ABSTRACT
While pervasive technologies explore new gaming styles, traditional games, such as cards and tabletop games are still appealing and have various irreplaceable flavors. We point out that tangible game objects and spatial interactions amplify emotional impacts in gaming; and the advantage cannot be reproduced in completely digitalized games. Thus we propose the concept of augmented traditional games, which aims at extending game features without losing original look-and-feel. In this paper, we introduce a case study on augmenting the game of Go. Our prototype supports several game modes, for example, a self-training mode for beginners. Based on an experimental study with the prototype, we discuss human factor issues in game design. We also suggest an augmentation framework for a wider range of traditional games as future work.

Author Keywords
Augmented reality, entertainment computing, tangible interaction.

ACM Classification Keywords
K.8.0 [Personal Computing]: General – Games; H5.1 [Information Interfaces and Presentation]: Multimedia Information Systems – Artificial, augmented, and virtual realities.

General Terms
Design, Human Factors

INTRODUCTION
The rapid growth of information and communication technology has given us brand-new user experiences in games. Recent game terminals have high performance CPUs and improved the reality of game applications. Keypads are not sole game consoles any more, and new game consoles utilizing motion sensors such as Nintendo Wii are gaining users who are not familiar with video games. Moreover, high-speed network enables users to compete or cooperate with other players in real-time. Upon these technologies, a new game domain called pervasive games is getting realized today [5]. For example, augmented reality is one appealing feature. Moreover, several new game environments have been developed with extending physical interactions [1].

Most pervasive games aim at exploring new gaming concepts, even though traditional games (e.g., card games, chess, billiards etc) are familiar and still appealing to us. Traditional games offer joy and excitement with irreplaceable flavors, e.g., social communication with sharing atmosphere and tangible interaction to game objects. Today we can enjoy traditional games on networked computers (e.g., online poker), but they are completely digitalized and as a result some of the aforementioned irreplaceable values are lost. Thus, instead of making digitalized ones, we propose an approach to augmented reality games design that aims at keeping the flavor of traditional games.

In this paper, we introduce a case study of traditional game augmentation. As the game we chose the ancient game of Go1. A physical Go board was augmented with visual feedback from a projector in order to support the players with various game-related information, such as hints and warnings. Based on the study, we discuss human factor issues for game augmentation and implicate future work towards more generalized framework implementation.

AUGMENTING TRADITIONAL GAMES
Hinske, et al. pointed out two advantages of traditional games: the socializing aspects and the interaction with the physical world [4]. Usually players gather around a single table and directly share experiences in real-time. It smoothens social communication and amplifies the excitement caused by the game. Digitally networked communication can enable users to simultaneously experience events, but some of important flavors (e.g., facial expression, the shakes caused by thrill) are lost through the indirect communication.

Moreover, traditional games offer tangible interactions to game objects (e.g., darts, playing cards, Go stones). Tangible interactions enable players to sense several kinds of information, even though they are not necessarily related

---

1  vn (Go) or 囲棋 (Igo) in Japanese
to the game itself. For example, one of important factors to evaluate other players’ mental condition is pace. In digitalized games, a player’s actions such as selecting cards in poker and putting Go stones on the board can be instantly performed with a single mouse click. There are certain distance between objects and players in physical games, thus it allows players to observe the duration spent for an action and get an idea of what the other player is thinking. Moreover, tactile interactions amplify expectation to uncertain things and the excitement caused by achieving a goal. For example, in mahjong, players cannot know what kind of mahjong tile will be drawn in the next turn, since the tiles are ordered on the table as walls (Figure 1).

During tile drawing motion (i.e., moving a tile from the wall to the player’s area), the player’s attention is drawn to the tile and expectation gets increased as the mark of the tile is gradually revealed. Skillful players can even recognize tiles by just feeling the surface of the tile. Therefore, the distance between the wall and the player’s area can be considered to make the most exciting moment of the game play. This advantage of tangible interaction cannot be reproduced in digitalized mahjong games.

We consider this most important factor of traditional games as *Ma* (間); Japanese word that represents distances among objects in a space. Ma is originally used in art and design, but it also can be used in a wider range of domains, such as martial arts and theatrical performances. In martial arts, players adjust distance to an opponent in order to keep their own territory to take good offence and defense. In theatrical performances, actors and actresses coordinate the timing of actions in order to make greater impression to audiences. Ma includes concepts of spatial distance, gap and pause, so both physical and mental distances among game objects including human players can be represented in this single word. At the same time, it is hard to reproduce Ma in digitalized games, since Ma is total information that players perceive in tangible interactions.

While digitalization causes the loss of the aforementioned advantages, pervasive computing technologies can support various aspects of traditional games [4]. For example, beginner players cannot recognize game situations as skillfully as experienced players. Thus, in order to avoid careless mistakes, it is helpful to superimpose valuable information that the beginner might be missing on the game board. It is also possible to record game events without manual observation, which facilitates repeating and reviewing the game for self-training.

In this paper, we propose an approach to augmenting traditional games in a way that preserves Ma by keeping the traditional look-and-feel of the game. Basically players can enjoy the game in a conventional style. If the player activates pervasive gaming features, game mode switches to support augmented interactions. As a case study, we augmented the game of Go and implemented several modes to support beginners’ playing and training. In the next section, we introduce our augmented Go game and its features.

**GO AUGMENTATION**

Go is a traditional board game for two players, where the objective is to occupy a larger portion of the board than the opponent. Black and white stones are used to control the territory and a board with a grid of 19 x 19 lines is used as the game field. The rules of Go are relatively simple, but the underlying strategies are extremely complex and rich. As in chess and reversi, numerous set sequences and strategies have been invented to reduce the complexity, but studying them requires the player to actually understand the strategic concepts. Thus, it takes a long time for beginners to do well against experienced opponents.

**Figure 1. Mahjong table and tile layout**

**Figure 2. Augmented Go setup**
Our augmented Go application supports several gaming modes in addition to normal play. The basic idea is to provide valuable information to beginners without additional interactions and devices. Figure 2 shows the instruments setup for our augmented Go application. In this prototype, feedback is provided visually by superimposing guiding information onto the Go board with a projector. A web camera connected to a PC is used to detect the position of the Go stones. Figure 3 illustrates the system architecture of our augmented Go application.

Match mode
Match mode represents the original concept of Go augmentation. In this mode, two players play Go as usual, but valuable information appears on the board to help beginners recognize the situation and make better decisions. The rules of Go are simple, but the vast number of possible moves in each turn makes it hard for beginners to make decisions. Moreover, on the large 19x19 board, beginners tend to concentrate on localized fighting and overlook the big picture in the process. It is difficult to recognize invaded areas, since an invasion process gradually progresses as new stones are put on the board. For choosing good offense and defense strategies, recognizing the links between the Go stones is important, but it requires experience.

Moreover, the match mode visualizes the strength of links between the Go stones. As shown in Figure 4, same-colored stones are connected with a line. The thicker line indicates a stronger link. Moreover, if a dangerous situation occurs somewhere on the board, a warning message appears to draw the player’s attention there to avoid losing the area. In addition, this mode supports stone position recording, so the players can review the match and discuss the efficiency of their strategy.

Kifu mode
Kifu (棋譜) means the record of stone moves, usually made in professional matches. One good self-training method is to repeat the sequences on the board and study professional players’ thoughts and strategies. In the conventional way, users have to hold a Kifu book to check the record, which makes it more difficult to concentrate on the board. Moreover, Kifu are usually written in a compressed format, which makes it difficult to recognize intuitionally. Thus in Kifu mode, the application visually indicates the position of the next stone, along with comments on the strategy. Users can follow the sequence without other materials, and train themselves by just interacting with the board.

Joseki mode
Joseki (定石) means a set sequence or common pattern that is frequently used in matches. Joseki awareness helps the players to shift the set sequence to fit one's own strategy or improvise when the sequence seems to favor the opponent. In this mode, a player can learn Joseki by interacting with the board. At first, the application show virtual stones on the board, but gradually decreases the number of visible stones as the sequence proceeds. This helps the player to remember the pattern and use it in actual matches.

Tsumego mode
Tsumego (詰碁) is a type of exercise where the user is presented with a game situation, usually with the objective of finding the best sequence of moves in the given situation. In this mode, the positions of the stones are visualized on the board. Players can try out different moves by placing

---

The augmented Go application supports four gaming modes: Match mode, Kifu mode, Joseki mode and Tsumego mode. In the following sections we explain each mode and how players interact with the Go application.
stones on the board, whereas the result and comments explaining key points are displayed as visual feedback.

As shown in these modes, the advantage of our approach is to allow players to get information through the original interaction offered by the Go board and the stones. By superimposing information onto the board, players can concentrate on the match at hand or self-training without fragmenting their attention towards an instructional book and etc. This is important to make it possible for the players to allocate enough cognitive resources for recognizing the situations in the game. Using original game items as the basis preserves Ma and traditional look-and-feel, such as distance between players, touch of a wooden board and sound of stones.

In the next section, we discuss human factor issues based on findings in the prototype development. Then we indicate future directions towards realizing a more generalized framework for traditional game augmentation.

**DISCUSSION AND FUTUREWORK**

In the rapid prototyping, we noticed feedback design is important aspect to consider, since it is tightly linked with human factor issues. In order to keep the traditional look-and-feel as much as possible, we should allow them to concentrate on the game, instead of disrupting them. Thus, timing, modality and the complexity of information should be sufficiently considered in the design process in order to offer well-managed feedbacks. Cognitive workload is one key criterion to evaluate traditional game augmentation.

Another issue is the accuracy of object tracking. Since we put importance on keeping Ma, originally used game items should be used without changing their look-and-feel. Moreover, since the players should not be forced to perform additional interactions in order to capture game status, passive observation is preferred in our augmentation concept. However, since the difficulty of object tracking depends on the game, a general approach that covers several kinds of games is difficult to realize. For example, in mahjong, where the tiles are piled as a wall, tag-based positioning analysis is not useful. Visual analysis might be an effective approach, but unique visual tags cannot be printed since players should not be able to identify them from their appearance. Thus, invisible markers are expected to be common, but it increases setup cost since the number of mahjong tiles is 136 in total and they are too small for printing distinguishable markers on the side.

In future work, we augment other traditional games in order to study these human factor issues and overcome technical limitations. Then we establish a framework and a guideline for traditional game augmentation.

**RELATED WORK**

In [1], Christian et al. introduced a computer-augmented card game. RFID tags embedded into cards are used to capture the game state; and players can check scores and advice with their mobile phone. Since card games are incomplete-information game, personal devices such as mobile phones are useful for giving each user individual feedback. However, as discussed in the paper, mobile phones also require visual attention and it leads to distraction from the game since players wanted to check system behavior and possible errors. Thus audio feedback might be useful to make lightweight feedback when simple notification should be given (e.g., confirmation of object tracking status).

In [2], Cooper et al. augmented one traditional game called Chinese Checkers to investigate user interface issues for tabletop augmented reality entertainment applications. Original game items are completely replaced with digital devices and players manipulate virtual objects on a large display with an augmented reality marker. Even though their approach loses the advantages of traditional games we pointed out, unified interaction style for a wider range of applications is useful in some cases. Moreover, they introduced Passive detection framework, which is an object recognition infrastructure for pervasive services in a meeting room environment. Having a single setup for multiple games is important for decreasing the installation cost and increasing the availability of the framework.

**REFERENCES**