Gameplay on a Multitouch Screen to Foster Learning about Historical Sites

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ABSTRACT
The use of gameplay has been shown to be an excellent educational tool, especially if such games are supported by innovative and engaging technologies. This paper presents two new games implemented on a large multitouch screen, designed to support young students learning about historical sites like archaeological parks during school visits. Students are encouraged to collaborate to solve the proposed challenges, but they can also play against each other, since direct competition is known to be another way to stimulate and reinforce learning. We believe that such games can make visits to historical sites more effective and exciting.

Categories and Subject Descriptors
K.3.1 [**Computer Uses in Education**]: *Collaborative learning*

General Terms
Design, Human Factors.

Keywords
Learning game, mobile system, multitouch.

1. INTRODUCTION
Visits to archaeological parks are traditionally accompanied by a guide, who provides information at various levels about what is seen during the visit, explaining the origins, functions and characteristics of objects and scenes encountered along the path. It is difficult to estimate how much interest this kind of visit can arouse in younger visitors, such as middle school students, who are the most frequent type of park visitors. It is desirable to offer them a more stimulating and engaging experience. The use of technology provides in itself an added value in terms of involvement, stimulating young people's motivation and curiosity [13], as well as offering a tool that allows them to "immerse" themselves in a reality that no longer exists.

Games have been shown to be an excellent learning technique, especially if they are supported by innovative, exciting technology [2, 13]. Game has also been adopted to foster history learning in young students visiting museums and/or historical sites [2, 3]. Game allows students to acquire basic knowledge and also engenders skills that would otherwise be very difficult to acquire. In [1, 3], we have described Explore!, an m-learning system that implements the excursion-game technique to support history learning during visits to archaeological parks [1, 3]. The excursion-game is like a treasure-hunt in that groups of 3-5 participants, by playing the game provided on cell phones, are required to roam around the archaeological park and identify some historically important places, marking them down on a map. This game phase is followed by a debriefing phase in which, with the aid of an application installed on a notebook and a projector, the game master (a teacher or a history expert) stimulates reflection and induces them to reformulate the knowledge learned during the game.

After the game in the park and before the debriefing phase, children might get further knowledge about the historical site. To this aim, we have developed History-Puzzle and Time-Voyager, two applications for large multitouch screens, which implement two different educational games, as described in this paper. Groups of students may actively collaborate to solve the challenges proposed in the two games, manipulating by hand gestures the objects displayed.

Educational games are very valuable since they foster relational skills, encouraging young people to work in groups and collaborate to attain given objectives [3, 13]. Each student can carry out the activities s/he feels most congenial and, by working together, the whole group can solve the game challenges and overcome difficulties thanks to their common efforts. Thus, these games also facilitate development of the team spirit.

The paper has the following organization. Section 2 describes main multitouch technologies and some applications. Section 3 briefly illustrates the system setup. Section 4 presents History-Puzzle and Time-Voyager. Section 5 concludes the paper.

2. MULTITOUCH TECHNOLOGIES
Research on gesture-based interaction has been an active area of interest. Much of the seminal work has been carried out in the last decades but recent developments, such as the introduction of Microsoft Surface and particularly Apple's iPhone, have accelerated the mainstream diffusion of this type of interaction.

Many different displays and input detection technologies have been developed. DiamondTouch, produced by Mitsubishi Electric Research Labs (MERL), is a touch-sensitive tabletop display [4]. This system recognizes touch inputs made by four different users thanks to a transmitting antenna behind the surface of the display and a receiver below each user's seat. For this reason, during the interaction users must not be seated too close to each other. DiamondTouch is complemented by DiamondSpin, a software toolkit for rapidly developing collaborative applications in which

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users can freely move about and use their fingers to rotate interface elements on the surface [14]. The DiamondTouch surface is used by Rick and colleagues for the OurSpace application, which allows children to design a seating plan for their classroom by moving representations of virtual students around a series of desks, visualized on the screen through a bird's eye view [12]. The results from a within-subjects test showed that, as compared to the single touch mode, multiple touch favors collaboration among the children.

The Microsoft Surface application uses five cameras and a projector mounted beneath a table display surface [8]. Surface recognizes gestural input as well as objects equipped with RFID tags. For example, by placing an MP3 player and a smartphone on the tabletop surface, a user can transfer music files between these two RFID tagged devices. The music files appear on the tabletop surface near each device, enabling users to drag material from one device to the other.

The Perceptive Pixel display makes use of "frustrated total internal reflection", a light property that causes refraction when it encounters an interface to a medium with a lower refraction index, i.e. glass to air [5]. Image processing techniques are able to correctly, non ambiguously identify each touch. However, when multiple users are interacting with the interface, it cannot recognize the interaction flow of each of them: the system can perceive that a finger is touching an object on the screen, but not whose finger it is.

Multitouch technologies have been employed in different applications. For example, reacTable is an innovative musical device based on a round table where musicians can control the instrument by caressing, rotating and moving physical artifacts on the luminous surface [7]. Another example in public settings is by Peltonen et al., who placed a large multitouch display in a downtown area of the city of Helsinki, Finland [11]. The display acts as a public "stage" on which passers-by can perform multimedia interactions in front of a standing audience.

Multitouch-enabled surfaces can also display 3D graphics; as such, interaction techniques need to be reconsidered to allow fruitful 3D interaction in these settings. Hancock et al. have proposed a new interaction device, a multitouch cube with edges measuring about 10 inches, which is manipulated by the user and permits 6 DOF interaction with virtual objects in a scene displayed on a large screen [6].

3. SYSTEM SETUP

The applications described in this paper are designed for large multitouch screens. The hardware system provided by MultiTouch Ltd [10] relies on the so-called "diffused illumination" technology, like what is used in the Perceptive Pixel display; it requires: a) an infrared emitter and an industrial cine-camera to detect the user's movements; b) one or more projectors and a screen on which images are projected. The screen consists of a safety glass behind which a rear-projection canvas is attached (Figure 1). The present system screen size is 2 x 1.2 meters but it is possible to use screens of up to 16 meters.

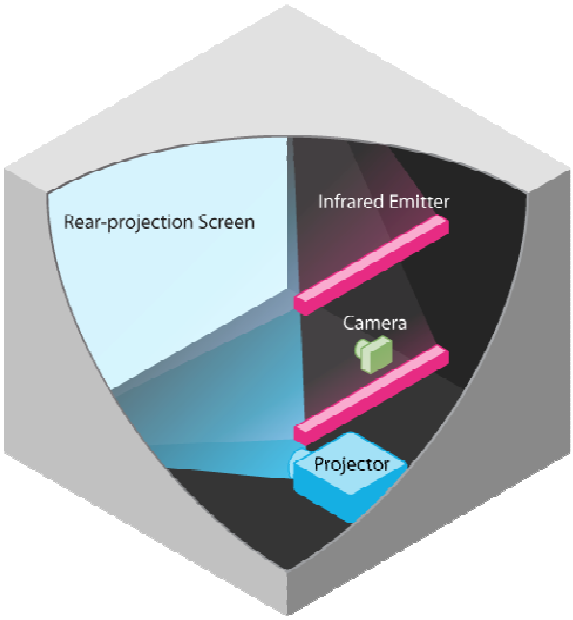

Figure 1. Schema of a multitouch box using diffused illumination [10].

This technology is less costly than a format consisting of several combined LCD panels and, above all, less delicate. In fact, the screen is made of a normal safety window like the ones used for shop windows, so in case of damage, by vandalism for instance, it is only necessary to replace the glass and not costly LCD panels. However, the screen needs to be completely disassembled for transport and, each time this happens, the projection system and touch sensors will then have to be re-calibrated.

Developing software applications for multitouch screens is still not easy. Multitouch hardware manufacturers provide Software Development Kits (SDKs), but customers need to have specific skills to be able to use them properly to program their own software applications. For example, MultiTouch Ltd provides an SDK, called "Cornerstone", that requires C++ and OpenGL programming. The games presented in this paper have been developed in Java, thanks to the open source MT4J (Multitouch for Java) development platform [9]. The TUIO protocol has been adopted to allow communication between the touch-capture system and the software application.

4. GAMES ON MULTITOUCH SCREENS TO LEARN PARK HISTORY

This section presents two games to be played by young students interacting with a multitouch screen, that are designed to reinforce knowledge learned during game. The scenario is that the multitouch system is in the museum by the Egnathia archaeological park and students play the games after their visit to the park and/or museum.

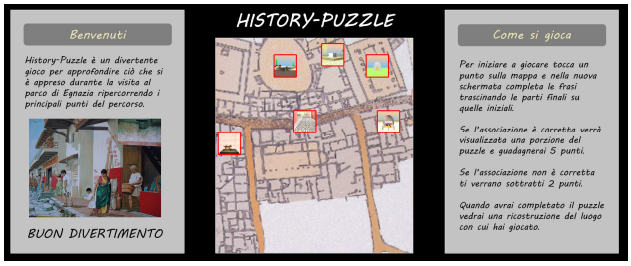

Figure 2. Initial display of History-Puzzle.

4.1 History-Puzzle

The first game is called History-Puzzle because it asks participants to complete puzzles of historical monuments. In the initial display of this application (Figure 2), a welcoming message is shown on the left and the game instructions on the right. The map of the park is displayed in the center, showing images of the main places of interest. When a player touches one of these images, such as the furnace, for instance, a screen like the one shown in Figure 3a appears. There are nine incomplete messages about the selected place in the center of the screen, that the player needs to complete by choosing the rest of the sentence from the boxes displayed outside and dragging it into one of the nine boxes in the central zone. If the selected association is correct, the box will reveal one ninth of the image of the 3D reconstruction of the original building. Figure 3b shows what it looks like when the player has discovered 6/9 of the image.

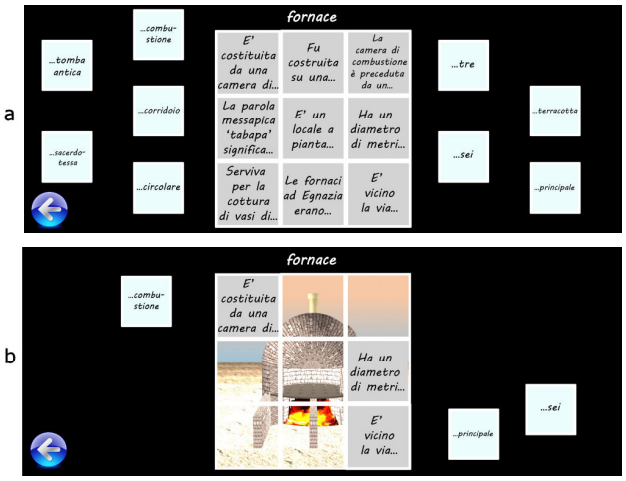

Figure 3. History-Puzzle shows a) nine incomplete messages that the player needs to complete b) in order to visualize the 3D reconstruction of the original building.

When the nine descriptions have been completed and the whole image is displayed, a 3D animated reconstruction of the place will appear. The system also reproduces context sounds, e.g., noises of the typical activities carried out in that place when the civilization of Egnathia was alive. In the example in Figure 3, showing the furnace where terracotta objects were baked, the crackling fire is heard. Finally, the system returns to the map of the park to allow the participants to complete the puzzles of the other places.

4.2 Time-Voyager

Time-Voyager invites players to organize photos according to a chronological scheme corresponding to the different historical eras of the park history; the photos depict scenes, buildings or objects related to specific Ages (Figure 4). In the case of Egnathia, these are: the Bronze Age, the Iron Age, the Messapian Age, Augustan Rome, Trajan Rome, the Middle Ages, the Present Day.

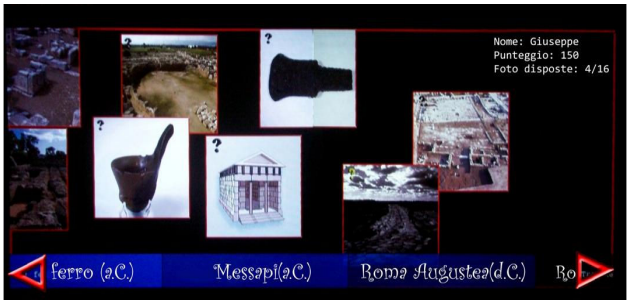

Figure 4. Time-Voyager play screen.

In the example shown in Figure 4, the "Messapian" and "Augustan" Ages are shown at the bottom. The red arrows pointing left and right indicate that other Ages before or after those shown are available. The player can visualize them by placing a finger on the Ages bar and dragging it from right to left; to go back it is dragged in the other direction. This can also be done using the upper part of the interface, by touching any part not occupied by photos and dragging the screen across in the same way.

The upper part of the screen shows photos referred to different Ages of Egnathia: for example, the ax in the center of the screen refers to the Bronze Age, the hut to the Iron Age, etc. The player must touch the photo of the bronze ax and drag it down into the Bronze Age portion of the Ages Bar. A correct answer prompts the appearance of a congratulations message and increases the player's score, displayed in the top right with the player's name.

If players need help, they touch the question mark displayed at the top left corner of each photo: a window will appear in which a magician asks "Do you need my help?". Three kinds of help are offered: 1) the application tells the player whether the Age is B.C. or A.D.; 2) the application displays the approximate year the photo is referred to, and the player should then associate the corresponding Age; 3) the application shows a sentence with useful information about the Age in question. The player can request each type of help only once in each game, for a total of three times in all.

If a player assigns a photo to the wrong Age, the dark background will turn red, flash for a few seconds and an acoustic warning alert will sound. The game ends when all the pictures have been correctly placed. The player's score depends on the time taken and the number of mistakes made.

4.2.1 Challenge between two players

With Time-Voyager, two players can also play against each other to see who can assign the photos faster. Competition is an essential part of the game because, when kept within reasonable

bounds, the chance to show off one's ability and knowledge is known to reinforce learning.

Figure 5. Two children playing against each other.

The screen area is shared between the two players (Figure 5), each of whom has a window like the one used for individual play, but with a different colored border to distinguish the player. In the upper part of the screen a bar shows the different Ages. When a player gives a correct answer identifying the right Age for a figure, the photo is displayed in the upper bar, that spans both windows. At the same time, the photo disappears from the opponent's screen, while the score indicator is updated and flashes for a few seconds. The game ends when all the photos have been correctly placed. The winner is the player that has identified the greater number of photos.

5. CONCLUSION

History-Puzzle and Time-Voyager are two educational games developed to stimulate reflection and to deepen knowledge acquired during a visit to historical sites. The current scenario refers to their use in a museum associated to an archaeological park. Similar games can be designed to be played in other locations. For example, we are thinking to an implementation in a historical building where visitors can look at mosaics and other objects of the Roman time.

The games have been designed according to a user-centered approach, and preliminarily experimented with students at a middle school in our city. Besides the user studies conducted during the requirements phase, evaluations of the different prototypes have been made with young students. Groups of 2-5 children were involved in each evaluation session. We observed them interacting with the multitouch screen while playing with either History-Puzzle or Time-Voyager. Such preliminary studies have confirmed that users find this novel technology highly engaging. We are planning to perform, in the near future, a rigorous user study in the field to test the learning advantage of using these games as well as the overall user experience.

6. ACKNOWLEDGMENTS

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