Interactive Edutainment: A Technologically Enhanced Theme Park

Chryssi Birliraki[1(✉)], Nikos Stivaktakis[1], Antonis Chatziantoniou[1], Vassiliki Neroutsou[1], Emmanouil Zidianakis[1], Ioanna Zidianaki[1], Emmanouil Apostolakis[1], Emmanouil Stamatakis[1], Michalis Roulios[1], Stavroula Ntoa[1], Michalis Sifakis[1], Maria Korozi[1], Spiros Paparoulis[1], Thanasis Toutountzis[1], Nikolaos Patsiouras[1], Antonis Dimopoulos[1], George Paparoulis[1], Nikolaos Partarakis[1], George Margetis[1], and Constantine Stephanidis[1,2]

[1] Foundation for Research and Technology – Hellas (FORTH), Institute of Computer Science, N. Plastira 100, Vassilika Vouton, 700 13 Heraklion, Crete, Greece
{birlirak, nstivaktak, hatjiant, vaner, zidian, izidian, apostolak, stamatakis, roulios, stant, misi, korozi, spirosp, atout, patsiouras, dimopoulos, groulis, partarak, gmarget, cs}@ics.forth.gr
[2] Department of Computer Science, University of Crete, Heraklion, Greece

Abstract. Heraklion Christmas Castle is a joint effort between ICS-FORTH and the Municipality of Heraklion-Crete (Municipal Public Service Enterprise of Heraklion), trying to pioneer and be innovative in the presentation of Christmas customs and ideas by creating a festive neighborhood governed by interactive technology. The approach followed by this research work was to employ interactive systems to give a feeling of Christmas to children and adults through the combination of education and entertainment. This work presents the innovative systems designed and developed for the Christmas Castle to augment and enhance the festive spirit through multimodal interaction techniques, such as virtual environments, kinesthetic interaction, physical object identification and serious games. All the systems were designed and integrated within art artefacts (special constructions) that match the Christmas look-and-feel and provide a user-centric design.

Keywords: Interactive systems · Edutainment · Multimodal interaction · Information visualization · Kinesthetic interaction · Serious games · Public spaces · Public installations · Ambient Intelligence (AmI)

1 Introduction

The creation of systems that are innovative, interactive, playful, usable and fit the context of use is a challenging task especially when such systems are being deployed in public spaces, such as theme parks.

© Springer Nature Switzerland AG 2019
C. Stephanidis (Ed.): HCII 2019, CCIS 1034, pp. 549–559, 2019.
https://doi.org/10.1007/978-3-030-23525-3_75

Public spaces form an important part of our everyday life – they create a sense of belonging, provide a place where we can socialize, relax, and learn something new [5]. A public space is a social space that is generally open and accessible to people. We encounter public spaces everywhere we go: town centers, parks, and public streets are all common settings of our everyday life. Public spaces involve necessary, optional and social activities [11]. According to the authors, in contrast to the compulsory ones, optional activities are seriously related to the quality of the public spaces. Social activities that occur spontaneously as a direct consequence of people being in the same places are equally affected by the quality of the environment.

Public displays are for anyone to interact in a walk-up-and-use [14] manner. In public displays, a large proportion of users are passers-by and thus first-time users. Most of the research on public displays has been carried out by running installations in local communities, yet this research has only recently started.

Ambient Intelligence allows the user to interact with several means often simultaneously, such as speech, body movements, gestures, eye and head tracking or even with physical objects. Multimodal interaction is a part of everyday human discourse: we speak, move, gesture and shift our gaze in an effective flow of communication. Jaimes et al. [15] define a multimodal system as a system that "responds to inputs in more than one modality or communication channel, such as speech, gesture, writing and others".

"Play is a very serious matter….It is an expression of our creativity; and creativity is at the very root of our ability to learn, to cope, and to become whatever we may be" [6, 19]. Over the years, interactive games have evolved in a number of areas [13] in terms of both hardware and software. Such a change is based on users' diversity and on the fact that games are part of society and culture [23]. Especially for children [3, 10] it is easier to engage in activities when playing is their motivation [1, 2, 9].

The purpose of this work is to use different ways of interaction so as both children and adults may use applications that can educate them while playing. By providing a combination of image, sound and interaction, users can communicate Christmas customs, while at the same time get involved in the action of each system. The technologies used vary by application, so users learn to handle technological advances in many different ways, helping them in a later encounter with corresponding systems. Although this work presents the case study of interactive systems at Heraklion Christmas Castle, the logic behind is that the systems can be adapted to any context of use with small changes in the content and the visual composition that surrounds them.

2 Related Work

Human behavior and interaction, both among people and between a person and an interactive system, largely affect the way that users perceive and react to their surroundings. Human behavior can trigger engagement through the feeling of curiosity, the point being fully described as a 'honey-pot' effect [24]. The different phases of interaction between users and public installations range from the ambient and implicit to finally using them on an immediate and more personal manner [22]. Moreover, the setup of the public displays and the location's architecture strongly influence user interaction and social

effects; as presented by Ten Koppel et al. [16], different display configurations can either promote or hinder interaction both with deployed systems and between users.

Moreover, playfulness constitutes another fundamental factor affecting the way people approach and interact with exhibits publicly accessible [2], fostering creativity, promoting social interaction and physical play. In the same context, edutainment [12] combines the domains of education with entertainment, thus presenting valuable input in a pleasant manner and allowing learning while enjoying interaction.

Interactive installations employ a diverse set of input methods which are often combined in order to provide the optimal user experience and further engage users, often being combined and providing multimodal interaction [4]. Gestural remote interaction constitutes a widespread approach for manipulating [7] public displays. In a similar manner, the entire body movement and posture can act as an input mechanism for deployed applications, providing less efficient but certainly more playful and enjoyable interaction between the end users and the system [8, 20, 21].

Finally, physical objects, often referred to as smart objects, are used as an interaction technique [18]. Tangible interaction has the advantage of the user using an everyday item which is enhanced by technological components (such as RFID cards, accelerometers, gyroscopes, distance sensors, etc.) and achieving more than initially expecting; as a result, users feel that the physical item or even themselves are empowered to perform actions otherwise impossible. An interesting example is presented by Marshall et al. [17], where authors use the concept of smart replicas in an effort to augment a museum and enhance the overall user experience of people's visit.

3 Heraklion Christmas Castle

In Heraklion Christmas Castle, four areas have been configured to host the interactive systems of the Institute of Computer Science of the Foundation for Research and Technology – Hellas (ICS-FORTH). These are: (a) the house of fairytales, (b) the house of the elves, (c) the house of surprises and (d) the sleigh with the reindeer. Each house is design-decorated to stimulate the Christmas spirit, but also to promote user participation, collaboration and fun. More specifically, the house of fairytales enhances user experience through kinesthetic interaction, immersion and playfulness. Users can become part of the system and interact with system's elements. The applications deployed in the elves' house combine education with fun. Through the use of the systems, users learn to operate with more ecological consciousness, but also educate themselves about geographical destinations around the world, enrich their knowledge about Christmas customs around the world and apply analytical thinking. The surprise house, on the other hand, is based on entertainment; through interactive games, which use controls found in everyday life, such as a steering wheel and a hand pump, the systems assist the development of skills like perception, speed and goalseeking. As far as the sleigh is concerned, the main goal for users is to familiarize themselves with the robotic technology through animatronics (servos, stepper motors, robotic equipment and electronics are integrated into the reindeer's body), but also to participate in a technological way in the experience of gift delivery, an established custom all over the world. All interactive systems developed are thoroughly described in the following sections.

3.1 The House of the Elves

Gift's Energy Efficiency. The main goal of this system is to develop ecological consciousness to users allowing them to contribute in the screening process of the gifts on their way to Santa Claus's bag. The system rates each gift with regard to its energy efficiency and allows users to interactively choose the more ecological material combination among several potential alternatives. In particular, users select one of the packaged gifts and place it in a suitable position on a belt. The belt is automatically activated as soon as a user has been tracked near it, and starts to move by promoting the present in a special area that hosts an "X-ray machine" (Fig. 1). As the gift reaches this area, virtual light beams scan the packaged gift and its interior are displayed on a digital screen. At the same time, aspects of gift's energy efficiency is revealed gradually via animations and related textual and imagery information. By studying the items displayed for each gift on the screen (Fig. 2), users are called upon to decide if it should be considered as ecological and make a selection using the appropriate buttons. When a gift is considered suitable for distribution, it is released and directed to the Santa Claus bag for delivery. If users feel that the gift's materials are not safe or friendly for the environment, they can change the construction materials' combination to be more environmentally friendly. If users' response is not correct then the system provides the appropriate feedback for users to review their choices. Upon choosing the correct combinations, the gift delivery progress is displayed on the digital screen. User interaction with the system is accomplished using physical controls (i.e., buttons).

Fig. 1. Construction design of the "Gift's energy efficiency" system

Fig. 2. System's game design

Global Gift Delivery. This system presents an interactive way of delivering Christmas gifts on the five continents. The information provided by the system helps to collect data from different sources and to broaden the analytical thinking of users as well as enrich their geographic knowledge.

In terms of the visual composition, specially shaped positions are created for the gifts that users can placeto see the letter accompanying each gift. A specially designed mechanism allows the wish to appear automatically on a digital display, when users place the gift in the specific position to be recognized. The wishes of each child are

displayed on a digital screen, accompanied by all the necessary information the user needs (text, images) (Fig. 4) to recognize which continent each letter comes from.

A surface has the appropriate holders per continent for each gift. When users place the gift on the continent that they think the wish corresponds to, the system recognizes whether the answer is correct or incorrect (Fig. 3). Once the correct continent is selected, its border automatically turns green and a message on the screen informs the users that they have made the correct choice. In case of an error, an appropriate message appears on the screen to prompt users to refine their choice, while the wrongly selected continent blushes with special lighting. Then, users can choose the next gift and follow the same procedure to recognize the next wish. When the gifts have been distributed to all five continents, a light animation is activated throughout the map and a reward message appearson the screen. The goal of the system is to help users learn by playing. The system combines technologies for identifying physical objects on non-technological surfaces and for presenting augmented information to auxiliary projections.

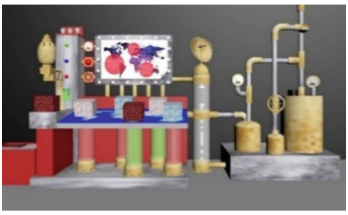

Fig. 3. Construction design of the "Global Gift Delivery" system

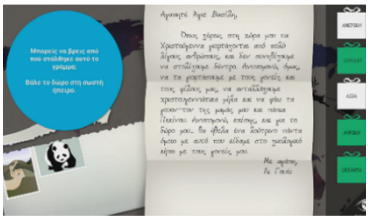

Fig. 4. Game screen of the "Global Gift Delivery" system

The Basil Pie. The system consists of a custom wooden "new year cake" and allows visitors to randomly select any piece and see if it was the lucky one (the tradition is that one piece contains the lucky coin symbolizing health and good luck for the coming year). The system recognizes the location of the golden coin and a corresponding sound message is played when the matching piece is selected.

The system consists of wooden pieces of a "basil pie" decorated and placed on a platter. Users are able to choose their own piece in an attempt to try to find the hidden coin (Fig. 5). The system incorporates a special mechanical and electronic mechanism to randomly change the position of the coin each time a selection is being placed (Fig. 6).The system combines technologies for recognizing natural objects on non-technological surfaces.

Fig. 5. System setup and user interaction

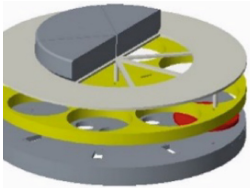

Fig. 6. Construction in layers

3.2 The House of Surprises

Gift Collection Assistant. This system provides the ability to interact with physical objects in order for the players to use a virtual vehicle to collect gifts scattered around the environment and load them on Santa's sleigh.

In a virtual 3D environment, there is a snowy mountainous landscape full of Christmas gifts scattered on the snow (Fig. 8). The purpose of the system is for users to help Santa Claus place the gifts back to the sleigh in an interactive way. By using really augmented controls, such as a gear lever and a steering wheel (Fig. 7), players direct a special machine to collect as many gifts as possible at a predetermined time and put them on the sleigh for Santa to continue his journey.

The system allows interaction with actual augmented controls and enriches users' experience by displaying a 3D environment.

Fig. 7. Construction design of the "Gift Collection Assistant" system

Fig. 8. Real-time game view of the "Gift Collection Assistant" system

Santa Claus Brings the Gifts. The system is an interactive game in which users are called upon to help Santa Claus share the gifts to the children at a specific time by using natural controls.

A digital screen shows a virtual environment in which Santa's sleigh with the help of a balloon flies over the city (Fig. 10). Using pressure sensors (Fig. 9), users can start

the game, direct the virtual balloon and take it to the chimneys of the houses to help Santa Claus drop the gifts. Users also try to avoid any obstacles that might show up during the flight. The virtual environment enriches users' engagement with the system via incorporating Christmas music and animated graphics. On the upper area of the screen, the remaining time and "lives" as well as the number of gifts delivered are being displayed. The system allows tangible interaction with physical objects via a sensor-equipped hand pump.

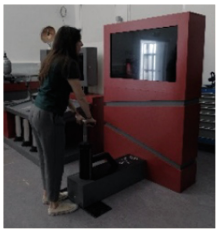

Fig. 9. Construction design of the "Santa Claus Brings the Gifts" system

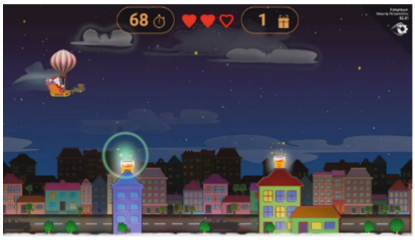

Fig. 10. Game design of the "Santa Claus Brings the Gifts" system

3.3 The House of Fairytales

This system presents various interactive fairytales and through storytelling, animations and interactive gaming, each story comes alive and integrates users into the virtual environment, making them a part of each story's plot. The system allows players to participate in fairytales with natural kinesthetic ways of interaction, such as by freely moving in space to interact with on-screen elements.

The system presents interactive fairytales that are placed in a specially designed room consisting of three large projection surfaces that frame the users (in a cave-like format), giving the feeling that they are immersed into the story, as the virtual elements will surround them via wall projections. Through these views users are actively engaged in the story plot. A custom designed rotating mechanism allows triggering the start of the fairytale's narration. Sound effects, real-life narratives and animations motivate users to participate in the flow of the story through interactive games that have to be completed in order to continue with the story. Using special image and depth sensors, the hands and the entire body of users are recognized to act as a means of interaction with the game, without the need for a controller or other mechanical part. The software subtracts users' background and integrates users into the virtual environment of the story (Fig. 11), allowing multiple users to see live their image embedded in digital sceneries and interact with elements of the virtual environment.

3.4 The Neighborhood with the Lights

The system supports the remote control of smart lighting using arrays of LED lights and headlights. The aim is to highlight specially designed Christmas decorations that beautify the castle's walls. The software provides the ability to create and customize scenarios to control the state, intensity and color of each light unit. It also allows the scheduling of scenarios as well as the creation of specific photo rhythmic effects based on selected musical sounds. The system supports remote control of custom lighting in a continuous flow to reproduce lighting in figures (Fig. 13) that decorate the area outside the Christmas Kiosks. The figures are special constructions made of simple materials (such as metal, wood, Plexiglas). Inside the constructions, appropriate equipment is incorporated to support remote control of both the hue and light intensity of individual parts. The software provides scenario activation, which synchronizes the lights with selected musical sounds.

Fig. 11. Game design with user actively engaged

The system enriches the user experience by combining technology with art as well as with light and music (Fig. 12).

Fig. 12. Technology and art combination using lights

Fig. 13. Lighting in figures

3.5 Rudolph

At the entrance of the "Christmas Castle", visitors are welcomed by a novel system that combines a mechanical speaking doll with videos of flight over the city of Heraklion,

the sleigh of Santa Claus with Rudolph the Red-Nosed Reindeer leading the pace (Fig. 15). Rudolph invites children to become Santa Claus' assistants and deliver presents to everyone in Heraklion, through a virtual interactive trip over the city center.

Users can get on the Santa's sleigh, start their trip to Heraklion city and share as many gifts as they can while seeing the city from above (Fig. 14). Interaction is done using joystick for navigation and a tablet for giving text input, as well as with a big screen where it shows video of the city that has been captured using a drone. In the end, users can send to their email their pictures, which have been taken by the traveling system using a camera.

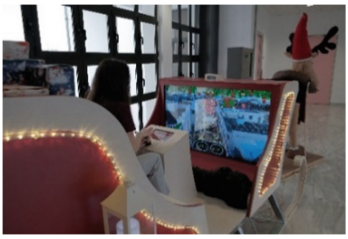

Fig. 14. Users interacting on the sleigh

Fig. 15. Rudolph and the sleigh

4 Conclusion

This workhas presented the technologically enhanced Heraklion Christmas Castle. In this context, eight interactive systems have been deployed which provide a more "innovative" view of Christmas. Through a combination of novel information visualizations and multimodal and playful interaction techniques the Christmas spirit is promoted. Users have the opportunity to live a unique experience in a theme park and use technology to discover their interests through different visualizations. Users' satisfaction and response justify that novel forms of interaction can enhance information provision capacity and increase their interest by providing more immersive and memorable experiences. As future work, an in-situ evaluation is necessary in terms of usability, interaction and user experience.

Acknowledgements. The installation at the Christmas Castle of the city of Heraklion was funded under a contract between FORTH and the Municipal Public Service Enterprise of Heraklion. The development of the interactive systems presented by this research work was supported by the FORTH-ICS internal RTD Programme 'Ambient Intelligence and Smart Environments'[1].

[1] FORTH-ICS AmIProgramme: http://ami.ics.forth.gr/.

References

1. Baranek, G.T., Barnett, C.R., Adams, E.M., Wolcott, N.A., Watson, L.R., Crais, E.R.: Object play in infants with autism: methodological issues in retrospective video analysis. Am. J. Occup. Ther. **59**(1), 20–30 (2005)
2. Bekker, T., Sturm, J., Eggen, B.: Designing playful interactions for social interaction and physical play. Pers. Ubiquit. Comput. **14**(5), 385–396 (2010)
3. Bratton, S.C., Ray, D., Rhine, T., Jones, L.: The efficacy of play therapy with children: a meta-analytic review of treatment out-comes. Prof. Psychol.: Res. Pract. **36**(4), 376 (2005)
4. Bressan, F., Vets, T., Leman, M.: A multimodal interactive installation for collaborative music making: from preservation to enhanced user design. In: Proceedings of the European Society for Cognitive Sciences of Music (ESCOM) Conference, pp. 23–26 (2017)
5. Carr, S., Stephen, C., Francis, M., Rivlin, L.G., Stone, A.M.: Public Space. Cambridge University Press, Cambridge (1992)
6. DeVary, S.: Educational gaming: interactive edutainment. Dist. Learn. **5**(3), 35 (2008)
7. Drossis, G., Grammenos, D., Birliraki, C., Stephanidis, C.: MAGIC: developing a multimedia gallery supporting mid-air gesture-based interaction and control. In: Stephanidis, C. (ed.) HCI 2013. CCIS, vol. 373, pp. 303–307. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-39473-7_61
8. Drossis, G., Ntelidakis, A., Grammenos, D., Zabulis, X., Stephanidis, C.: Immersing users in landscapes using large scale displays in public spaces. In: Streitz, N., Markopoulos, P. (eds.) DAPI 2015. LNCS, vol. 9189, pp. 152–162. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-20804-6_14
9. Engelen, L., et al.: Increasing physical activity in young primary school children—it's child's play: a cluster randomised controlled trial. Prevent. Med. **56**(5), 319–325 (2013)
10. Fromme, J.: Computer games as a part of children's culture. Game Stud. **3**(1), 49–62 (2003)
11. Gehl, J.: Life Between Buildings: Using Public Space. Island Press, Washington (2011)
12. Grammenos, D., et al.: Design and development of four prototype interactive edutainment exhibits for museums. In: Stephanidis, C. (ed.) UAHCI 2011. LNCS, vol. 6767, pp. 173–182. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-21666-4_20
13. Haddon, L.: The development of interactive games. The media reader: continuity and transformation, pp. 305–327 (1999)
14. Izadi, S., Brignull, H., Rodden, T., Rogers, Y., Underwood, M.: Dynamo: a public interactive surface supporting the cooperative sharing and exchange of media. In: Proceedings of the 16th Annual ACM Symposium on User Interface Software and Technology, pp. 159–168. ACM, November 2003
15. Jaimes, A., Sebe, N.: Multimodal human–computer interaction: a survey. Comput. Vis. Image Underst. **108**(1–2), 116–134 (2007)
16. Ten Koppel, M., et al.: Chained displays: configurations of public displays can be used to influence actor-, audience-, and passer-by behavior. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM (2012)
17. Marshall, M.T., Dulake, N., Ciolfi, L., Duranti, D., Kockelkorn, H., Petrelli, D.: Using tangible smart replicas as controls for an interactive museum exhibition. In: Proceedings of the TEI 2016: Tenth International Conference on Tangible, Embedded, and Embodied Interaction, pp. 159–167. ACM, February 2016
18. Price, S., Rogers, Y., Scaife, M., Stanton, D., Neale, H.: Us-ing 'tangibles' to promote novel forms of playful learning. Interact. Comput. **15**(2), 169–185 (2003)
19. Rogers, F., Sharapan, H.: How children use play. Educ. Dig. **59**(8), 13–16 (1994)

20. Salah, A.A., Schouten, B.A., Göbel, S., Arnrich, B.: Playful interactions and serious games. J. Ambient Intell. Smart Environ. **6**(3), 259–262 (2014)
21. Tieben, R., Sturm, J., Bekker, T., Schouten, B.: Playful persuasion: designing for ambient playful interactions in public spaces. J. Ambient Intell. Smart Environ. **6**(4), 341–357 (2014)
22. Vogel, D., Balakrishnan, R.: Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users. In: Proceedings of the 17th Annual ACM Symposium on User Interface Software and Technology. ACM (2004)
23. Wimmer, J.: Digital game culture(s) as prototype(s) of mediatization and commercialization of society: the world cyber games 2008 in cologne as an example. In: Fromme, J., Unger, A. (eds.) Computer Games and new Media Cultures, pp. 525–540. Springer, Dordrecht (2012). https://doi.org/10.1007/978-94-007-2777-9_33
24. Wouters, N., et al.: Uncovering the honeypot effect: how audiences engage with public interactive systems. In: Proceedings of the 2016 ACM Conference on Designing Interactive Systems, pp. 5–16. ACM, June 2016