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A design of augmented tabletop game based on RFID technology

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Abstract

Context-aware technology provides a potential to interact between real physical world and virtual information space more directly and naturally, which can improve efficiency and user experience. This paper introduces an exploration of integrating context-aware technology into traditional game, aiming at offering players innovative playing experience. One kind of context-aware technology, namely RFID, and one genre of traditional game, namely tabletop game, were selected to combine together to develop a new genre of game, called Augmented Tabletop Game. The procedure of user-centered design (UCD) was applied during the development. Firstly, player requirements were surveyed and analyzed. And then we determined which functions of RFID could be augmented into the traditional tabletop game, making the game different and more enjoyable. After that, specific game rules and a low fidelity prototype were designed for a usability evaluation, in which six experienced players were invited to do the heuristic evaluation. Finally, a high fidelity prototype was implemented, including game board, control panel, game pieces, graphical/audio output device and data process center, based on the improvements of low fidelity prototype.

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Keywords: Augmented tabletop game; Context-aware technology; RFID; User-centered design

1. Introduction

Context-aware technologies, such as Wifi, RFID, GPS and Motion Sensing, sense status of users and their ambient environment to offer users useful information based on the sensing data. The application of context-aware technology provides a potential for people to interact between real physical world and virtual information space more directly and naturally. Many studies were conducted on how to utilize this feature of context-aware technology

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to offer more efficient interaction and better user experience in many domains, such as driving, education and entertainment.

Game is also a very important domain for the application of context-aware technology. As we can see, today there are two main categories of game, traditional game and digital game. Traditional game is played in real physical world with other persons, whose history can be traced back to as early as 2600BC. The rich tangible experience and social interactions are sources of enjoyment for players. In the twentieth century, the invention of computer developed digital game. In digital game, players interact with virtual information space and immerse into fantastic virtual world.

The exciting feature of context-aware technology inspires game designers to explore the possibility that the game play in real physical world and virtual information space can be merged together to create novel playing experience. Today there are two orientations to explore how to merge real physical world and virtual information space together in game play.

The first orientation brings the social and tangible elements of traditional game into digital game. This orientation was firstly addressed by Ishii as the concept of "Tangible user interface" [1], in which a digitally-augmented tabletop with embedded display was developed. The digitally-augmented tabletop can reflect the real-time situations of the game dynamically by tracking the physical game pieces on tabletop [2]. The tracking technologies range across optical, electromagnetic and acoustic approaches [3]. Many research have been carried on the development of digitally-augmented tabletop [3-7] and some mature products have been launched into entertainment market, such as Microsoft Surface [8], Wii, PS Move and Kinect. These products free players from traditional controllers and enable them to use their postures to interact with system. However, users of above products still mainly interact in virtual information space via screen.

The second orientation, which follows the concept of "Ubiquitous computing" [9], integrates digital devices into traditional game, offering players extra information and bringing appealing graphical and audio experience. The Smart Playing Cards [10] and The Smart Jigsaw Puzzle Assistant [11] are two very interesting prototypes to augment traditional card game and traditional Jigsaw puzzle. Both of them use RFID as unobtrusive embedded technology to offer players graphical and acoustic interactions. The augmented game environment W41k is based on a very popular tabletop miniature war game, to automatically determine the attributes of game objects on game board [12]. Compared with the first orientation, the progress of the second orientation is not so advanced. Many research have been still in the phase of concept design or prototype.

The objective of this paper is to explore how to integrate context-aware technology into traditional game and offer novel playing experience to players. Design of game is under the procedures of user-centered design. And a high fidelity prototype is to be developed as a platform for further usability study.

2. Game and context-aware technology

In this paper we selected tabletop game as the foundation of our game, concerning with the factors of flexibility, popularity and technology coherence to develop an augmented game with context-aware technology. Compared with other genre of traditional games, tabletop game requires less space. The number of players and playing duration can be changed flexibly according to real situation. Tabletop game is so popular that it is easy to find experienced players. Since we augmented tabletop game with context-aware technology, our game can be called "Augmented Tabletop Game".

Many types of context-aware technology can be implemented to support the design of augmented tabletop game. As we can see, RFID technology has comprehensively implemented in many research. The major benefits of RFID [13] are as followed: (1) the technology can be hidden and thus works unobtrusively; (2) the reading time is fast and the reading method is simple; (3) the objects are almost maintenance-free; (4) the players do not have tocalibrate the equipment; (5) each game object is uniquely and unambiguously identifiable; (6) no line-of-sight is required.

After determining the integration of tabletop game and RFID technology, we planned to follow procedure of user-centered design (UCD) to develop our augmented tabletop game. UCD is a design philosophy and a process in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage of the design procedures [14]. In this paper, we firstly analyzed users' requirements of traditional tabletop game in order to determine the potential augmented functions by RFID. In second step a low fidelity prototype was developed and a

heuristic evaluation was carried out to find usability problems of the low fidelity prototype. In the last step we finally implemented the improved high fidelity prototype by developing the software and hardware system.

3. User requirement analysis

User requirement analysis is the first step of UCD. We need to analyze the advantages and disadvantages of traditional tabletop games and determine the augmented functions in our augmented game.

In order to understand players' playing experience and requirements of traditional tabletop game, we observed and interviewed several experienced players, who are skilled at different types of tabletop games, including trading card game, table RPG, tabletop miniature war game and board game. Generally, players thought that traditional tabletop game owns the following advantages:

- Plenty of human-to-human interactions, including verbal and nonverbal ones. During the game play there are many social activities irrelevant to the game, these activities are the main source of enjoyment for players, instead of the game itself.
- Elegant game pieces, which can give players aesthetic feeling. For instance, in Magic the gathering, many figures on the cards are designed by very famous artist and so beautiful.
- Fun of DIY. In some tabletop game, players must purchase and paint the units they control. The different appearances of the units representthe own preference of players.
- Flexible rules. The maximum creation and innovation of players can be stimulated. Players can create and change the rules dynamically. The best example is Porker, which is uniform worldwide but has millions of playing rules.

During our analysis, we also found some disadvantages of traditional tabletop game, which have negative impact on players when playing:

- Some tabletop games have complex game rules, which require long time to study. The typical example is table RPG. Players usually need to remember many rules before actually involving into the world of the game. The complex rules lead table RPG very hard to have fast popularization.
- The memory workload of players sometimes may be so high that players may make mistakes in game. Since in most tabletop game, during the development of game play, more and more information requires to be remembered and mistakes occur inevitably because of forgetting something.
- The parameters of game play can seldom be changed after the design of game. Extension packs of the game must be designed to satisfy players' curiosity when experiencing the game.

The analysis of user requirements can help us determine what augmented functions should be designed. We hoped that our augmented tabletop game can keep the positive characteristics and meanwhile remove the negative ones of traditional tabletop game with help of RFID technology. Below are some potential functions we planned to add in our augmented tabletop game.

- Players can receive hints at each step of playing.
- Some crucial parameters of the game would fluctuate or change dynamically in each turn or each game.
- Some "incidents" may happen randomly during the game to influence the game process.
- Players can review their real-time actions and statements.
- Some calculations in the game can be done automatically.

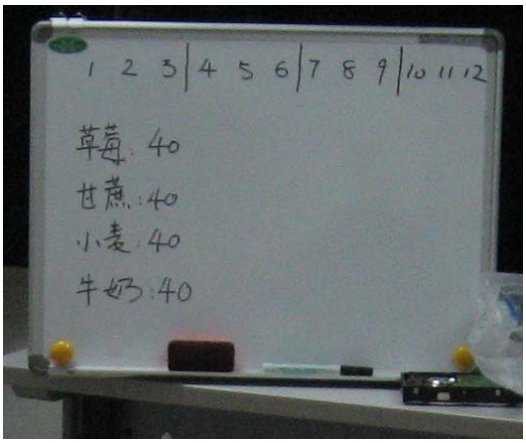

Fig. 1. Usingawhiteboardtodisplaygamestatementinlowfidelityprototype.

4. Development of low fidelity prototype

After determining the augmented functions, the next step was designing a concrete tabletop game and building a low fidelity prototype for heuristic evaluation.

A turn-based board game with game board, game pieces and assistant GUI was designed. We refereed some successful board game, such as Monopoly and The setters of catan, to develop the game rules and added the augmented functions in our game.

In our game, at most four players can play together as competitive merchants, whose target is to earn most money in certain time. Players need to manage their own food business in an entire supply chain, including producing raw materials, selling final products, building workshops, extending inventory, making sales strategy and negotiating with other players. Here are some game rules representing the augmented functions in our game:

The major objective of this step was evaluating the usability of our game and finding usability problems. Thus, the augmented functions of context-aware technology were substituted by other means manually. For instance, we used a white board and wrote players' statement manually on the blackboard manually (see Fig. 1), in order to imitate the real assistant GUI in our game. The game pieces were also represented by using printed paper.

5. Heuristic evaluation and development of high fidelity prototype

During the heuristic evaluation, we invited two experienced players and four experts in HCI to experience our low fidelity prototype. They were divided into two groups. Each group played together. During game play, they can discuss with each, present opinions about the usability problems of this prototype and offer suggestions. One experimenter also joined this test, whose job was recording opinions of experts and answering their questions. After game play, these six experts gathered together to share and discuss their experiences and opinions.

And then we improved the detailed game rules of our augmented tabletop game according to the heuristic evaluation. 20 usability problems were summarized and 24 improvements were applied.

The last step of UCD was implementation of high fidelity prototype (see Fig. 2). In this step, we must design the technical solution of integrating RFID technology into our tabletop game. We needed to develop the entire hardware system and run the game on this system. Below was an introduction about the hardware implementation (see Fig. 3) and the design of control procedure (see Fig. 4).

Fig. 2. High fidelity prototype.

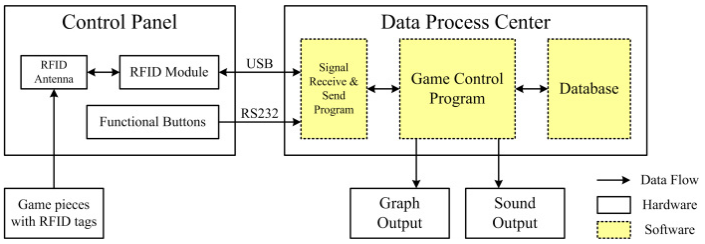

Fig. 3. Hardware connection in the system.

- *Game Pieces:* All game pieces were attached with RFID tags, which contain the detailed attributes of this game pieces such as serial number, name, amount and so forth.
- *RFID Module:* In our augmented tabletop game, the real-time statement of players can be reviewed, which means that the RFID module requires to sense multiple objects at the same time. The ultra-high frequency RFID module was selected with the size of 53mm*63mm and the RIFD antenna with the size of 50mm*50mm.
- *Game Board And Control Panels:* The RFID modules were designed to install into the game board and control panels. Besides the RFID modules, some functional buttons were also installed on the control panel to achieve some interactions during the game. The Game board and control panels were all connected via USB cables to a backend data process center, which we achieved by a PC.
- *Assistant GUI:* An LED display was used to be the graphical output in our augmented tabletop game.

In order to use the RFID technology to detect each step of players' actions in the game and reflect the real-time statements of players, we designed a complete control procedure for our augmented tabletop game, which will be described below.

- *System initialization:*This step is to initialize the hardware and the data of the entire system.
- *Trigger the functional button:*When player presses a functional button, a signal will be sent to the backend data process center.
- *Run the relevant function:*When receiving a signal, the backend data process center will run a relevant function.
- *Activate RFID modules:*The RFID modules are activated by backend data process center.
- *Execute operation:*When detecting the existing game pieces on game board or control panels, the backend data process center will confirm the operations from players. If players press the "Yes" button, the statement of players will change real-time. If players press the "Cancel" button, all data will restore to previous step.
- *Modify data from database:*After a confirmation of operation, the change of statement will be record to the database in backend data process center.
- *Graphical feedback:*The change of statement will be present in the assistant GUI dynamically.
- *End function:*The function is ended. The whole system is waiting player to press the functional buttons another time.

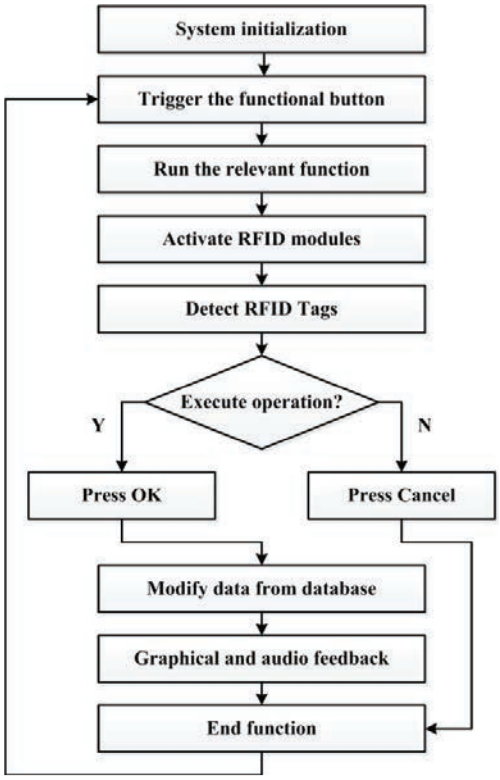

Fig. 4. Control procedures.

6. Conclusion

Merging real physical world and virtual information space together is an exciting topic to researchers. In this paper, we followed the procedure of user-centered design to develop an augmented tabletop game, which was planned to offer players novel playing experience by integrating context-aware technology into traditional game.

The concept of ubiquitous computing represents us such picture that in the future, with the development of information technology, computers will finally be integrated into almost everything unobtrusively. The real physical world and the virtual information space will totally merge together. The design of our augmented tabletop game gives a helpful trial to explore the use scenario in the period of ubiquitous computing. Further study will be focused on evaluating the usability, namely, playability of our augmented tabletop game.

References

[1] Ishii, H., et al. PingPongPlus: design of an athletic-tangible interface for computer-supported cooperative play. in Proceedings of the SIGCHI conference on Human Factors in Computing Systems. 1999. ACM.

[2] van den Hoven, E. and A. Mazalek. Tangible play: research and design for tangible and tabletop games. in International Conference on Intelligent User Interfaces: Proceedings of the 12 th international conference on Intelligent user interfaces. 2007. Citeseer.

[3] Klemmer, S.R., et al. Where do web sites come from?: capturing and interacting with design history. in Proceedings of the SIGCHI conference on Human factors in computing systems. 2002. ACM.

[4] Mandryk, R.L. and D.S. Maranan. False prophets: exploring hybrid board/video games. in CHI'02 extended abstracts on Human factors in computing systems. 2002. ACM.

[5] Leitner, J., et al. IncreTable, a mixed reality tabletop game experience. in Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology. 2008. ACM.

[6] Radgohar, M., F. Evéquoz, and D. Lalanne. Phong: augmenting virtual and real gaming experience. in demo paper, 19th ACM Symposium on User Interface Software and Technology, UIST. 2006. Citeseer.
[7] Tse, E., et al., Multimodal multiplayer tabletop gaming. Computers in Entertainment (CIE), 2007. 5(2): p. 12.
[8] Banes, D., Microsoft Surface-a new approach to access and technology. Journal of Assistive Technologies, 2009. 3(1): p. 29-31.
[9] Weiser, M., The computer for the 21st century. Scientific american, 1991. 265(3): p. 94-104.
[10] Römer, K. and S. Domnitcheva, Smart playing cards: A ubiquitous computing game. Personal and Ubiquitous Computing, 2002. 6(5-6): p. 371-377.
[11] Bohn, J. The smart jigsaw puzzle assistant: Using RFID technology for building augmented real-world games. in Workshop on Gaming Applications in Pervasive Computing Environments at Pervasive. 2004.
[12] Hinske, S. and M. Langheinrich. W41K: digitally augmenting traditional game environments. in Proceedings of the 3rd international Conference on Tangible and Embedded interaction. 2009. ACM.
[13] Hinske, S. and M. Langheinrich, An RFID-based infrastructure for automatically determining the position and orientation of game objects in tabletop games. Concepts and Technologies for Pervasive Games-A Reader for Pervasive Gaming Research, 2007. 1: p. 311-336.
[14] Abras, C., D. Maloney-Krichmar, and J. Preece, User-centered design. Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications, 2004. 37(4): p. 445-456.