The Farm Game: A Game Designed to Follow Children's Playing Maturity

Emmanouil Zidianakis[1(✉)], Kalliopi Stratigi[1], Danae Ioannidi[1], Nikolaos Partarakis[1], Margherita Antona[1], and Constantine Stephanidis[1,2]

[1] Foundation for Research and Technology – Hellas (FORTH), Institute of Computer Science, 70013 Heraklion, Greece
{zidian,stratigi,ioanidi,partarak,antona,cs}@ics.forth.gr
[2] Department of Computer Science, University of Crete, Crete, Greece

Abstract. This paper presents the design, implementation and deployment of a new version of the popular farm game as deployed within an Ambient Intelligence (AmI) simulation space. Within this space, an augmented interactive table and a 3D avatar are employed to extend the purpose and objectives of the game, thus also expanding its applicability to the age group of preschool children from 3 to 6 years old. More importantly, through the environment, the game, which builds on knowledge stemming from the processes and theories used in Occupational Therapy and activity analysis, becomes capable of monitoring and following the progress of each young player, adapt accordingly and provide important information regarding the abilities and skills of the child and their development over time.

Keywords: Ambient intelligence · Serious games · Occupational therapy · Virtual assistant · Tabletop interaction

1 Introduction

Play is widely used in therapy to treat children's emotional and behavioral problems because of its responsiveness to their unique and varied developmental needs [3]. Current interactive technologies provide the means to achieve a radical transformation of play much beyond desktop computers games. A large number of products is available to young children that incorporate interactivity such as activity centers, musical keyboards, and radio-controlled toys [4]. This range of toys and devices is part of a move towards pervasive or ubiquitous computing in which technology blends into the environment and is not necessarily visible. AmI environments offer opportunities to support children's playing needs. Designing and creating playing experiences under the perspective of Ambient Intelligence has the potential to provide enhanced gaming experience to all age groups and in particular to children.

The farm game presented in this paper is tailored to the needs of preschool children, aged 3 to 6 years old, and supports playing through tangible interaction with physical objects. In general, the theme of the farm game is considered to be one of the most popular puzzle games for children and at the same time for OT therapists as a mean to

A.L. Brooks and E. Brooks (Eds.): ArtsIT/DLI 2016, LNICST 196, pp. 20–28, 2017.
DOI: 10.1007/978-3-319-55834-9_3

assess children's developmental issues. Using the employed technological infrastructure (an augmented interactive table and a 3D avatar) and its support for combination of physical and virtual objects, the farm game presented in this paper extends the age range supported by the traditional one. This is achieved by increasing the difficulty and playing demands according to developmental standards for ages up to 6.

2 Background and Related Work

Play is one of the areas of human occupation that OT focuses on, thus appropriate activities for children are widely used in order to evaluate and facilitate the development of their skills and abilities [15]. Therapists proceed with **activity analysis** process to define the numerous demands that a specific activity requires for execution. OT expertise has been employed at the design of the farm game, so as to meet the needs of OT practitioners, and also to provide the knowledge at the basis of interaction monitoring and adaptation logic employed by the game. As a result, the farm game builds upon child development theories and the definition of expected skills and tools to provide the scientific basis for the rationale of the game [6, 13].

Aiming to analyze play performance, a thorough and systematic process needs to be applied in order to address the factors that may affect children's functionality and identify the context related factors as well as the interrelations among them. All factors are interrelated and can be grouped as follows: (a) child factors, (b) performance skills, (c) activity demands and (d) context and environment [1, 5]. Relevant studies in the domain of activity recognition for monitoring children's developmental progress have focused more on the recognition part than on the 'play' aspect [8, 14].

Historically, children have been encouraged to play with physical objects such as building blocks, shape and jigsaw puzzles, in order to enhance a variety of their skills [11]. In general, a growing number of research projects have begun to investigate the usefulness of tangible interfaces because they present a lot of advantages, which have also been validated by many authors [2, 9]. Tangible interfaces aim to open up new possibilities for interaction that blend the physical and digital world together [7], and have the potential to provide innovative ways for children to play and learn through novel forms of interaction [10, 12].

However, little work has been conducted so far that employs developmental theories and AmI technology to offer games capable of monitoring and adapting to child's development in an unobtrusive manner. To this end, this paper presents three main contributions: (a) the novel design of the farm game which has been conducted in collaboration with occupational therapists so as to embed aspects of their work and therapeutic procedures, (b) the adaptation logic of the game relying on OT expertise and activity analysis based on the ICF-CY [16] and Denver II scale [6] together with runtime interaction monitoring and statistical analysis [18], and (c) the game itself was developed using a distributed service architecture were technology is embedded in everyday objects and deployed within the environment thus providing a unique enhanced playing experience to children, while also maintaining and expanding the therapeutic qualities of the game itself.

3 Technological Infrastructure

The design of the game was conducted on the basis of an existing technological infrastructure that includes an augmented interactive table called Beantable [17] and a cross-platform remotely-controlled 3D avatar called Max [19], shown in Fig. 1. Beantable is made up of technological components that offer the child the opportunity to engage in virtual play situations either alone or with the presence of a virtual partner called Max. The "means" that the child can use during interaction include: (a) force-pressure sensitive table surface, (b) physical object recognition, (c) speech recognition, (d) gesture recognition, (e) body movement recognition, (f) force-pressure and orientation sensitive pen, and (g) digital dice [17, 20, 21].

Fig. 1. Beantable: An augmented interactive table accompanied by a cross-platform 3D avatar.

Max can act as a guide, assistant or information presenter for novel, cross-platform Ambient Intelligence (AmI) edutainment scenarios. The role of Max depends on the client-application's requirements. In order to achieve natural communication channels both non-verbal and verbal behavior are essential. Non-verbal communication includes full body animation and facial expressions.

4 The Farm Game

The farm game is organized in 4 levels, each one addressing the developmental needs of a specified age range between 3 to 6 years. Each level targets selected activities from two categories: (a) specific activities related to child's matured abilities (based on the Denver II scale) and (b) general activities related to the activity's prerequisites (e.g. watching, listening). Based on the data stemming from activity analysis and OT expertise, targeted activities were identified along with the adaptation logic and the physical design of the game.

The player has to execute a number of tasks for achieving the game goals. Involved activities include watching, listening, adapting to time demands, communicating with the virtual character Max, etc. Furthermore, the farm game requires various body functions related to the execution of playing actions such as mental functions (discriminating shape, size, color, etc.), problem solving, time management, voice, speech functions, etc. Finally, the farm game targets various performance skills such as (a) remaining seated, (b) listening to spoken messages, (c) matching items, etc.

The game is responsible to monitor and evaluate the play performance and commit a representative score to the adaptation infrastructure mechanism (AIM) which is part of the Bean framework and provides the child's profile [18]. AIM analyzes the play performance of the current level's specific activity and makes appropriate adaptation suggestions back to the game. Through statistical analysis, AIM is able to identify potential activity limitations, extract the current child's capacity in the execution of targeted activities as well as estimate the child's developmental rate. As a result, the adaptation logic is able to identify children whose play performance deviates significantly from the average population of their age using Denver II scale and report the outcomes to parents and caregivers. Additionally, using this information, the game can adapt to the child's evolving skills so as to choose the most appropriate level according to child's estimated abilities.

The design of the game was based on an actual physical puzzle game. The puzzle pieces act as the physical part of the game, while the background is provided digitally on the Beantable's surface. Wooden pieces, including physical objects and the identity card, were scanned in order to create their virtual counterparts employed in the game. Special visual markers were added on the bottom side of the physical pieces (Fig. 2A) which are recognizable by the system. Additionally, in the case of identity cards, lanyards were placed on the top of the physical objects (Fig. 2B). Children store all the physical items in a box called the "Farm Box", which also has a visual marker attached.

Fig. 2. (A) Physical items and attached visual markers. (B) Tagged identity cards with lanyards.

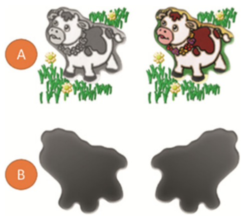

Fig. 3. Alternative instantiations of virtual animals.

At the beginning of the game, Max asks the child to place his identity card on the surface as shown in Fig. 4A. The system recognizes the identity card and remotely requests child's profile from AIM in order to initialize the game accordingly. Max welcomes the child by announcing his/her name and asks the child to find and place the "Farm Box" on the Beantable's surface as shown in Fig. 4B. Thereafter, the game is started at a level corresponding to the child's maturity profile, while Max explains the relevant instructions.

Fig. 4. (A) Waiting for the identity card. (B) Waiting for the “Farm Box”.

At the **1st** level (age 3 to 4), the child has to place each physical object to its corresponding virtual position (Fig. 5A). Each virtual position depicts an animal in the form of black and white. The system recognizes successful matching between the physical object and its virtual position even when its orientation is wrong. Upon successful recognition, the gray-out virtual position is colored (Fig. 3A) and the system rewards the child by the reproduction of the animal’s sound.

Fig. 5. Indicative game level instances.

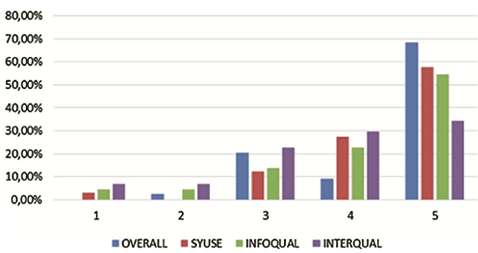

Fig. 6. Usability factors (children).

Fig. 7. Young children playing the farm game.

The game tracks various interaction data such as the number of invalid placements for each virtual position and submits them to AIM. The latter sends feedback including indications about possible weaknesses regarding child’s play activities making the game to adapt appropriately. For instance, the sound of the virtual animal is produced even when the physical object is placed on it after several misplacements, thus the child is assisted to identify the depicted animal. The game level is completed when every physical object is placed on its corresponding virtual position by activating the **congratulation mode** of the game, where Max congratulates the child by saying a random rewarding message. When AIM reports severe weakness, the **free play mode** is activated allowing the child to interact freely, without any errors signaled, thus keeping him as much as possible engaged.

At the **2nd** level (age 4 to 5), the child has to place more physical items in their virtual positions (Fig. 5B). The game's logic is extended to require properly aligned physical object placement. At the **3rd** level (age 5 to 6), the child has to place every physical object (Fig. 5C) while no feedback is provided even when matching is successful. The system checks for correct matching, proper orientation and reports interaction data to AIM only when every virtual position is covered by a physical object. That functionality remains the same at the **4th** level (age 6 to 7) with the only difference that the virtual positions are created using the mirrored and the normal outline of each physical object (Figs. 3B and 5D).

5 Evaluation

A small scale evaluation of the farm game was conducted in order to explore usability, playability and applicability in the context of OT practice. The participants list of the evaluation consists of: (a) 14 children, (b) their parents, and (c) early intervention professional comprising of two occupational therapists, a psychologist and a special education teacher. Each child played the farm game while the child's parent(s) and professionals were observing. The children were encouraged to play freely without any external interventions by adults (Fig. 7). After each evaluation session, children and parents were required to fill in a questionnaire developed separately for each user group. Early intervention professionals completed their questionnaire after the completion of all the evaluation sessions. The interaction of children with the game was recorded in consensus with their parents. The evaluation results were extracted through an analysis of the recorded sessions and the results of the questionnaires. The recorded sessions were analyzed by usability experts to produce recommendations regarding further improvements of the game, while the questionnaires were used to calculate quality factors. Overall, four factors were calculated, and namely OVERALL (overall satisfaction), SYUSE (satisfaction when using the system), INFOQUAL (information quality) and INTERQUAL (satisfaction regarding the user interface). Figure 6 shows the results for children. Overall, it can be concluded that the young users were satisfied from the game. However, there is a lot of room for improvement such as the interaction quality. In case of parents, the game scored well in all the calculated usability factors with scores for 8 to 10, gathering the majority of their goals for all usability factors. Professionals' rating was also very positive and this was also expressed during the informal interviews conducted after the completion of the evaluation. They commented very positively both the design of the game and the adaptation mechanism.

Regarding playability, children reported a few problems as follows: sometimes Max was unable to understand their answers, the game remained the same between levels (although the virtual positions and the background were randomly selected), and the 4th level was not quite similar to the previous ones. Some parents commented that the game should give feedback every time the child places a physical object to its correct virtual position. For example, a visual or an audio feedback to give the feeling that the item is correctly placed as happening in the actual traditional game. Moreover, parents think that the voice of Max should be louder and less computerized. Professionals commented that the game should demonstrate the "how to play" guidelines only for the first time the child chose to play. Furthermore, they noticed that Max was slow in his reactions while the game's idle time was too short. They also expressed concern about the size of the secondary screen presenting Max that in their opinion should be bigger. Finally, they found that the monitoring and adaptation logic of the 4th level should not be as tolerant as it was. More importantly, both parents and early intervention professionals commented that the game could successfully adapted to children's skills and abilities. In case of a 5.5 years old child, facing learning difficulties, the game efficaciously adjusted the difficulty level due to possible skill immaturities indicated by AIM.

6 Conclusion and Future Work

This paper has presented the design, implementation and deployment of a popular farm game capable of monitoring and following the progress of each young player. The farm game is able to adapt accordingly and provide important information regarding the abilities and skills of the child and the inferred development progress over time. This was achieved by employing OT knowledge during design process and by exploiting existing technological components such as an interactive table for preschool children, a remotely-controlled 3D avatar and an adaptation infrastructure mechanism. The presented game adjusts the difficulty and playing demands according to the measured developmental progress of the young player following the developmental expectations of child's play performance for age related activities.

The produced version of the game was evaluated in the context of a small scale study with children of the aforementioned age groups, their parents, as well as early intervention professionals. The results of the evaluation were positive for all the aforementioned user groups, but also generated feedback regarding possible improvements of the game in the future. In the case of children, the game in general was proven to be suitable for all age groups and this was also mirrored in the way the adaptation mechanism was functioning while playing. Currently, the farm game is hosted in a children's playroom setup within FORTH-ICS's AmI research facility. Regarding future work it is considered crucial to design an evaluation strategy comparing the presented game to the traditional one along with the active contribution of the aforementioned end users.

Acknowledgments. This work is supported by the FORTH-ICS internal RTD Programme 'Ambient Intelligence and Smart Environments'.

References

1. American Occupational Therapy Association. Occupational therapy practice framework: Domain & process. 2nd edition. Amer Occupational Therapy Assn (2009)
2. Ananny, M.: Supporting children's collaborative authoring: practicing written literacy while composing oral texts. In: Proceedings of the Conference on Computer Support for Collaborative Learning, Boulder (2002)
3. Axline, V.M.: Play Therapy. Random House LLC, New York (2012)
4. BECTA. Keyboard Skills in Schools. British Educational Communications and Technology Agency, Covertry (2001). http://www.becta.org.uk/technology/infosheets/index.html
5. Fisher, A.: Overview of performance skills and client factors. In: Pedretti's Occupational Therapy: Practice Skills for Physical Dysfunction, pp. 372–402 (2006)
6. Frankenburg, W.K., Dodds, J., Archer, P., Shapiro, H., Bresnick, B.: The Denver II: a major revision and restandardization of the denver developmental screening test. Pediatrics **89**(1), 91–97 (1992)
7. Ishii, H., Ullmer, B.: Tangible bits: towards seamless interfaces between people, bits and atoms. In: Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems, CHI, pp. 234–241 (1997)
8. Kientz, J.A.: Decision support for caregivers through embedded capture and access. Ph.D. thesis, College of Computing, School of Interactive Computing, Georgia Institute of Technology, Atlanta, GA, USA (2008)
9. Marco, J., et al.: Bringing tabletop technologies to kindergarten children. In: Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology. British Computer Society (2009)
10. Marshall, P.: Do tangible interfaces enhance learning? In: Proceedings of the 1st International Conference on Tangible and Embedded Interaction. ACM (2007)
11. O'Malley, C., Fraser, D.S.: Literature review in learning with tangible technologies (2004)
12. Price, S., Rogers, Y., Scaife, M., Stanton, D., Neale, H.: Using 'tangibles' to promote novel forms of playful learning. Interact. Comput. **15**, 169–185 (2003)
13. Vygotsky, L.S.: Play and its role in the mental development of the child. Sov. Psychol. **5**(3), 6–18 (1967)
14. Wang, P., Westeyn, T., Abowd, G.D., Rehg, J.M.: Automatic classification of parent-infant social games from videos. In: Electronic Proceedings of the International Meeting for Autism Research (2010)
15. WFOT: http://www.wfot.org/AboutUs/AboutOccupationalTherapy/DefinitionofOccupationalTherapy.aspx
16. World Health Organization (ed.) International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY (2007)
17. Zidianakis, E., Antona, M., Paparoulis, G., Stephanidis, C.: An augmented interactive table supporting preschool children development through playing. In: Proceedings of the 2012 AHFE International Conference (4th International Conference on Applied Human Factors and Ergonomics), pp. 744–753, San Francisco, California, USA (2012)
18. Zidianakis, E., Ioannidi, D., Antona, M., Stephanidis, C.: Modeling and assessing young children abilities and development in ambient intelligence. In: De Ruyter, B., Kameas, A., Chatzimisios, P., Mavrommati, I. (eds.) Ambient Intelligence. LNCS, vol. 9425, pp. 17–33. Springer, Heidelberg (2015)
19. Zidianakis, E., Papagiannakis, G., Stephanidis, C.: A cross-platform, remotely-controlled mobile avatar simulation framework for AmI environments. In: SIGGRAPH Asia 2014 Mobile Graphics and Interactive Applications, p. 12. ACM (2014)

20. Zidianakis, E., Partarakis, N., Antona, M., Stephanidis, C.: Building a sensory infrastructure to support interaction and monitoring in ambient intelligence environments. In: Streitz, N., Markopoulos, P. (eds.) DAPI 2014. LNCS, vol. 8530, pp. 519–529. Springer, Heidelberg (2015). doi:10.1007/978-3-319-07788-8
21. Zidianakis, E., Zidianaki, I., Ioannidi, D., Partarakis, N., Antona, M., Paparoulis, G., Stephanidis, C.: Employing ambient intelligence technologies to adapt games to children's playing maturity. In: Antona, M., Stephanidis, C. (eds.) UAHCI 2015. LNCS, vol. 9177, pp. 577–589. Springer, Heidelberg (2015). doi:10.1007/978-3-319-20684-4_56