Tangible Mudding: Interfacing Computer Games with the Real World

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Introduction

Games and play are fundamental human activities, through which we both learn and entertain ourselves. Typically designed for the world we live in, games like hide and seek, treasure hunts, or role-playing games make effective use of the physical world, in which our sensory engagement adds context, and content to the gameplay. The physical world can be compared to a board game, where players and objects become pawns and tokens that interact within a predefined physical space and according to agreed-upon rules. In some sense, games provide us with an excuse to interact, not only with each other, but also with the physical world.

It is sometimes argued that it is the computer game industry that pushes the development of new computer technologies and software techniques (Bushnell 1996). Computers inarguably offer exciting possibilities to the design of games but they also transform gameplay and interactions within game contexts. Despite the powerful machines that personal computers are, it is somewhat striking that an interface optimized for tasks such as word processing compromises its suitability for gaming applications. PCs are intended for individual use, and as such have been suggested to effectively shield users from their social and physical environment by demanding an excessive amount of foreground attention. This is also true for computer games in that players primarily interact with computers rather than with each other or with the physical world. Where the real world offers a significant richness in texture to the games we play, computerized game worlds fail by disengaging players from the physical world, depriving them of multi-sensory interaction within it. While computer games are often designed to mimic our world's physicality of (e.g. geometrical spaces), and our skills for interacting within it (e.g. walls blocks a route, if I see you, you see me, etc), they typically do not allow for the same type of richness in interaction as offered by games that are situated in physical space. There is a considerable difference in using the world as a *metaphor* for interaction, as in the case of a computer game, and using it as a *medium* for interaction, as in the case of a game taking place in the real world (Dourish 2001).

A compelling design space therefore is to extend digital computer game worlds to also span the physical domain, and create an *out-of-the-box computer game world* where points of interaction are not confined to a virtual environment and a personal interface, but also has networked, distributed, and tangible interaction aspects. This paper describes the *Tangible MUD* project, in which we are taking some first steps towards this vision by exploring how computer game mechanisms can be designed to reside in physical objects. Some related work and inspirational fields of research are mentioned, followed by the description of the Tangible MUD itself. The final sections will give an account of the general motives for the design and the implications that have been driving the project.

Related Work

Pirates! was one of our first efforts to design an of 'out-of-the-box' computer game (Björk et al. 2001). The primary goal was to design a computer game in which a player's engagement with the physical world was made meaningful to playing it. *Pirates!* is a multi-player game running on handheld computers in a wireless client-server network. Each client is equipped with a short-range radio transceiver that detects the player's relative proximity to other players, as well as to a number of physically distributed locations. These locations are tagged with beacons transmitting unique radio signals. The proximity information is used to trigger various game events, such as finding a treasure or encountering another pirate ship. Because the tagged locations are distributed over a large enough space, the game forces the players to explore the game world by moving around in the physical world. Designed to be played in settings that are also social (it was for example tested at conference receptions), *Pirates*! involves players and non-players the like. This was particularly evident in one situation where a non-player who observed it earlier gave a player direction to one of the radio beacons.

When designing 'out-of-the-box' computer games it is sensible to build on findings from established research fields that attempt to bridge the gap between the physical and the digital. Although not usually concerned with computer games, *ubiquitous computing* (Weiser 1991) is aimed at taking computing beyond the dedicated workspace, to create a resource that is accessible 'anytime, anywhere'. Of particular relevance to our work is its focus on providing seamless, even 'invisible' computational access to users engaged in informal social situations where attention is primarily on the interaction with other humans rather than with computers.

Context-aware computing (Selker & Burleson 2000) is a field of research aimed at the design of computers and applications that deliver task-relevant functionality tailored to the context of the users. By granting computer applications access to information such as a user's location, activity, social context, or even biological state and matching that information against a set of predetermined rules and preferences, information that is timely and relevant to that context can be delivered in a seamless fashion. Of specific relevance in this approach is the notion of making applications aware of and react to the user's actions and inferred intent.

Tangible user interfaces (Ishii & Ullmer 1997) provide physical form, or embodiment, to digital content and controls. Tangible interfaces take advantage of the inherent skills with which we interact with and make sense of the world, and capitalize on the affordances of physical objects to bring new modalities to human-computer interaction. For our purposes, tangible interfaces are in some sense the direct opposite of context-aware computing in that the concern is not as much about making the physical world accessible to computers as it is about making the digital world accessible to the user by literally moving into the physical world.

The challenge we are presented with is to design a computer game that takes focus away from interacting with a computer, and instead engages the player in interaction within a physical and a social environment. Tangible interfaces, ubiquitous and context-aware computing can be applied to help resolving that challenge.

The Tangible MUD Project

The Tangible MUD project's goal is to create interfaces that allow computer game mechanisms to reside in physical objects. We have three approaches to this challenge. Firstly, borrowing from work in the field of context-aware computing, we are designing interfaces that allow the game to be aware of the real world. Secondly, borrowing from work on tangible user interfaces, we are designing interfaces to let the game to literally move into the real world. Ultimately, our ambition is to arrive at a ubiquitous computer game with a physically distributed interface.

We envision a fully implemented version of the Tangible MUD as a fantasy adventure game, in which players are sent out on a quest to solve a mystery by collecting clues and skills, which they have to manage while various threats and obstacles are challenging them. In this vision, a designated physical environment is instrumented to support exploration of and interaction with objects, other players, and distributed locations. In our current demonstration, the Tangible MUD, the player finds herself in a wizard's library, where the task is to learn a magical spell. We have set up a physical space, containing a large desk, a lamp, and a stack of books, to function as the library.

Connecting the physical space with a virtual game world, we have designed a virtual representation of the library and its content using a Multi-User Dungeon. A MUD, or a Multi-User Dungeon, is a network-accessible, multi-participant, virtual reality with an entirely text-based interface[1] (Curtis 1992). Often set in fantasy or science-fiction themes, they allow players to engage in fantastic adventures and explorations of vast areas of interconnected virtual 'rooms' populated by creatures and objects to interact with. Virtual objects typically support actions associated with them (e.g. containers can be opened, objects can be picked up or looked at), which is performed by typing in commands to the game. Most of these commands, such as 'examine', 'look at', 'get', 'drop', etc., are standard commands commonly found in MUDs, but can also be commands that a programmer of those objects have defined. Furthermore, players have at their disposal a large array of communication possibilities (e.g. the ability to send messages to one another, or perform descriptive actions). Although often exhibiting very complex game mechanics, these environments, in their textual representation of the game world, present in comparison to graphical games a very "low-key" interface. In the Tangible MUD Project, the challenge has been to integrate physical objects with the text-based game engine, through which the interaction is made closer to physical interaction. Presently there are two such objects: a desk-lamp and a book (see Fig. 1).

[1] I am adopting the traditional definition of a MUD, which refers to text-based environments.

Fig. 1: The set-up of the Tangible MUD demonstration. The physical space has been set up to mimic a virtual space. The books and the lamp are physical representations of virtual game objects and can be used to display as well as affect the behavior of the virtual objects.

The Tangible MUD components

We use a generic MUD as the game server[2] and host to the virtual representation of the wizard's library. While a MUD world is generally very large in terms of the number of rooms and objects it contains, our demonstration of the game is limited to a single room in the MUD, populated by two virtual objects, a book and a desk lamp. These objects are "wired" to two tangible objects, a corresponding book (modified to contain some computational electronics), and a desk lamp (rewired to be controlled by a computer controlled switch (see Fig. 1)). The MUD server runs under the Linux operating system and via custom-built serial port hardware is capable of establishing communications links between the tangible and virtual objects.

Implementation

The book and the lamp interfaces are built using the iRX board[3], a hardware prototyping platform developed at the Massachusetts Institute of Technology's Media Laboratory. The circuit board measures 1.25" x 3" and supports an RS-232 serial port, a visible light emitting diode, an infrared port, and a PIC16F84 microcontroller. Further, the iRX board contains a prototyping area that a developer may populate with additional hardware components, such as sensors or actuators. In the case of the book, two sensors have been added. As can be seen in Fig. 1, the margins of the page are lined with a conductive tape contact, which is either a closed or an open circuit depending on if the book the open or closed. This sensor makes it possible to determine when the book is open or closed. A second sensor detects pressure applied to a section on one of the pages (as shown in Fig. 3). In the case of the lamp, because it requires to be plugged into a mains outlet, a separate switching circuit was built to

[2] MudOS and a modified version of the LPMud mudlib.
[3] Robert Poor, http://web.media.mit.edu/~r/projects/picsem/irx2/

isolate the high voltage/current from the iRX board. This circuit interfaces with the prototyping board. Both the lamp and the book are connected to the serial ports of the computer running the MUD server.

Interacting with the Tangible MUD

To illustrate how a player's interaction with virtual game objects can be made to affect a physical object, consider first Example 1. The first 8 lines of text describe the room itself, what the exits are, and what objects are present. Currently, the room contains a table, upon which a desk lamp and a stack of books are placed. As the following lines of text show (user-entered commands written in bold face), the virtual desk lamp has a button that the player can press to toggle the light on and off.

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The dimly lit room, set in old brick and mortar, is lined with tall
wooden shelves that reach all the way to the ceiling. Many books and
manuscripts fill the shelves, most of them gathering thick layers of
dust. By one wall, just beneath one of the tall shelves, stand a desk
and a chair.
There is one obvious exit: west.
Atop the desk is a lamp.
A tall stack of books is on the table.
> look at lamp
It is a metal lamp.
There is a black button on top. Press it to turn the lamp on.
> press button
You press the button on the lamp and turn it on.
> look
The dimly lit room, set in old brick and mortar, is lined with tall
wooden shelves that reach all the way to the ceiling. Many books and
manuscripts fill the shelves, most of them gathering thick layers of
dust. By one wall, just beneath one of the tall shelves, stand a desk
and a chair.
There is one obvious exit: west.
Atop the desk is a lamp (lit).
A tall stack of books is on the table.
--
```

Example 1: Demonstrating the text-based dimension of the Tangible MUD demonstration. The player finds herself in a room with a lamp that can be turned on and off. The virtual lamp has been programmed to turn a lamp in the physical room on and off in response to the button press in the MUD.

In turn, the virtual lamp has been programmed to control the physical lamp via the serial port interface, in such a way that it can be turned on and off from commands in the MUD. This shows how the behavior of a virtual game object can be manifested in a physical change. The real lamp becomes a display, through which the game can reach into the real world. Conversely, to illustrate how tangible objects can affect the behavior of objects in the virtual game world, consider the following example:

```
--
The dimly lit room, set in old brick and mortar, is lined with tall
wooden shelves that reach all the way to the ceiling. Many books and
manuscripts fill the shelves, most of them gathering thick layers of
dust. By one wall, just beneath one of the tall shelves, stand a desk
and a chair.
There is one obvious exit: west.
Atop the desk is a lamp (lit).
A tall stack of books is on the table.
> look at stack
The old books are of various sizes and bindings.
One of them in particular catches your eye.
--
```

Example 2: A player is interacting with the book object in the MUD environment.

As the player directs her attention to the virtual stack of books, the MUD sends a notification to the physical book at which point a red light emitting diode (LED) that is embedded in its front cover (see Fig. 2) starts to blink, attempting to get the player's attention and to beckon her to interact with the physical book. As the player opens the physical book, a notification is sent to the MUD at which point it appears, or is "cloned" into the MUD's room (see Example 2b). In addition, the MUD receives notification whenever the physical book is either opened or closed, causing the virtual book to behave accordingly.

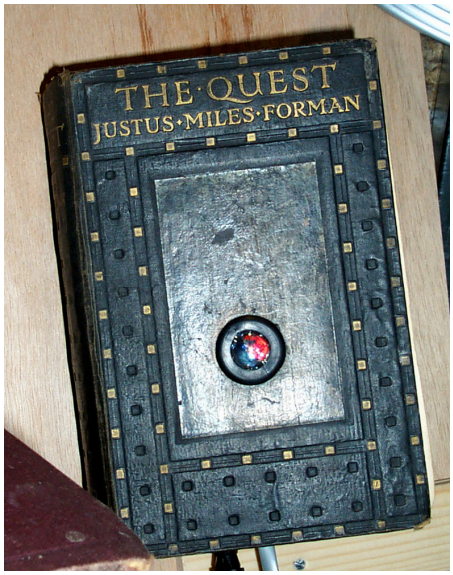

Fig. 2: The tangible spell book interface has a red light emitting diode in its front cover, used to beckon the player to interact with it.

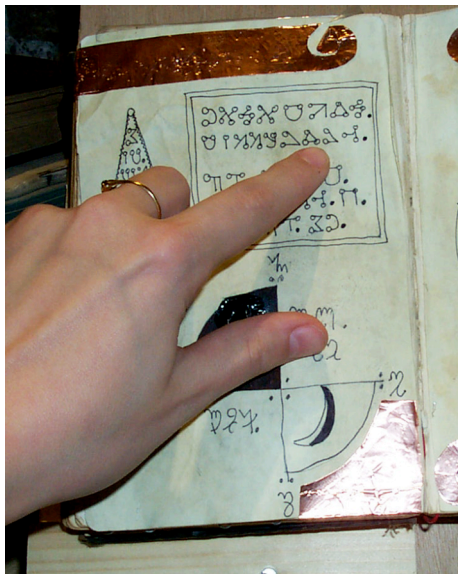

Fig. 3: A pressure sensor embedded within the pages in the book detects when the player touches the glyphs (as if reading them).

Once the book has been opened, the player can learn the magical spell it contains by either typing in the command "look at glyphs", as show in Example 2b, or by touching the glyphs in the physical book, as shown in Fig. 3. A sensor embedded within the pages of the book detects and notifies the MUD when pressure has been applied and subsequently the player has learned the *Formula of Light*.

```
--
> look
The dimly lit room, set in old brick and mortar, is lined with tall
wooden shelves that reach all the way to the ceiling. Many books and
manuscripts fill the shelves, most of them gathering thick layers of
dust. By one wall, just beneath one of the tall shelves, stand a desk
and a chair.
There is one obvious exit: west.
Atop the desk is a lamp (lit).
A tall stack of books is on the table.
There is an open book on a book-rest.
> look at book
It is open on a page showing ancient glyphs.
> look at glyphs
You study the glyphs and learn it is the Formula of Light.
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Example 2b: After the spell book has been discovered by the player, she can learn the spell "Formula of Light" by studying its glyphs.

Once the Formula of Light has been learned, the book can be used to turn the desk lamp on and off opening or closing the book, the idea being that the spell is invoked when the player opens the book. This functionality illustrates how one networked tangible object can affect another.

A note on Multi-User Dungeons

One of the great strengths of MUDs compared to graphical game environments is that they are easily customizable and expandable. Modifications can be done at run-time from within the MUD itself, and the flexibility and structure of the MUD driver cater for a continuous development of the game environment. Secondly, because interaction within MUDs is purely textual it is very easy to infer (i.e. parse) the players' actions and in the case of the tangible MUD map them to have an effect on physical objects. In using a MUD to implement our game we took advantage of these features (i.e. the powerful development process, and the relatively unambiguous nature of user's actions within the MUD), to create a demonstration of our vision of ubiquitous games, which was particularly powerful in its mapping between the physical room and the MUD room.

However, using a MUD as part of an interface to a ubiquitous game is somewhat limiting. A MUD is a game engine that is normally connects multiple people in remote and distributed locations. If specific locations in the MUD environment are mapped to specific locations in a physical environment, discrepancies will inevitably occur for those players that have a purely virtual game space, since they are unable to interact with the physical game space.

Discussion and Future Directions

Our goal is to design interfaces that allow physical objects that are new forms of game input controls and new channels for game output. The lamp and the book were the first object we implemented to illustrate how objects in the real world may be used not only to manipulate but also to embody computer games. The wizard's library in our demonstration is a limited demonstration of our ambition to create a distributed ubiquitous game environment. Even if the MUD offers a powerful back-end to our tangible computer game, it does not bring the player away from the desktop computer.

One compelling solution is to distribute the interface over a larger area to encourage players to explore the physical and social space and create a more engaging gaming experience. We are also considering designing a wearable object, possibly in the shape of a necklace or amulet equipped with a radio, or infrared, transceiver, through which communications between with the distributed interface can be established.

The Tangible MUD project presents us with some additional interaction design research questions that are interesting to address. In what ways can a ubiquitous game provide "sensory proof" of its reality? Graphical games use a metaphorical representation of the real world, complemented with sound and animations to create the interaction space. A tangible computer game uses the physical world as the medium for interaction, in which the sensory gratification could be further supported by a much wider array of interaction modalities. When game worlds are superimposed on the physical world, how do we as interaction designers create these new expressions of functionality so that they effectively resonate with the players'

engagement within it? What are the issues of scale in terms of deployment of such interfaces?

Conclusion

Whereas our knowledge of the physical world and the skills with which we engage in it are powerful facilitators to non-electronic gameplay, the virtual worlds generated in computers cater poorly for those skills. Clearly, computer game spaces do not allow for the same sophisticated sensory engagement, mainly because our means for interacting with the real world (our perception of space, sensory input, and even the psychology of non-electronic games) are transformed into abstractions in computer games. As computer game contexts begin to push beyond the digital domain and become pervasive aspects of everyday social spaces, the social interaction in those spaces will necessarily be affected. In the light of this, the Tangible MUD project is not only about researching the future of computer game design but also about interaction design.

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