Augmenting a Virtual World Game in a Physical Environment

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Abstract

Computer games and virtual worlds offer unique possibilities for learning and personal development. Physical world play on the other hand offers its own unique opportunities. To combine these opportunities, we have developed the Augmented Home, a game which combines the qualities of both worlds and integrates them into one. This game is designed for children and their parents who can through the system benefit from advantages of both worlds. The Augmented Home draws the virtual world into the physical by binding it to the physical environment. Interaction with the virtual world is made possible through a device that functions as a channel between the two worlds. It channels output of the virtual world to our senses and vice versa channels our actions to the virtual world. The system allows children and parents to experience the virtual world together while they are engaged in activities that benefit the child's educational, social and creative development.

Keywords: *virtual worlds, physical play, educational games, development of children*

1 Introduction

In recent years, computer games and virtual worlds have come to play an increasingly important role in the development of children. They provide a relatively safe playground to experiment with concepts that are important in our everyday life such as social contacts, math, language and financial principles. Moreover they provide the opportunities for tailored educational activities that are considered to be fun.

A disadvantage of this development is that children could be addicted to these virtual worlds and games [1]. This leads to problems such as social isolation [2] and obesity [3]. Most of these virtual worlds and games separate the children from their physical environments. This also means that other people from the physical world, such as parents, can hardly be involved in the virtual experiences.

In this paper we introduce 'the Augmented Home', a virtual world game that appears to be part of our everyday physicality, for parents and children to play together. This is a computationally generated and mediated world that is not bound to its generative medium - a personal computer, but rather is accessible in the physical world. It combines the qualities of both the physical and the virtual world.

The augmented home draws the virtual world into the physical by binding it to the physical environment and placing the virtual (objects and characters) in our physical world. Interaction with the world is made possible through a device that functions as a channel between the two worlds. It channels audio from one world to the other and allows you to 'feel' and manipulate the world through movement and touch, which stimulates the children's imagination. Through the interaction devices of the augmented home, the children can, together with the parents, participate in challenges and educational games, and experience narratives that stimulate the development of creativity, reasoning and social skills.

Next related work is introduced, followed by a discussion on the qualities of the virtual and physical worlds. The concept of the Augmented Home is then presented, together with implementation details. It was evaluated in a controlled lab setting. The results of the experiment are summarized and discussed, before the conclusion.

2 Related Work

Digital Virtual worlds are online virtual environments where people flock together to have alternative everyday experiences. These environments emerged together with the rise of the Internet [4], and have been growing ever since. Though the appearance of the environments has changed from text-based message boards to advanced 3D worlds, the general concept is still the same. In virtual worlds, the same phenomena appear to emerge as we can see in our common reality: social structures, economies, relations, etc. One of the examples is Second Life [5]. There are however many more and they all vary in their scope, theme, and extend to which they are governed. Some of these worlds have a more game-like set-up, such as World of Warcraft, where there is a larger set of rules given by the world itself.

From complete virtual towards reality, augmented reality concerns the concept of merging computer generated digital content the physical world [6]. It is a concept that has emerged together with the emergence of the computer and has evolved dramatically since the beginning. With enabling technologies becoming smaller and more affordable, augmented realities have also started to spread into everyday life. With platforms such as the smart phones, an increasing number of applications use sensors such as camera and GPS to couple digital information to the physical world. Examples are Layar and Wikitude [7] for Android and iOS phones.

Emphasizing the quality of physicality, tangible interaction proposes the use of physical artifacts to act as representations as well as controls of the digital realm [8]. In the 1990's systems, this field emerged with mainly tabletop systems with both physical as well as digital elements used to represent and control parameters of an underlying computational model. Since then, tangible interfaces have explored different application domains, modalities and methods of integrating representation and control. Today, there are numerous examples of systems that adopt the tangible interaction philosophy by focusing on the physical control part of the concept. Examples of these concepts are the reacTable [9] ApartGame [10]. Research also shows that, with proper design, tangible interfaces can enhance learning [11] and support the development of children [12, 13].

3 The qualities of the Virtual and Physical World

The fields described in the previous section provide us with an insight in the potential of both the virtual and the physical. The virtual and the physical have different qualities for the development of children.

3.1 The Qualities of the Virtual

Interactive. Virtual worlds provide a form of interactive free play, allowing children to participate in their own narrative. They can be director, actor and observer at the same time [4]. It allows for guidance, and triggers children to explore areas they were unfamiliar with.

Dynamic and Tailored. Virtual worlds have the capability of switching rules and roles and the capability of tailoring an activity towards a specific user. The difficulty and theme of a virtual world game can be set to match age, preference and previous experiences of the children. A virtual world can take into consideration what is the norm and can detect any unbalances in development based on previous experiences.

Exploration and identity development. The choices made in the virtual worlds are relatively free from the consequences in the physical world. The virtual world therefore provides a safe playground for exploration. Children can therefore experiment with the effects of their actions, which contributes to their identity development.

Unusual Experiences. In virtual worlds children can experience what they cannot usually experience in the reality, allowing for a high diversity of experiences, and for instance fantasy and strong feeling of achievement.

3.2 The Qualities of the Physical

Sharing experiences with parents. Sharing experiences with the parents is of great importance for the development of children. It strengthens the bond between parent and child, and when playing together, the parents can show the children how to do things and are able to supply extra information when needed. In virtual worlds this is usually not well supported.

Social context. It is important for children to be an active participant in the social context in which they live [14]. It allows children to learn about relations in such a context and experiment with social behavior and consequences.

Physical Activity. Being physically active is important for the human body in general and physical play is important for children the develop not only physical but also mental capabilities [15]. Today children's obese is a real problem for many countries [3], the advantages of the digital games should help to counteract this problem, not to contribute to it.

Physical Behavior. Interactions with our physical world teach children about the properties and behaviors of material and objects. Learning about the way the world behaves makes it much easier to later grasp concepts like mass, balance and centrifugal force. Although some computer games and virtual worlds incorporate a certain level of physics and sometimes even focus on the understanding of these physics, this does not provide the same experiences as in the physical world.

To further understand the potential qualities of the integration of the virtual and the physical, the Augmented Home, a virtual world game was designed for parents and children to play together.

4 The Augmented Home

The Augmented Home is realized by creating an overlap of the virtual world over the physical environment [16], by integrating the values of both the virtual and the physical [17], and by making the virtual world available to all members of the family, allowing them to perceive it as part of their daily life.

4.1 design concept

A virtual world is designed to be an overlapped layer of the physical home, as a game platform for children (age between 4 and 12) to play together with parents at home. The story in this is about a group of characters live inside the house with some virtual objects. The users can communicate with the characters and do something with the objects. This is the basis for progression in the world, very similar to various digital virtual worlds. Different from the most of the virtual worlds available online, the Augmented Home is only apparent through sound and touch, allowing and encouraging the imagination of users and especially the children. The approach taken here is very similar to reading a book or telling a story; the visual aspect of the virtual world is constructed by the person listening to it or reading it [18]. This stimulation of imagination contributes to the child's development, especially in terms of creativity.

4.2 scenario and prototype

One scenario of the Augmented Home is worked out as a working prototype for user evaluation. The scenario and the prototype are briefly described next.

Scenario. The story is about a character called Dibbel who has lost his cat (Fig. 1, see also Fig. 4). Dibbel asks for cooperation from the user to help him find his cat and return the cat to him. There are however some difficulties. The cat is asleep and can't be found unless the user ring its bell in the same room. Furthermore, the cat is quite shy, and therefore tends to run away if the user approaches. If the user keeps the cat at ease with a cup of milk, the user can pick up the cat and return it to Dibbel. For the cup of milk the user needs to get it from Lilly, another character. She is somewhere in the house and the user has to find her first. If the user gets the milk from Lilly, the user has to walk carefully in order not to spill the milk from the cup.

Prototype. The prototype initiates the conversation with prerecorded sentences; the user can talk back to the virtual world through the channeling device (Fig. 2). Speech recognition is used to

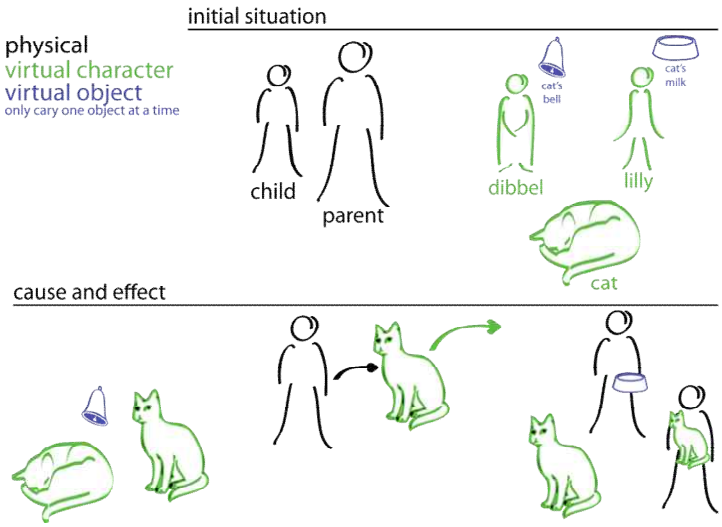

Fig. 1. Scenario

Fig. 2. Channeling device between the virtual and the physical in Augmented Home

understand possible responses. The virtual objects that can be carried using the channeling device in the prototype are the bell, the milk and the cat. When carrying a virtual object, the user would feel the channeling device to be heavier. When carrying the bell, shaking it will create a ringing sound. When carrying a cup of milk, tilting the device will spill a bit of the virtual milk. When it is tilted too far, it will spill all the virtual milk and the user would feel the device to be lighter. The user has to return to Lilly to get new milk. When the cat is picked up, a purring sound would be heard from the channeling device.

The channeling device uses sound and tactile feedback to let the users experience the virtual world, and in turn, the users can influence the world via the same modalities. The users can talk to the characters in the virtual world. The sounds from the virtual world come out on one end of the channel, and are 'physically' output through the speaker on the other end. Speech from the user to the virtual world goes exactly the other way round.

The channeling device is also used for exploring the virtual world in the physical environment. The user can point the device at places around the room, until a character or an object is felt or heard. Distance to the virtual character or object can be felt through vibration with different levels of intensity. The closer, the stronger the vibration is. At the same time an identifier sound can be heard for the user to identify the character. The volume of the identifier also indicates the distance to the character.

When a virtual object is received, the channeling device can be felt heavier – the illusion is created using a weight distribution system inside. The virtual object can then be carried around and given to other characters by moving it closer. Depending on the object, having or using the object may also generate sounds. When the user would carry a bell, shaking the device will generate the sound as if the bell is ringing.

4.3 Implementation

The channeling device. The device contains a battery and a power conversion system, an Arduino microprocessor, an xBee radio for data transfer, a vibration motor and an accelerometer (Fig. 3). In addition, it has an infra-red detector with signal strength measurements, Bluetooth audio, an audio amplifier and a speaker. A weight distribution system is used to create the illusion of the device becoming heavier or lighter. The prototype determines its location based on infra-red signals that it receives from beacons hidden in the environment. The device is programmed using the Arduino software.

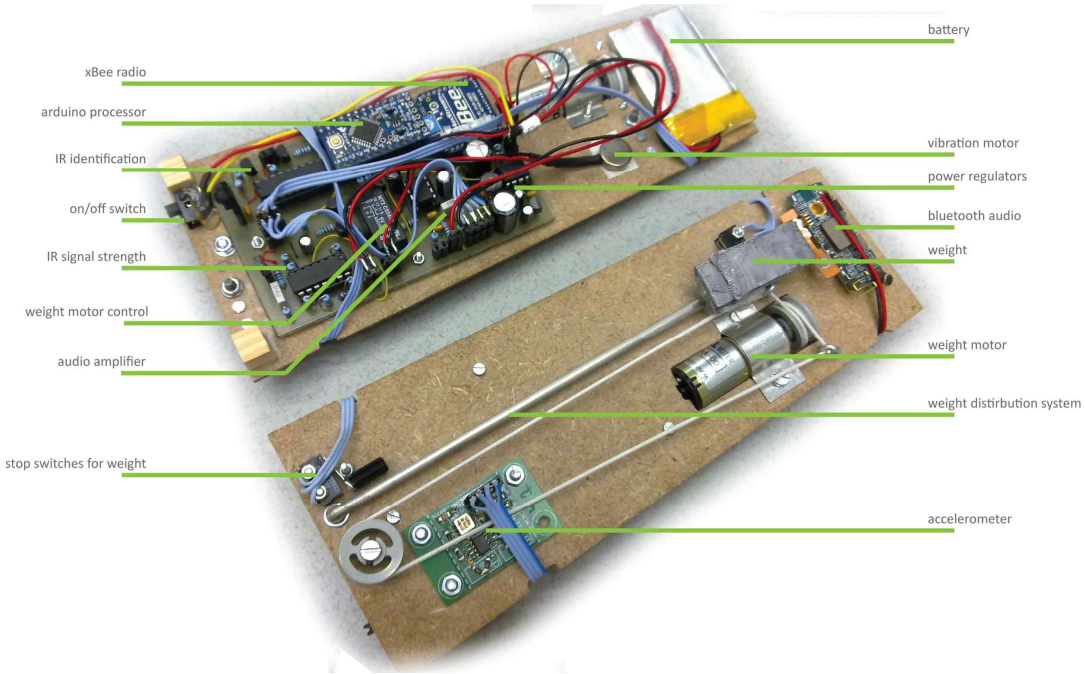

Fig. 3. Implementation of the channeling device

Server. The server is a distributed system, with a component that controls the virtual world and for each channeling device, a communication component that connects the device to the virtual world. The virtual world component contains a basic model of the house (a set of locations) and the positions of the devices based on the information received from the devices. The server assigns all virtual characters to a physical location (an IR beacon). All virtual objects are associated to a character. A virtual character can move from one location to the other, and a virtual object can move among characters, depending on the user interaction. For instance if the user approaches the location of a cat without the milk, the cat will run away to another location. If the user is carrying the milk but the milk is spilled (device tilted too much), the server will take away the milk from the device and give it back to Lilly. The server is also responsible for the conversation management. The server components are programed in Processing.

5 Evaluation

The Augmented Home was evaluated with three groups of a child and one of the parents. The evaluation consisted of observations and semi-structured interviews. The purposes are

1. To evaluate the extent to which the participants understand the concept of the overlapped layer of the virtual world in the physical home environment. An important indicator for this would be whether the participants feel the virtual world is around them in their physical environment or whether it is perceived to be in the channeling device.
2. To evaluate the extent to which the participants understand the characters and objects that are invisible in the physical environment, and the extent to which they can interact with the virtual world through the channels of sound and tactile feedback.
3. To evaluate the shared experience of cooperation and communication between the parent and the child in interacting with the virtual world in the physical environment.

5.1 Participants, Setup and Procedure

The children participating in the evaluation were all between the age of 5 and 9. These age limits were chosen together with a primary school teacher based on complexity of the challenge that was worked out in the prototype.

The evaluation took place in the Context Lab of the Department of Industrial Design of Eindhoven University of Technology. The Context Lab is a home like setting consisting of a living room, and two bed rooms for parents and children.

Both the parent and child received a channeling device. A task was then introduced to them as described in previous section. Before the experiment started, the participants are given the opportunity to ask questions if there was anything not understood. They were also told that questions could be asked during the assignment if needed. The participants then performed the task (Fig. 4), after which a semi-structured interview took place with both the parent and the child together.

Fig. 4. User evaluation with the Augmented Home

5.2 Results

All children perceived the overlapping virtual world as very “real”. After the evaluation, they indicated that they thought that Dibbel and the cat were still around. One of the children said: “I think they are playing together outside, because they are now reunited.” This also indicates that the Augmented Home triggered the imagination of children as they came up with their own stories.

Two of three children tried to find the virtual cat, based on the behavior of real cats they were familiar to. They started by looking for the virtual cat in the couch and the bed, as these were the places where the real cats they knew would usually stay. One child also kept on reasoning after the evaluation, about how they could have done better by trying to understand the behavior of the virtual cat. Although one of them did not manage to find the cat at the beginning, "We might have found the cat if we were a bit more quiet, she might be scared". All children also immediately knew how to ring the bell with the channeling device when they were asked to do so by one of the characters.

All group showed roughly the same behavior concerning the division of their roles. The child did the primary conversations and took all the decisions that could be made, while the parent guided by asking rhetorical questions. The parents also carried the milk as that allowed their child to carry the cat; "I would not want to take the opportunity away from my son to carry the cat, so therefore I took the milk."

The cooperative nature of the game was considered to be a very positive aspect. Compared to the digital games that the participants played before, this was the first game where they could actually work together as equals in a team. "It allows you to do things together rather than play against each other or help from the sideline." Another parent stated that "It's a very social game…"

When asked about similarities and differences with other existing games, most comparisons were made with "hide and seek" for its explorative and surprising nature as well as for its physical part of the game. The comparison to reading to a child was also made by one of the parents, with the annotation that the interactivity of this game added a great advantage. "With this system you are able to influence the story…" The main similarities here were the imaginative aspect, the extent to which the story is experienced together and the division of the roles in this experience. Comparisons were also made to other digital games. Similarities here were mainly the way you can progress through a narrative and the 'quest'-like setup. Having virtual characters was mentioned by two of the parents as one of the similarities. Differences were mainly the interaction, except when comparing it to Nintendo Wii, a system that two out of three couples had experienced. The parents saw similarities in the interaction as it is both relatively physically active. "It's like the Wii, but with this you can move around the house…"

Concerning the understanding of the world and the way in which the characters and objects could be interacted with, little was unclear to the participants, especially after an initial introduction. One parent however stated that "when you start, you quickly need confirmation about whether you are doing it right."

The interaction with the virtual characters and objects through the channeling device in general went smooth. Moving around the physical house to pay a virtual world game was considered to be a fun activity. The multi-functionality of the device and the use of virtual objects did not lead to any problems and was understood by all participants. The tactile feedback did contribute to the experience and conveyed the intended information.

Triggering the imagination of the children by removing the visual aspects of the virtual world and using only sound and tactile feedback was considered to be one of the strongest points of the design. One of the parents stated that "I didn't notice that it did not have a screen or something, now that you mention it I believe that really allows my son to imagine it for himself."

6 Discussion

The Augmented Home tries to integrate the qualities of both the physical and virtual worlds for the benefit of the development of children. The system was intended to be perceived as part of everyday reality, stimulating imagination and allowing children and parents to experience it together. In the evaluation of the Augmented Home, we have seen that the children perceived the virtual world as real and combined ideas presented in the virtual world with ideas from the physical world. This indicates that a clear distinction between the two was not made. The children were also able to imagine various aspects of the game that were not provided by the system such as character locations, activities and behavior. We have also seen a more cooperative relation emerge between parents and children. It allows the parents to support the development of the children while being engaged in a virtual world.

Furthermore the evaluation showed that children can be engage in a virtual world and benefit from its educative qualities without being separated from the 'real world'. The qualities of the virtual world,

such as the tailored complexity and interactivity, were present and not compromised by the lack of physical qualities such as physical play and the ability to involve others in their activities.

When looking back at the work, and especially at the field of tangible interaction, another thing stands out. Within the field of tangible interaction there are numerous projects that support the learning of children. However, besides what we learn through dedicated learning activities, a large part of our development takes place through our everyday experiences. Virtual worlds provide these everyday situations, but with the drawback of the separation from our everyday world. The Augmented Home combines the qualities of everyday computationally enhanced learning. It would be interesting to see more systems that exploit this area.

One could argue that the system proposed still tends to pull the children out of their everyday reality and into the virtual world. We however believe that with the proposed integration, the distinction between virtual and real is no longer relevant. We already live our lives surrounded by –and immersed in– various virtual worlds in a broader sense. A reality is not determined by its material form, but by our common perception and agreement upon its existence.

The system as proposed is a stand-alone system that ends roughly around the home environment. It would be highly interesting to further explore the opportunities for networked worlds where children could together explore their shared virtual worlds in the schoolyard or at each-others place.

Another advantage of virtual worlds such as Second Life is the possibility for user generated content. People have the possibility to shape their own environments and create their own characters. The Augmented Home as proposed does not yet implement such creativity. It would be interesting to see how this could be implemented.

7 Conclusion

The Augmented Home allows experiencing the designed virtual world with a large subset of its qualities in the everyday physical environment. Besides the combined qualities, there are some distinct qualities that are a result of this integration in the Augmented Home.

One of these distinct qualities is the cooperative opportunity that this approach offers. Parents and children can cooperate in an interactive narrative in their physical environment where they can together determine the path of the story whilst interacting with artificial actors and external influences.

A second distinct quality is using sound and tactile feedback as interaction modalities, instead of the visual channel. Envisioning the virtual world requires and triggers imagination of children.

The proposition of the Augmented Home allows people to benefit from the qualities of virtual worlds in their physical daily live. In this paper this advantage is proposed as a part of the education development for children. This concept could however be implemented in a broader perspective, making the virtual available to in other everyday physical contexts. Similar benefits of the virtual world can be found for adults. The desire for such worlds can be observed in the popularity among adults of the online virtual worlds.

With the Augmented Home, we have done a first exploration of the design space, a preliminary evaluation of the system and the potential of its underlying principle. It would be interesting to see further explorations aiming at studying the effect of such systems in a more formal manner in the future.

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