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Bridging the PHYSICAL AND DIGITAL *in Pervasive Gaming*

*A new generation
of entertainment
technology takes
computer games to
the streets—and
ultimately beyond.*

Pervasive games extend the gaming experience out into the real world—be it on city streets, in the remote wilderness, or a living room. Players with mobile computing devices move through the world. 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 even how they are feeling. The game player becomes unchained from the console and experiences a game that is interwoven with the real world and is potentially available at any place and any time.

This is an exciting idea, both from a commercial viewpoint where pervasive games extend current wireless games toward more connectivity and including real locations and activities, and where they may deliver much needed content for 3G mobile telephony. From a research perspective, pervasive games open up new technical and human challenges.

There are already various forms of pervasive games. One approach is to reinterpret classic computer games, mapping them onto real-world settings

so that players must literally run about in order to control their avatars, as demonstrated by Human Pacman [4] and ARQuake [7]. Other examples focus strongly on social interaction, for example, Pirates!, a fantasy game about trading and fighting at sea [3], or the STARS platform for augmented tabletop games that preserve the rich social interaction found in traditional board and tabletop games [6] (see the sidebar “Computer-Augmented Tabletop Games”). Touring artistic games have mixed players on a city street with online players in a parallel virtual city, requiring them to exchange perspectives as in the chase game Can You See Now? [5], or exploring the theme of trust in strangers as in Uncle Roy All Around You [2] (see the sidebar “Mixing Street and Online Players”).

Pervasive games also have educational potential by encouraging learning through highly physical role play as shown by Savannah, a game in which groups of children hunt as lions on a school playing field [1]. Finally, early commercial offerings include Bot-Fighters! from Its Alive, a multiplayer shooter for mobile phones, and Majestic from Electronic Arts, a seminal

Mixing Street and Online Players

CAN YOU SEE ME NOW? (CYSMN) is a game of catch, but with a twist. Online players are chased through a virtual model of a city by up to four street players, who must run through the actual city streets in order to capture them. The game accommodates up to 15 players at a time, who access the virtual city model over the Net. The four street players, referred to as “runners,” are professional performers, who chase online players through the city streets using hand-held computers with wireless network connections (using 802.11b) and GPS receivers.

The online players can move through the virtual model of the city at a fixed maximum speed, can access various views of the city streets, can see the positions of other players and the runners, and can exchange text messages with one another. As the runners move through the city they can see the positions of the online players and other runners on a hand-held map. They can

University of Nottingham (www.mrl.nott.ac.uk) as part of the Equator project. It has toured cities throughout the world since 2001, including Sheffield, Rotterdam, Oldenburg, Cologne, and Barcelona. Ethnographic studies of the game have generated insights into how players experience uncertainty and into the process of orchestrating a live game from behind the scenes [5].

Uncle Roy All Around You is another touring game from the same team [2]. Here, however, players are on the streets and online. Street players (not performers) journey through a city in search of an elusive character named Uncle Roy, guided both by location-based clues from the game itself and also by remote online players who are able to track their progress in a parallel virtual model of the city and search for useful information such as the location

Figure 1. (top) Can You See Me Now? Runner on the street (left) and online view (right). Figure 2. (bottom) Uncle Roy All Around You: Street player (left) and online view (right).



also see the players' text messages, and can communicate with one another via walkie-talkies. Communication from the runners is streamed over the Net to the players, providing real-time descriptions of their experience on the street, including reports of traffic conditions, descriptions of local street scenes, and the sounds of the physical labor involved in tracking players down.

CYSMN was created by the artists group Blast Theory (www.blasttheory.co.uk) and the Mixed Reality Laboratory at the

of Uncle Roy's office. By mixing live action with digital content, the game is carefully designed to involve passers-by in the action. It also encourages street players to cross boundaries; for example, entering an office or getting into a limousine with a stranger. The overall theme of the game is trust—in strangers, online partners, and technology—and in the end, street and online players are invited to make a year-long commitment to help a stranger if called upon. **G**

experiment aimed to interweave a fictional conspiracy with players' daily lives.

These kinds of pervasive games build upon three core technologies:

- Displays that can make digital content available to players as they move through the physical world, including mobile phones, hand-held computers, earphones, wearable computers, and also interactive projections and tangible interfaces embedded into the surrounding environment;
- Wireless communications that enable players to communicate with remote servers and other players, including cellular telephony (3G, GPRS, and GSM) and Bluetooth; and
- Sensing technologies that capture players' contexts including GPS positioning, cameras, microphones, and potentially even physiological sensors.

This blend of technologies, combined with the location-based and often public nature of game play, gives pervasive games their distinctive identity. At the same time, it also poses significant new challenges, five of which we now briefly discuss.

Dealing with uncertainty. Our first challenge arises from the considerable uncertainties associated with sensing and wireless communications. Both are constrained by limited coverage, especially in congested urban areas, so that players may often be unable to obtain a fix on their position or communicate with others. Sensing technologies are also associated with further uncertainties such as error and jitter, which can vary with both location and time. Previous research has proposed different approaches to dealing with uncertainty [5]: removing it, for example, by carefully choosing game locations and times; revealing it, so that players are able to understand; adapting to it; and even exploiting it by deliberately incorporating uncertainty into the structure of a game, for example, enabling players to "hide in the shadows" by moving out of network coverage.

Hybrid architectures. Our second challenge involves reconciling client-server and peer-to-peer architectures. Whereas client-server architectures enable players to share a consistent game experience, peer-to-peer architectures support highly localized and ad-hoc game play during encounters on the streets. The challenge here is to integrate these two approaches. For example, can we design games in which publicly visible and legitimate actions take place at central servers, but where there is the exciting possibility of more secret or private interactions occurring in peer-to-peer mode; for

example, "pickpocketing" other players or black-market trading without revealing sources?

Hefting domains. Game elements in computer games are mostly tied to the virtual world, while traditional games reside in the real, physical world. Since pervasive games take elements from both the real and the virtual worlds, their design requires careful consideration of which elements to represent virtually, physically, or as a blend of both.

Configuration. A pervasive game may need to be configured to work at many different locations. For a game intimately tied with its local setting, the challenge is to quickly integrate rich local information—maps, plans, images, and sounds—into the game content. Pervasive games that are less integrated with a local setting; for example, Savannah, which takes place on an empty playing field [1], may still require considerable configuration of network and sensing technologies.

Orchestration. Our final challenge concerns orchestration, the real-time management of a live game from behind the scenes—an important issue when game providers assume responsibility for the safety of players who are on the streets of a city. Successful orchestration requires tools for managing the status of players; for example, knowing their connection status and last known location, and also for subtly intervening without disrupting the game; for example, by improvising game messages.

Pervasive games are therefore both an exciting and commercially promising new form of computer game that build on a combination of hybrid interfaces, wireless networking, and context-sensing technologies. However, while recent projects hint at a wide variety of potential gaming experiences, they also reveal some of the research challenges that must be addressed if pervasive games are to move forward, including designing for uncertainty, exploiting hybrid architectures, and support for configuration and orchestration. These challenges are being addressed in a number of new projects worldwide, including the U.K.'s Equator project (www.equator.ac.uk) and the new Integrated Project on Pervasive Gaming (www.pervasive-gaming.org) that draws together industry and academic partners from across Europe. **C**

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Computer-Augmented Tabletop Games

Computer-augmented tabletop games assume a special role within the pervasive gaming paradigm. While most pervasive games attempt to transform the real world into a game board [3], augmented tabletop games take the opposite approach—building directly on the success of old-fashioned board games, especially their strong social situations and interaction metaphors, but also enriching them with IT benefits to realize a new hybrid form of entertainment. The result has the potential to combine the best of both worlds, emphasizing direct interaction between human players while presenting a computer logic that keeps track of the game



state, provides atmospheric visual and audio assets, and even takes an active role as a participant.

Playing computer-augmented tabletop games with the STARS platform.

To research the opportunities of hybrid computer-augmented tabletop games, an experimental platform called STARS [6] uses wireless communications to integrate dedicated interaction and sensing devices with a smart game table, providing various means to bridge the gap between the real world and the virtual world, supported by a software platform that facilitates prototyping different tabletop games.

Several applications based on the STARS platform are in

development to demonstrate different opportunities for computer-augmented tabletop games. The KnightMage game implements a basic set of rules for medieval hack-and-slash style role-playing adventures. Players explore and ransack dungeons and landscapes filled with horrifying monsters in a typical pen-and-paper playing style, including a human game master. Due to the mixture of cooperative behavior when fighting monsters and the competitive interests when searching for treasures, KnightMage profits by the platform's capability to convey game information via public and private communication channels, including large public displays, ear-



phones, and PDAs. Certain game events can be privately communicated from the game master or the computer to a player. To preserve the human-centered group dynamics of tabletop games, great care is taken regarding which game elements are represented in software or are left to the group in the real world. For instance, the rolling of dice remains an engaging physical act, although the outcome is communicated to the virtual world via visual recognition or radio transmission so the computer can automatically react to the outcome. In these ways KnightMage aims to combine the emotionally involving social situations of tabletop role-playing games with the typical features found in corresponding computer adaptations. **C**

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