Building Your Own Tangible Virtual World: a Design of an RFID-based Tabletop Game Platform

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***Abstract*—Augmented tabletop game is one genre of pervasive games which attempt to combine the advantages of both traditional game and computer game and to remedy their disadvantages by using the context-aware computing technology. In this paper, the design of an augmented tabletop game platform is introduced in detail. This platform uses an RFID reader matrix to satisfy the requirements of flexibility and programmability of developing augmented tabletop games. Based on this platform, augmented tabletop games can be developed by using the imagination and creativity of players. This platform is also designed for educational purposes.**

Keywords: Pervasive Game, Augmented Tabletop Game, RFID

I. INTRODUCTION

A. The concept of pervasive games

In the pre-computer age, traditional games were designed and played out in the physical world with real-world properties. Interactions in pre-computer games consisted human to physical-world interaction and human-to-human interaction [1]. Since the first electrical game PONG appeared occasionally in 1958, the electrical entertainment industry has been popular across the whole world. However, the development of computer games has often decreased the users' physical activities and social interactions.

New gaming experience comes from the innovation of the nature of game [2]. There is a growing trend in today's games to bring more physical movement and social interaction into games while still utilizing the benefits of computing and graphical systems. Thus, the real- world is coming back to computer game with a new gaming genre, referred to as *pervasive game*, which can supply players with both direct human-to-human interaction experience and the attraction of computer virtual domain experience.

B. Our objective: building your own tangible virtual world

Many research have been taken in the area of pervasive games, and so many technical demos and prototypes have been developed to illustrate the possibility of applying different technologies into the pervasive games. However, the focus of these demos and prototypes are the new technologies. What they want to study is how to make the game adapt to the technology. They don't firstly consider the enjoyment of the game, making the technology adapt to the design of the game.

The most funny and enjoyable ideas mostly come from the imagination and creation of human being. To get more enjoyment from pervasive games, we need to get use of human's creativity as much as possible. Thus, an easy-to-use development tool for players which can be used to develop pervasive games by themselves is significantly necessary.

Our objective is to explore a tool to encourage the effect of people's imagination and creation when developing the pervasive game. In this paper, we focus on one genre of pervasive games, the augmented tabletop game, to do our research. An RFID-based tabletop game platform was designed, which is flexible and programmable. On this platform, players can develop their own augmented tabletop games. Unlimited creativity can be used to show the infinite possibility in pervasive game design. Especially, we hope this platform can do some contribution on educational game design and serious game design, for example, the simulation of Bullwhip Effect, the competition of business strategy and the illustration of facility layout. A simple prototype was developed to illustrate the functions of the game platform.

II. CLASSIFICATION OF PERVASIVE GAMES

Magerkurth et al classified the pervasive games into five categories: augmented tabletop games, location-aware games, augmented reality games, smart toys and affective games [1].

A. Augmented tabletop games

The drawback to computer games is the lack of social interaction in a face-to-face setting, which tabletop games provide. At the same time, computer games offer the attractions of computer technology, which tabletop games lack. Therefore, it is natural for people to explore how to combine the benefits of computer and tabletop games into a novel type of game.

Recently, there are two directions for the research of augmented tabletop games.

The first direction follows the concept of ubiquitous computing [3]. The augmented tabletop games which designed based on this concept are called *Augmented*

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Traditional Tabletop Games. The main challenge of ubiquitous computing is to envision such unobtrusive smart environments that provide a reasonable advantage for people using it, without violating social and legal rules of our society and life [5]. Thus, augmented traditional tabletop games must involve three characteristics: unobtrusive integration, robust and social compatibility [6].

The other direction follows the concept of tangible user interface [4]. This type of augmented tabletop games is called *Tangible Digital Tabletop Games*. Compared to augmented traditional tabletop games, the mainly difference of tangible digital tabletop games is the digitally-augmented tabletop with embedded display (i.e. inside beamer under the table, top beamer above the table or LED display as the tabletop). In contrast to traditional tabletop, the digitally augmented tabletop can reflect the real-time situation of the game dynamically by tracking physical game pieces on the tabletop [7]. The tracking technologies range across optical, electromagnetic and acoustic approaches [8].

B. *Location-aware games*

While augmented tabletop games utilize pervasive computing technology to enrich physical game boards, another popular approach in the pervasive gaming field is to regard the entire world, the architecture we live in, as a game board. Technically, it is quite feasible to identify and track the positions of passive physical playing pieces on a handy game board. When an entire building, a block, or even a city becomes the game board and the human players themselves become the proactive and highly unpredictable playing pieces, a host of technical and conceptual challenges arise [11].

C. *Augmented reality games*

Augmented reality is a variation on virtual reality that draws virtual objects into a real-world environment. Users see their view augmented with 3D objects registered such that they appear to exist in real space.

In augmented reality games, players are not immersed in virtual content; rather, virtual elements are added to the real world. Augmented reality systems strive to track a user's full range of motion. This allows augmented reality games to use a wide range of physical interactions, including location, gesture, and posture. A limitation of the current technology is that while physical objects may affect virtual objects, it is more difficult to affect physical objects with virtual ones in augmented reality games[1].

D. *Smart Toys*

Augmented traditional toys with pervasive computing technology are the first, and not necessarily complicated, step towards the realization of pervasive games. Most current realizations include traditional physical toys equipped with simple sensing technology linked to computer logic. The logic reacts to changes in the toy's physical state by either playing sounds or displaying graphical information.

E. *Affective Games*

Affective games aims to integrate a player's emotional state into games so that game environment can adapt to create a magical game experience.

Sensing an individual's emotional state is a complex and open research issue; but sensing certain aspects of a player's experience while engaged in entertainment technologies is more manageable [9]. The most common approach to sensing an affective state is via sensors that measure the user's changing physiological activity. Skin surface sensors like those that measure galvanic skin response or activity in the cardiovascular, respiratory, and muscular systems can accurately measure physiological activity. Other methods for measuring affective states include thermal cameras [10], voice analysis, and facial expression analysis.

F. *Application of RFID in pervasive games*

Many technologies can be implemented to support the design of pervasive games. As we can see, RFID technology has comprehensively implemented in many augmented tabletop games and location-aware games.

The reason of choosing RFID technology is that RFID technology offers great possibilities for detecting and identifying objects. In the context of gaming applications, the major benefits are [6]:

1. The RFID can be hidden so works unobtrusively
2. The reading time is fast and the method is simple
3. The objects are almost maintenance-free
4. Players do not have to calibrate the equipment
5. Unique and unambiguously identifiable objects
6. No line-of-sight is required

III. SYSTEM DESIGN

The objective of this paper is to develop an augmented tabletop game platform, which is a hardware support for the development of *Augmented Traditional Tabletop Games*. Before this paper, some explorations have been taken in this field, such as Smart Playing Cards in 2002 [5], Smart Jigsaw Puzzle Assistant [12] and W41K in 2007 [6]. But all of these augmented tabletop games just integrated the existing games on market with the RFID technology. At the beginning of their designs, the compatibility and flexibility for new game development were not under their consideration. Different from the previous research, building an underlying augmented tabletop game system and infrastructure to support players to make their own game is our purpose.

Because of the benefits of RFID we mentioned above, we determined to use RFID as the auto identification technology embedded into our platform. Following functions were realized on the platform.

A. *Movement tracking*

The system can sense the position of the entities with enough accuracy on the platform, and can track the movement of the entities.

B. *Entity identification*

The platform must know the identity of every entity on the platform. For example, if we want to use this platform to develop a chess game, the system must know the identity of every chess piece on the game board. Is it a pawn, a knight or a queen? Also we know that in a Simulation Game (SLG), every game piece represents a character, and every character has its own attributes such as Hit Point, Magic Point and Speed.

C. *Entity interaction*

In a chess game, one chess piece can "eat" another, and in an SLG, one character can affect another (for example, one character can attack another, or two characters may make conversation). Thus, the tabletop game platform must have the function of making interaction among entities on the platform. The interaction was designed to be represented on the change of entities' existence and attributes. For example, in a chess game, when a knight "eats" a pawn, the assistant computer screen can show that the pawn disappears and the knight moves to the pawn's position. In a mediaeval SLG, a solider attacks another enemy, the enemy's hit point (one of attributes) may be reduced.

D. *Programmability*

One of the most important features of our game platform is programmability. The tabletop game platform was design as a development tool for the designers to develop various augmented tabletop games. The development environment of our game platform is Borland Delphi 7.0. Delphi is an object-oriented computer language which has powerful functions and many efficient and effective tools to support our research.

E. *Assistant GUI (Graphical User Interface)*

In our design, the assistant GUI was designed to provide game information when players are playing the game. The assistant GUI must offer four functions:

1) **Display function:** The assistant GUI must display the state of the whole game synchronously. For example, if we play chess game using the platform, the GUI can display a chessboard and the real-time movements of chess pieces on the screen. Also, the GUI can offer information of each entity on platform.

2) **Query function:** The GUI has the ability to query data, since the total information is not all useful for the player at every time.

3) **Error detection and backup function:** The system has the ability to detect errors during game play and also should have the ability to correct these mistakes, thus the backup function is necessary.

4) **Help function:** The GUI was designed to help the players play the game by displaying some hints.

IV. TECHNICAL ACHIEVEMENT

A. *Working principle of the game platform*

To actualize the functions of the tabletop game platform, a detailed design of working principle of the game platform is shown below.

In Figure 1, three physical parts (Player, Entity and Auto-Identification Device) and three informational parts (Tracking Program, Control Program and Database) compose the entire system. Each part interacts with other parts with physical movements or data flows.

(1) *Player* to *Entity*:

When playing, players can interact with the entities on the platform the same as the traditional tabletop game.

(2) *Entity* to *Auto-Identification Device*

The auto-identification device can sense the identity of each entity on the platform, track their movement and record their positions on the platform.

(3) *Auto-Identification Device* to *Track Program*

The track program sends different commands to devices and receives the feedback data from them.

(4) *Track Program* to *Control Program*

After receiving the feedback data from devices, the track program sends the data to control program. On the other side, the control program used the track program to send commands to devices.

(5) *Control Program* to *Player*

The control program offers players visual and audio information through the assistant GUI, while players use the mouse, keyboard or other control devices to use the function of display, query and help.

(6) *Control Program* to *DataBase*

Almost all of the information is stored in the DataBase. The control program reads the data from the database and revises them when necessary.

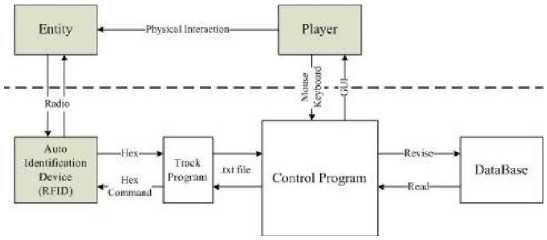

Figure 1. Working principle of the game platform

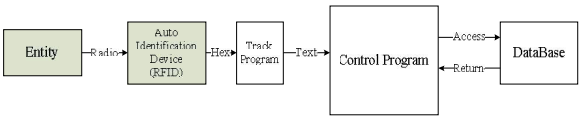

Figure 2. Workflow of identifying entities

B. *Realization of identifying function*

Fig. 2 shows the workflow of identifying entities. Every RFID tag has its own unique serial number, thus we can use this serial number as an ID to represent the entity. Whenever the track program sends a 'Finding Tag' command to the readers, if the RFID reader senses an active RFID tag in its sensing scope, it will return the serial number of the active tag to the track program. Then the track program converts the results into a text file. According to this file, the control program can know the situation of the game at that time. The control program then accesses the database according to the active serial number. At last, the control program will find the identity and the attributes of the entity on the platform by querying the database.

C. *Realization of tracking function*

Two different methods can be used to tack the movement of entities on the platform: time driven method and event driven method.

Time driven method

In time driven method, the system scans the platform in a certain time interval (e.g. 0.1s) and reflect the change of game play. This method is adequate for those games which require real time reflection very much, such as Bomber Man.

Event driven method

In event driven method, the system only scans the platform when an event occurs (e.g. clicking a button). This method is adequate for games played in turns, such as chess, card game and simulation games.

The choosing of methods depends on game style. 500 milliseconds delay time is unacceptable for Bomber Man, but maybe quite okay for chess game on our game platform.

D. *Design of the physical interface*

The platform is divided into different square grids, which are 6 grids by 6 grids. RFID readers are installed under each grid. Each entity is tagged with RFID tag. We give every grid a two-dimensional coordinate, which can help to describe the position of entities on the platform. Since every grid has an RFID reader which has a unique device ID under the grid, the device ID and the coordinate of the grid is one-to-one relationship. See Fig. 3.

The platform is divided into 4 small separate squares whose sizes are 3grids×3 grids. On one hand, both power supply PCB and data transmission PCB can connect only nine RFID readers. On the other, the smaller size of reader matrix makes connection and error detection easier.

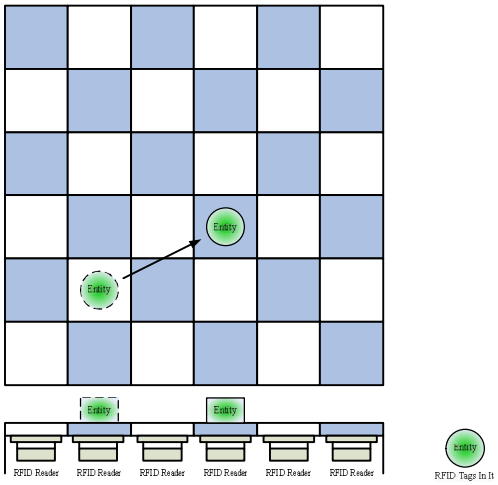

Figure 3. Design of the physical interface

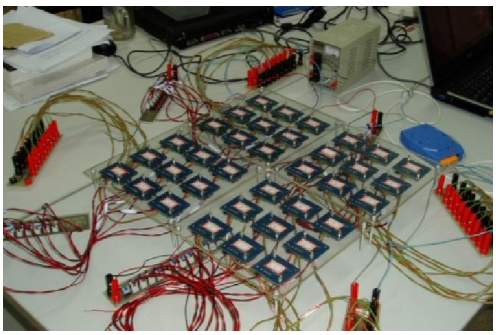

Figure 4. Final prototype of the game platform

Fig. 4 is the figure of the finished prototype of the game platform.

V. CONCLUSION AND OUTLOOK

Traditional games and computer games are both very important forms of entertainment in people's daily life. Traditional games give players the experience of human to physical-world interaction and human to human interaction, while computer games supply colorful video and audio contents for players and make them immerse into a virtual game world.

The exploration of pervasive games leads a way to combine the advantages of these two types of games. Augmented tabletop game is one genre of pervasive games. In recent year, many people are interested in this idea and many experiments have been made. Different technologies are applied in these games under the idea of augmented tabletop game. However, many of the research are making games adapt to technologies, other than making technologies adapt to games. We want to explore the way to get use of human's creativity as much as possible by developing an augmented tabletop game platform.

In this paper, an RFID-based tabletop game platform

was designed, which is flexible and programmable for players to develop their own augmented tabletop games.

We used the high frequency RFID readers and tags to realize the specific functions of this game platform. Difficulties on making this platform are the selection of appropriate RFID product and parameters. Now, the long delay time of the game system is what we need to overcome in the next stage.

In the future, we plan to use this game platform to develop some augmented tabletop applications for educational purposes. A simulation tool for the teaching of facility layout is on schedule. More funny creations are under consideration.

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