Going through digital versus physical augmented gaming

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ABSTRACT
This paper presents three systems that explore the use of tangible user interfaces to enhance gaming experience and physical interaction with digital information. TJass is an augmented reality game that extends regular card playing, without modifying players' habits, with computational supports, in particular with a learning by trial assistant. Elcano is an augmented virtuality system, augmenting digital multimedia information management with physical access and allowing the creation of multimedia albums that can be associated to tagged personal objects. Finally, Phong is a mixed reality game, which uses localization of objects as a solution to augment the players' physical implication in the digital board. The paper presents the three systems and briefly presents the lessons learned from their implementation and user evaluations.

Author Keywords
Tangible Interfaces, Augmented Reality, Mixed Reality, Tabletop Games

ACM Classification Keywords
H5.2. User Interfaces.

INTRODUCTION
Mixed reality games, as illustrated in this article, can augment various aspects of games purely digital (collaboration, socialization, communication, cognitive load) and also games purely physical (flexibility, assistance, modalities of interaction). The challenge of mixed reality games is first to take the best of each world to create an augmented gaming experience and further to create novel paradigms of interaction that are superior to just their sum.

This paper presents three systems we developed that explore three paradigms of interaction: the systems *TJass* [5], an *augmented reality* game that extends regular card playing; *Elcano* [1], an *augmented virtuality* system that allows tangible browsing of personal information; and finally, *Phong* [6], a *mixed reality* pong game, combining augmented reality and augmented virtuality to augment gaming experience.

AUGMENTED REALITY: TJASS, A SMART BOARD FOR AUGMENTING CARD GAME PLAYING AND LEARNING
The goal of Tjass [5] is to extend card gaming with computational aids in a non intrusive and transparent way to support both beginner and expert players and to enrich their gaming experience. In comparison to another similar system mentioned in [7], which uses TFT display, the output devices in Tjass are designed for a maximum transparency and a minimum intrusiveness. Furthermore, while help is provided by a relative external PDA in the Smart Playing Cards project [7], Tjass beginner's assistance is directly available on the game board. In the traditional jass card game the players have to count and notate manually the scores. As well they need to observe continuously the status of the score to determine the winner team. In addition the rules of jass are complex and require keeping in mind the overview of all played and remaining cards. Therefore beginners often have difficulties to learn the game. Tjass will disburden the players of these tasks by (1) counting and displaying the score automatically in real time and (2) putting at beginner's disposal a decision assistance to teach them the game.

TJass avoids the use of mouse, keyboard and monitor, in order to preserve card players' habits and guarantee non-intrusiveness. Instead an augmented game board and real cards have been preferred. Tjass design has been guided by this motto, augmenting gaming experience without modifying players' traditions. Each card is marked by an RFID tag that identifies it uniquely (Fig. 2d). An RFID reader is then used for card identification and game observation. The Tagsys Medio L200 RFID Reader [8] middle range reader that we used is designed for 3D and volume detection applications. The reader is able to read a high number of tags simultaneously. At the distribution phase, the timesharing between the four antennas is done by tickets which correspond to missing cards. The more tickets an antenna owns, the longer time it is active. At the playing phase, the active player's antenna has a higher reading priority than the others, which optimizes tag reading performance. Physical devices built using Phidgets [2] are used for additional interaction during the game. Fig. 2a

illustrates the setup of Tjass. On each side of the table resides a player. Each of the 4 players is supported by one antenna which is attached under the table right in front of him (Fig. 2c). The card detection zones for the players are marked in Fig. 2a. The playing zone is the square in the middle of the table. To get into that zone each card passes through the sensor field of an antenna. This feature guarantees habitual playing comportment like in the traditional jass. To help the players know who shall play, the yellow led in front of the active player will blink. If a played card is valid according to the rules of jass, the green led lights up and a discrete sound is played. If the card is not valid, the red light will blink and the player should play another card. This prevents mistakes and denounces cheating attempts. Other sonorous outputs acknowledge for several events like announces, end of game or trump selection. Another RFID reader, a single tag short distance reader, allows users to define the trump color in a tangible way by putting trump tokens on the antenna. When a round is finished, the points are calculated and added to the score. The round points and the global score are then shown on each player's LCD (Figure 2a). In addition, to provide a constant score overview, the score needle (Figure 2e) of each team, animated by motors, increases in real time to give a tangible visual output. Decision support can be obtained pressing the help button (Fig. 2a). The button is useful to check if a card is optimal, good, miserable or denied to play, which is indicated by a multicolor led. For this, the button has to be pressed while the card to be tested is passed over the sensor field. Thus the game can be learned by playing the game itself, following a "trial and error" concept. Finally, the system is modular and thus allows rapid prototyping of card games (poker, Bridge, etc.) since it is based upon a framework that manages input and output interfaces, e.g. phidgets, RFID readers, sounds, etc.

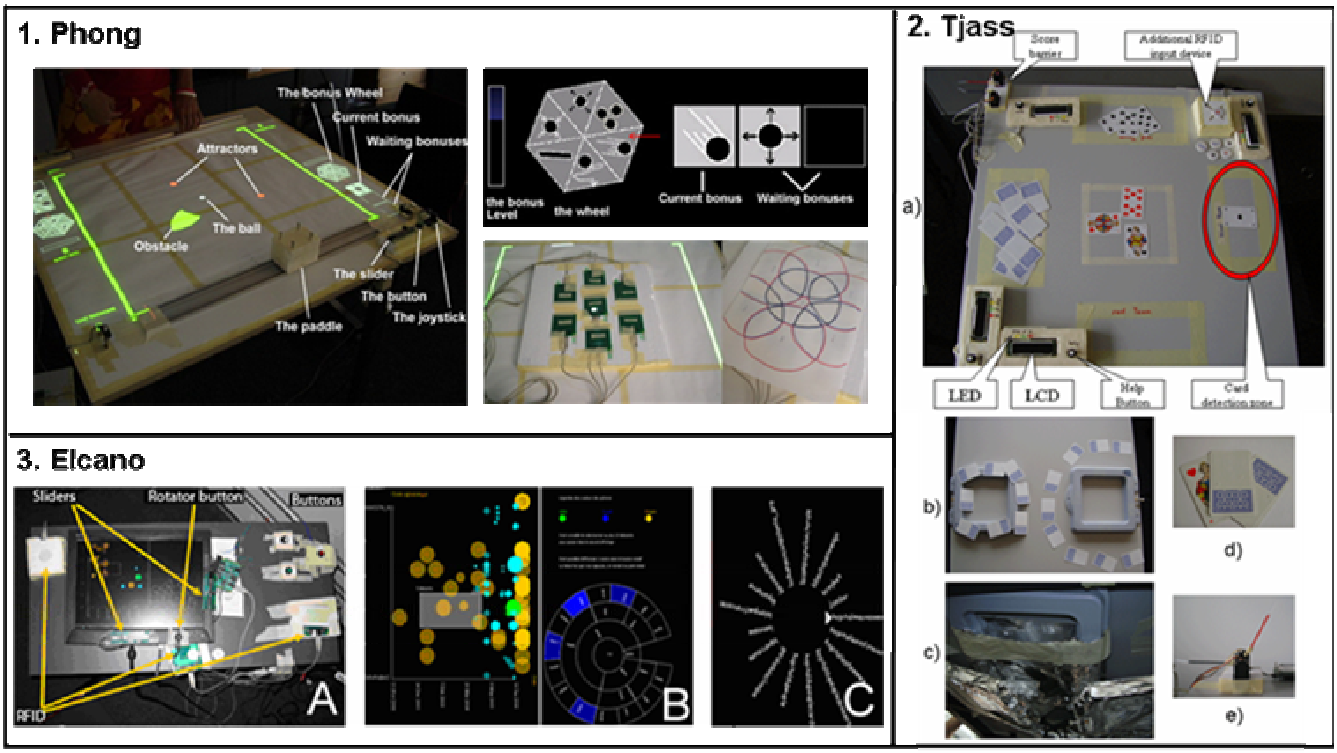

Figure 1: Phong, Tjass and Elcano, exploring augmented and mixed reality gaming and tangible multimedia browsing.

Transparent and pleasant for learners

Tjass is a good example of augmented reality system that supports real card playing with computational assistants such as score counting, winner determination, and decision support. A recent user satisfaction test has shown that Tjass satisfies players because of its usability, its preservation of the game physical playability and the augmented computational supports. Furthermore, it has appeared to be a suitable solution for beginners to learn card games in real context and to take decisions by their own, without disturbing the other players and the normal game process.

AUGMENTED VIRTUALITY: ELCANO, A TANGIBLE MULTIMEDIA BROWSER AND ORGANIZER

Nowadays, it is possible to store a great quantity of documents on a storage medium and it won't stop increasing. A natural drawback is that browsing becomes increasingly difficult. The goal of the Elcano project [1], similarly than in [3], was to develop a simple tangible browser providing original views of the multimedia content of a storage medium, facilitating navigation using tangible sorting and filtering mechanisms and interactive visualizations. In this case, a memory stick is used as storage medium to provide mobility to the user.

Elcano provides interactive visualizations to ease navigation through a great quantity of documents. The main visualization (see Figure 3b) is divided into two parts. On the left part, documents are plotted according to two axes and are represented by circles in the resulting scatter plot, different circle colors being mapped onto different types of files (jpg, mp3, avi), and a circle's size representing the actual size of the document it stands for. To navigate in this plot, i.e. to select a subset of documents, two physical sliders, each one being connected to one axis, are used to move a rectangular selection box. A special "rotator" button may also be turned to resize the selection area, or pushed in order to zoom in and out in a cyclic way. In the case of zooming in, the scatter plot is rescaled to contain the selected elements only. Hence the navigation space is narrowed down through physical filtering. On the right part of the visualization, a "sunburst" represents a sample of the tree structure of the memory stick. Directories to which belong the selected documents in the scatter plot are highlighted in the sunburst. This gives a compact preview of the selected documents' locations in the tree structure, rather than the exact directories containing the documents, which would take up more room.

When the satisfying subset of documents has been selected in the scatter plot, the user may switch to the documents wheel visualization (see Figure 3C) by clicking on the appropriate button. In the documents wheel, documents names are displayed around the perimeter. The rotator button triggers the rotation of the circle in order to select a particular document. Pushing the rotator button runs the selected document. Three additional buttons map onto other tasks: (1) create an album, i.e. a link between a personal object and a document, (2) read an album and (3) switch back to the scatter plot view. The technology used to attach a document to a personal object is explained in the next section.

Sorting and filtering algorithms as well as binding to personal objects are activated using physical tokens augmented with RFID tags. Two RFID antennas are used to control the visualization sorting algorithms. In the scatter plot visualization, filtering and sorting mechanisms are available. Filtering reduces the amount of documents displayed, while sorting algorithms applied on the axes of the scatter plot re-organize the layout of the documents accordingly. Three types of sorting algorithms are useful for any type of files: alphabetical order, modification date of file, frequency of use. The remaining sorting algorithms are suited to music files: album's date, author's name, real name of song, style of song, album's date. A third RFID reader allows users to associate documents to personal objects, in order create a direct link between one's digital memories and an object of the real world.

Rematerializing multimedia information for home

Although Elcano is not a game, it is a good example of augmented virtuality; the virtual world is augmented with physical access to information. Further, Elcano shows how tangible user interfaces can be used not only to manipulate multimedia digital data but also to allow end-users program their own links between digital information and tangible personal objects. A heuristic evaluation of Elcano has been performed by three usability experts to detect usability problems. Experts followed a list containing ten themes, which guided them in discovering 30 major usability problems, mainly falling in the category "Match between system and the real world". For example, the position of the phidgets was not found adequate. Most usability holes have been fixed and a satisfaction evaluation, on 8 users, conducted afterwards, showed encouraging results: users found the visualizations useful and most of them were in favor of using it for a home usage, although they experienced some difficulties to interact with the tangible devices.

MIXED REALITY: PHONG, AUGMENTING VIRTUAL AND REAL GAMING EXPERIENCE

The goal of the Phong project [6], contraction for Physical Pong, is to implicate players physically in digital games. Tangible user interfaces have proved to be an intuitive and natural mean of interaction [3], particularly useful to reduce the gap between digital and physical worlds, since objects can co-exist in both dimensions. A recent project, PingPongPlus [4], also dealt with an augmentation of a real ping pong game by projecting animations on the table. The purpose of Phong is to go further adding both physical elements to the virtual world and virtual elements to the real world, making it a good example of mixed reality system.

Phong's basic gameplay is inherited from pong, the most classic arcade game; each player moves his racket and tries to return the ball. Missing the ball makes the opponent scores. The main difference with pong is that the racket is no longer a virtual object, but becomes a real one. Besides, to extend the original pong gameplay, special actions can be triggered by bonuses collected by each player during the game. The first category of bonuses involves manipulating other physical controllers: a joystick, a push-button and a slider. These affect the virtual ball properties in an indirect way. A second category of bonuses allows players to place additional physical elements in a direct way on the game board, which affect the behavior of the ball.

Thanks to a beamer, fixed on the ceiling, and to a loud speaker, virtual items such as balls, scores, bonuses, are animated on the board and enriched with sounds. On the other hand, the principal interactor, i.e. each player's paddle, is physical. It can be moved can move horizontally to interact physically with the virtual ball (see Figure 1). Its position is detected by two IR distance sensors, one on each side. Three phidgets, placed on the right side of each player, are dedicated to bonuses manipulation and are activated when the player has reached a certain number of balls successfully returned. A slider controls the ball speed, the button launches an extra ball or blasters, and the joystick controls the direction of the ball. Certain bonuses, such as

obstacles or attractors, modify the trajectory of the ball. We call them localization bonuses. They must be put on the game board, within one of the 25 areas that can be seen on the bottom-right side of Figure 1. The player uses a stamp to place a modifier directly onto the game board. No mouse or keyboard is needed to set the location of the bonus; instead it is directly placed on the board. The localization works with seven RFID readers which create 25 distinct zones, drawn by their intersections. The bonus location corresponds to the intersecting zone of radius of the readers that detect it. Since the readers do not work when they are too close to one another, they are switched on and off sequentially, rapidly enough not to disturb the game play.

When the bonus wheel (top-right of figure 1) rotates, a bonus can be caught. To stop the wheel, the player must push the button. The selected bonus is then put in the bonus boxes under the wheel. A maximum of three bonuses can be accumulated in the stack of boxes, which follows a "last in, first out" rule. A bonus is activated if it is on top of the stack, in the "current bonus" box. All bonuses last for a limited time, except extra ball that is not limited. The first category of bonuses, extra ball, speed and direction, do not need localization. To use these bonuses, the player has to push the button that is located on his right side to load them during the game. After that the player may manipulate, if necessary, the appropriate physical device to apply the bonus. If extra ball is activated, another ball will be sent simply by pushing the button. If the speed bonus is selected, the slider will be activated, allowing changing the speed of the ball, etc. To use the second category of bonuses, called the localization bonuses, namely attractors, expulsors and obstacles, the player has to load the current bonus in the stamp. This action is simple, he only needs to put the stamp on the virtual bonus box and wait for the sound that validates the transfer. Then he can stamp the game board where he wants the localization bonus to appear. If it is an attractor or an expulsor, the ball will be deviated from it. If it is an obstacle, the ball will behave like on a wall.

Good playability and augmented fun

Phong combines augmented reality with augmented virtuality to form a "real" mixed reality system, emerging from both physical and digital worlds. Phong is an augmented pong game with tangible interactors, allowing players to physically interact with digital elements. This interaction style puts players in between real and virtual worlds. A preliminary user evaluation of Phong, in the form of a satisfaction questionnaire, has shown encouraging results, i.e. high playability and good system reactivity, and in general players were enthusiastic because they could directly manipulate and control the digital world.

CONCLUSION

This paper presents three systems that explore the use of tangible user interfaces to enhance gaming experience and physical interaction with digital information. TJass is an augmented reality game that extends regular card playing with computational supports. Elcano is an augmented virtuality system, augmenting digital multimedia information management with physical access and allowing the creation physical multimedia albums. Finally, Phong is a mixed reality game, which uses localization of objects as a solution to augment the players' physical implication in the digital board. Each system and interaction style provides advantages: Tjass has been appreciated for being not intrusive and very adapted for learners to play in real conditions with computational guides. Elcano has been valued for rematerializing information and creating tangible shortcuts to multimedia data. And finally Phong has been recognized fun to play for its novelty, since the interactions it proposes can not be mimicked in pure digital versus pure physical games. In the future, we plan to concentrate our efforts in building mixed reality systems that combine the best of the physical and digital worlds, in a complementary way, and hopefully bringing to light novel interaction paradigms.

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