Controller on walkie-talkie: Runner 4, we have the connection and you're getting GPS.
> Runner 4 on walkie-talkie: Runner 4, confirm that – GPS down to 5 metres, connectivity 98%.
> Controller to Networker: Yep. So we now have 3 runners online all reporting GPS.
> Networker: Down to 2 to 3 metres, which is nice.

A second fragment shows how the runners would monitor the status of GPS as shown by their handheld interfaces:

> Runner 2 on walkie-talkie: Runner 2. I'm heading seawards on Wilamena, waiting for a server update.
> *He continues walking down the street, looking at the handheld and his place on the street.*
> Runner 2 on walkie-talkie: My GPS is currently 35 metres.
> Runner 2 on walkie-talkie: My server position is about 50 metres out.

This fragment also illustrates the main approach to resolving GPS problems – moving to a new (and hopefully better) location. The same technique was used for dealing with connectivity problems as shown by the following exchange:

> Runner 2 on walkie-talkie. *Looking at his handheld.* Runner 2. I've just lost all players, I've lost all players.
> Runner 2: *Looking at jornada.* I've got disconnection here.
> *The runner turns around and starts walking back down the street.*

Runner 2 on walkie-talkie: Runner 2. Heading seawards on Otto. I am currently disconnected.

The runner walks down the street for about thirty metres.

Runner 2 on walkie-talkie: Runner 2. I've connectivity again. I'm in Vern.

The runner then crosses the road into the carpark. Consulting the handheld, he turns left, moving towards the top of the carpark.

Runner 2 on walkie-talkie: Runner 2. I'm in Vern. I can see 1 player on the extreme end of the gameplay. That player is Dave. Runner 2 is closing in on Dave.

Our analysis shows that the runners and crew built up an extensive working knowledge of good and bad locations over the course of more than ten days rehearsal and live game play. The control room would also update runners with ongoing changes to conditions as the following example shows:

John on walkie-talkie: John to control room.

Controller on walkie-talkie: OK, what's the status of runner 4?

John on walkie-talkie: Can you pass on a message to all runners not to use Edam at all.

Controller on walkie-talkie: Not to use where, Edam *(a street in the runners' place)*?

John on walkie-talkie: Do not go down Edam.

Controller on walkie-talkie: OK, why?

John on walkie-talkie: Because we have low coverage and that's what's screwed runner 4's jornada up.

Controller on walkie-talkie: OK. Runners 1 and 2, do not use Edam, there is a problem with waveLAN connectivity. Do not use Edam.

And runners would respond accordingly:

Runner 2 on walkie-talkie: This is runner 2. I'm into Vern now. I can see Jules and Mike heading into Edam. I'm going to leave them. I'm looking for Tommy.

A particular ongoing concern was the changing nature of GPS uncertainty over time as different configurations of satellites became available. This could change radically throughout a single two-hour session, occasionally worsening to the point where only three or four satellites were potentially available, making GPS very unreliable. In response, a member of the crew printed out charts of satellite availability over the day, highlighting availability during game time in particular, which were pinned on the wall of the control room and discussed in daily briefing sessions so that the crew and runners would be aware of difficult periods of gameplay.

Runners also exploited their knowledge of GPS uncertainty tactically. This became apparent after the initial Sheffield experience, as shown by the following conversation between a runner and crewmember.

Crew: So your tactics: slow down, reel them in, and get them?

Runner: If they're in a place that I know it's really hard to catch them, I walk around a little bit and wait till they're heading somewhere where I can catch them.

Crew: Ambush!

Runner: Yeah, ambush.

Crew: What defines a good place to catch them?

Runner: A big open space, with good GPS coverage, where you can get quick update because then every move you make is updated when you're heading towards them; because one of the problems is if you're running towards them and you're in a place where it slowly updates, you jump past them, and that's really frustrating. So you've got to worry about the GPS as much as catching them.

In short, runners and technical crew were able to cope with and even exploit the uncertainties in CYSMN, but only as a result of building up extensive knowledge of the behaviour of the technologies in the context of the game zone. While our interfaces for revealing these uncertainties to them appear to have been useful, they were clearly only one part of a complex mix of processes and technologies.

Strategies for dealing with uncertainty

Our observations show that uncertainty, especially with regard to location and connectivity, was a significant and ongoing issue for CYSMN. They also reveal that uncertainty is a complex issue that can affect participants' experiences in different ways depending upon their role (e.g., street player or online player), the extent of their technical knowledge and the information that is currently available to them.

One response to uncertainty is to employ improved technologies that remove it. Much of the research community is focused on this, trying to develop better positioning and wireless networking technologies. While acknowledging the importance of this research, we anticipate that for the foreseeable future, the designers of location-based games will have to cope with a significant level of uncertainty. Our focus is therefore on the strategies for dealing with uncertainty when it is present.

One option is for game designers to remove some of the uncertainty through careful choice of the game zone. GPS and network traffic logs from Rotterdam showed that some locations (the narrow built-up streets at the centre) were consistently poor with regard to positional accuracy and/or connectivity. With careful scouting, game designers can focus play on good areas of coverage. Furthermore, analysis of CYSMN showed a variation in GPS uncertainty over time, suggesting that designers should be flexible about their choice of playing times. However, this will not always be possible as locations and playing times are determined as much by available access, safety and sponsors needs as they are by suitability to the underlying technologies. These are significant factors for non-gaming applications too as one cannot reasonably ask the providers of location based services to move their premises just to fit the technology.

Our experience with CYSMN suggests two further strategies: *hide* the uncertainty so that participants are less aware of it and minimally disrupted by its worst effects; and *reveal* the uncertainty so that participants are able to work with it.

Hiding uncertainty

CYSMN introduced several mechanisms to hide the worst effects of uncertainty from the online players.

We implemented a position validation scheme to filter out situations where inaccurate GPS measurements would place runners in impossible locations, such as inside buildings or in the water. GPS reports were first input into a 'raw' data space in the game server which would then compare them to a predetermined map of acceptable locations. Unacceptable positions would be corrected to the nearest acceptable position in the game space before being published via a second 'validated' data space. This technique was effective at hiding some of the most obviously disruptive effects of GPS uncertainty (we did not observe runners appearing in forbidden locations and online players did not refer to this in their text messages). However, this mechanism did involve a trade-off as its use would sometimes lead to sudden jumps in position, for example a small update in GPS position that moved a runner across the midpoint of a virtual building would instantaneously change the nearest valid location from being on one side of the building to the other. In our case this was an acceptable trade-off as appearing in a building was deemed to be more problematic than a sudden jump in position.

We implemented an animated sequence to show online players the moment of their being seen by a street player. Once the system determined that they had been seen, the virtual camera would smoothly zoom into a close up view of the player over several seconds and show the runner's avatar nearby. A player would at least always end up seeing a runner, although if there had been a significant GPS jump, they may not have been in view before the moment of being seen (hence some of the comments above). We also deliberately used the term 'seen' rather than 'caught' to introduce a degree of fuzziness as to how close a runner had to get to a player. In general, we would recommend that game designers consider employing these techniques to smooth out critical moments of gameplay that might be disrupted by uncertainties in the underlying technology.

The use of streamed audio as the main channel through which online players directly experience events on the streets also served to hide some of the effects of uncertainy from the online players. In addition to supporting communication from the runners, audio was a rich source of context and was also highly atmospheric. Unlike visual media such as video, it was also not overly precise in terms of allowing a direct comparison between the positions of the runners shown in the virtual world and their actual positions on the city streets. Furthermore, given that the walkie-talkie channel was separate to the 802.11b data channel, the runners could continue to talk over the walkie-talkies even when disconnected from the game (in fact they would tend to talk more to cover the problem and provide a sense of continuity to gameplay). As an online player was prevented from ever seeing an overview of the entire game zone, it was difficult for an individual player to determine that there weren't any runners present in the game.

Finally, we suggest that the overall structure of CYSMN also served to hide uncertainty from the online players. Rather than creating an augmented virtuality [10] style experience where the physical world is explicitly overlaid on or embedded into the virtual world, CYSMN creates what might be termed an 'adjacent reality', where the virtual and physical worlds are separate, often quite divergent, and connected in looser ways. Online and street players have access to different information and can exchange this as part of game. For example some of the buildings in the CYSMN virtual model haven't yet been built in the physical space, and many features of the physical world such as traffic are absent in the virtual model. We would recommend that game designers avoid situations in which players are likely perceive a direct mismatch between reality and uncertain measurements of position (e.g., where the system tries to show them both worlds in a precisely aligned way, or where they are present on the city streets and being shown a position on an electronic map that is clearly erroneous). Instead, our experience suggests that designers deliberately give online and street players different and limited perspectives in the game, providing each with a distinct role and encouraging them to communicate and share information. More generally, we argue that this 'adjacent reality' structure provides sufficient space for players to be able weave their own interpretations of technical quirks back into the game experience (e.g., accounting for connection failures as invisibility power ups as described previously). This enables them to maintain a willing suspension of disbelief without breaking their engagement with the game.

Revealing uncertainty

Our second strategy is quite different – it is to deliberately reveal uncertainty to participants. Our experience of CYSMN suggests that runners were better able to work with the uncertainties of GPS and wireless networking once they had built up a working knowledge of their presence and characteristics, something that we enabled by providing information about estimated GPS error and connectivity on their PDA interface. Indeed, this is a familiar approach from mobile phones where information about signal strength is routinely made available to users to help them deal with the uncertainty of connectivity. The approach of revealing uncertainty was taken to greater extremes in the control room, where a variety of interfaces provided detailed information about the behaviour of GPS and wireless networking in relation to each runner so that technical crew could troubleshoot the system and advise the runners how to proceed over the walkie-talkie system.

Although this strategy of revealing the uncertainties in the infrastructure to some participants does seem to have helped them work with the technology, we feel that we could have gone further. Runners' main concerns when faced with problems were whether they should move to a new location or whether their equipment was somehow malfunctioning (in which case they should call out a member of the technical crew to assist them). In addition to showing current GPS error and signal strength, we should also have given the runners a sense of how uncertainty varied across the game zone, for example by providing colour coded maps of good and bad areas of play so that they would better be able to judge whether to change location and if so, where to go. Given our observations about changes in uncertainty over time, these maps would need to be dynamic. Discussions in debriefing sessions also raised the idea of showing runners the status of other runners so that they could better assess whether any difficulties were specific to them or shared by others.

In summary, our experience of staging CYSMN suggests that designers can adopt two broad strategies to dealing with uncertainty in location-based games. They can hide it to some extent by using mechanisms such as position validation techniques and animated sequences for key moments of game play. More generally, adjacent reality game structures and use of audio as a rich but relatively imprecise medium can provide an open structure that allows participants to make their own interpretations of uncertainty as part of the game itself. On the other hand, designers should deliberately reveal uncertainties to some participants in order to help them build up a working knowledge of its characteristics and effects and so better work around it. Which of these strategies is chosen depends on the nature of the participant and their task. Tasks that involve maintaining engagement with a compelling experience – games and art for example – should seek to hide uncertainty. More work oriented tasks that involve making important decisions on the basis of uncertain information should seek to reveal it. Tasks that involve both, such as CYSMN where the runners work to create an experience for the online players, may adopt both strategies simultaneously.

We are carrying these ideas forward into a second game called Uncle Roy All Around You [11] which differs from CYSMN in several important ways: the public are now both street players and online players; the experience is more contemplative and mysterious, involving a journey across the city rather than a frenetic chase; and we are using GPRS rather than 802.11b and a positioning system based on self-reported and implied location from map usage rather than GPS. We are making greater use of our strategies in Uncle Roy, both requiring a greater degree of interpretation of uncertain information between street and online players, while at the same time providing technical crew with more sophisticated management interface to enable them to understand the state of the game and intervene where necessary.

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