MIT Libraries | DSpace@MIT

MIT Open Access Articles

Exploring the Design of a Wearable Device to Turn Everyday Objects into Playful Experiences

Massachusetts Institute of Technology

Exploring the Design of a Wearable Device to Turn Everyday Objects into Playful Experiences

Judith Amores*

MIT Media Lab

75 Amherst Street

Cambridge, Ma 02142 USA

amores@media.mit.edu

Xavier Benavides*

MIT Media Lab

75 Amherst Street

Cambridge, Ma 02142 USA

xavib@media.mit.edu

Roger Boldu

MIT Media Lab

75 Amherst Street

Cambridge, Ma 02142 USA

rboldu@media.mit.edu

Pattie Maes

MIT Media Lab

75 Amherst Street

Cambridge, Ma 02142 USA

pattie@media.mit.edu

* Equal contribution to this work

Abstract

In this paper we present a wearable device in the form of a bracelet that turns everyday objects into interactive physical gameplay. We combine physical exploration and interactive entertainment by providing real-time audio and light feedback without the need to be in front of a screen. In contrast with today's computer, video and smartphone games, our system has the potential to enhance children's physical, social and outdoor play. We designed a set of playful applications that seamlessly integrate technology with outdoor game play, music, sports and social interactions.

Author Keywords

Wearable Device; Interactive system; Children; Play; Physical interaction; Intuitive Interfaces; Multi-sensory interfaces; Ubiquitous Computing; Smart Environments.

ACM Classification Keywords

H.5.2 Information interfaces and presentation: Interaction.
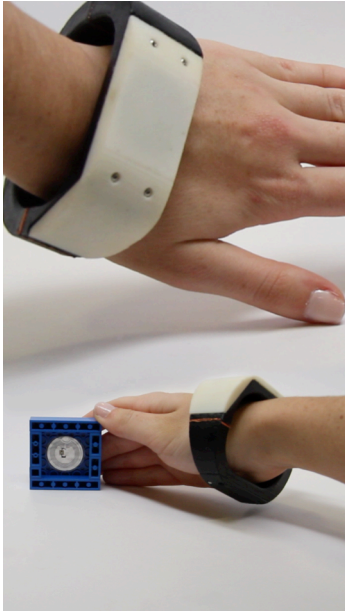
Figure 1. The 3D printed prototype and a Lego piece with an embedded RFID tag.

Introduction

Millions of children around the world use a variety of interactive games to entertain themselves, ranging from video game consoles to smartphone and tablet applications. Many children and young adults use these and other screen-based technologies for more than 8 hours per day [1], taking away from time spent interacting with families and friends. In addition, these technologies provide little need or opportunity for being physically active nor do they encourage social engagement.

We are witnessing the first generation of children who were born surrounded by digital technology and who have spent most of their childhood playing with computers and video game consoles instead of learning through hands-on experiences and direct manipulation with materials and nature. Unfortunately, coordination, social skills and problem solving are best developed away from screens. Researchers have been trying to overcome this problem by proposing novel interactive physical technologies [2, 4].

The current trend of wearable devices opens up new possibilities for human computer experiences. We now have devices to be worn on our arms, head, ears, clothes or even nails, and they have the potential to not only monitor our health, but also to enrich our social and playful experiences.

So far, research and industry have presented child-oriented wearable systems that offer parents the possibility of monitoring the health and outdoor location of their children [3]. However, these systems are designed to meet parents' needs rather than engaging kids in play and promoting social interactions and physical activities.

In this paper we propose a solution to this problem in the form of a wearable device (Figure 1) designed to turn the physical environment into a playful experience, seamlessly enriching the gaming and social experience as well as encouraging kids to engage in physical activities.

Related Work

Research has shown that in order to promote healthy development, children have to engage in social interactions, object manipulation and direct experiences in nature [5]. Tiffany Field argued that touching and manipulating objects as well as social interactions are necessary in order to grow emotionally, physically and cognitively [7]. Other researchers have argued that a lack of sensorial stimulations causes a delay in children's development [8]. Sociologists claim that children who play in nature are more likely to have a positive feeling about each other [9]. Finally psychologists have also shown that music plays a crucial role in the early cognitive development of children [6]. The prototype proposed in this paper is supported by this research as it aims to create a portable platform that enriches outdoor games, social interactions and physical play.

Games have the potential to help children in their development and learning processes [16]. Technologists have aspired to create novel systems and games that support physical play. An example of this is Makey Makey [10], an electronic board that turns everyday objects into touchpads. Antifakos [11] proposed a game that incorporates wearable computers
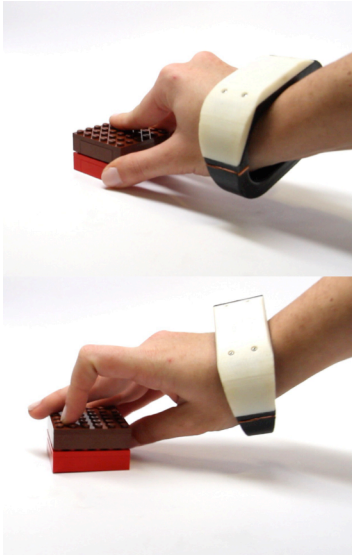
Figure 2. The user interacts with Lego pieces to reproduce different sounds. Each Lego piece has an associated instrument (the red one is a guitar sound and the brown is a drum base). In this case the user stacks pieces to add instruments and rotates the pieces to increase or decrease the volume.

and sensor data from players in order to enhance real world games.

RFID technology and wearable devices [17, 18] have been also used to augment the gaming experience; Tagaboo [12] is a glove with an embedded RFID reader that combines traditional games with tagged physical objects. Another example is SoundTag [13], a system that augments the experience of playing the Tag (game) with sounds. OnObject [14] presents a ring that reproduces sounds when the user performs gestures while holding an object.

We differ from the work just mentioned as we have created a compact and portable solution that brings everyday objects to life. We have designed a set of playful applications that mix kids game play with Internet connected devices through the use of RFID technology.

Interactions Supported

We support a set of interactions that take advantage of the physical properties of the environment as well as the user's gestures to create a hands-on experience that promotes play in the physical world. The interactions we designed are focused on necessary factors to achieve healthy child development such as physical object manipulation, movement and exposure to the environment. We describe these interactions and usage scenarios in detail in the following paragraphs as well as in the Applications section.

Our system consists of a bracelet with embedded RFID reader and several sensors. Simple non-powered RFID tags can be attached to everyday objects. When the user touches the tagged object, the reader reads the

corresponding tag. Based on what tag is read and in what order as well as what gestures the user performs before/after and during, the system then plays certain sounds or audio files, turns on certain lights and more.

Touch and Haptic Feedback
The system can detect when the user is touching or catching an object depending on the proximity between the bracelet and the RFID tagged area. Once the tag is detected, the bracelet executes the actions associated with the identified object. The bracelet has the capability to read several tags at the same time, offering the opportunity to design applications with several nearby objects.

Object Manipulation
The bracelet has an embedded triple-axis gyroscope, an accelerometer and a magnetometer that enable the system to read the user's gestures and determine if there is an object manipulation. The system tracks the rotation, movement and acceleration performed by the user and recognizes certain patterns. This can be used, for example, to turn an inert object into a controller knob to change certain properties or actions (Figure 2).

Physical Movement
The system can be used to support activities or games that involve sensory-motor actions, including fine as well as gross motor skills such as coordination of movements (striking, kicking, and catching) and locomotion (crawling, body rolling, and jumping).

Exposure to the environment
The system can be used to create games for outdoor and indoor environments. RFID tags can easily be embedded into nature without a need for batteries or
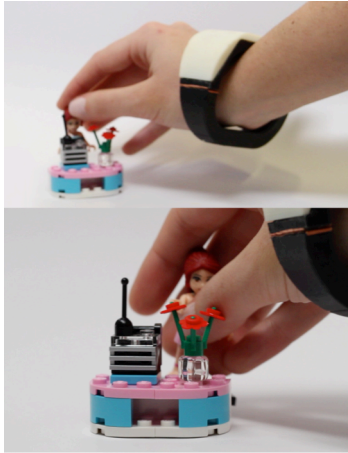
Figure 3. A kid playing with Lego pieces augmented with our system.

sensors. By embedding RFID tags into nature we can encourage children to have outdoor experiences while at the same time creating a controlled situation. For example, a treasure "tag" hunt can be created to encourage kids to pay close attention to and thereby learn about different trees or rocks or historical monuments.

Applications

Playful activities that involve a full sensorial experience are difficult to find in current technical toys. In this section we explain a simple set of playful activities that require little more than the bracelet and a set of RFID stickers. The applications are focused on pre-schoolers, and children within the early years of grade school.

Music and game play

By linking music and game play in the environment, kids can improve their musicality and coordination while using daily life objects as a tool to create music. The player's actions change the behaviour and characteristics of the music, not limiting the player to a fixed set of songs, but choosing any song or sound from his/her music collection.

- In Figure 2, an RFID tagged Lego piece is used as a knob. When the piece is rotated, the volume changes; if we shake the piece, a different rhythm will sound. Each Lego piece has a specific sound or instrument, therefore while the user is building a structure, different sounds and music will be played, adding a sound for each piece, finalizing with a whole symphony.

- Daily objects can come to life and create sounds in indoor and outdoor spaces. For example, a child can create a virtual piano using door handles. Each musical note can be associated with a door handle by attaching an RFID tag. The child can then touch the different door handles to create music.

Physical Activity and Social Engagement

Magical stories can be created to engage kids in indoor and outdoor physical play. In this case, the application brings natural play spaces to life, which may arouse the interest of the kids in nature. For instance, by embedding RFID tags into trees, or burying them underneath flowers or bushes we can guide children toward a hidden treasure in a park or forest. These clues will drive the player to find the next object that will lead to find the treasure.

Another application consists of using the RFID tags as control points to create exercise circuits. The bracelet can monitor basic movements associated with the activity (such as sit-ups or rope jumping) as well as the time spent performing the exercise. In this application kids can challenge their family or friends while encouraging outdoor physical exercise and socializing.

Social Engagement

It is well known that fashion accessories such as bracelets, necklaces or rings have personal meaning beyond the physicality of the object. In this application we explore their meaning to build and represent ties between people. Children and parents could potentially customize the exterior of the bracelet with the same design and configure their bracelets with a certain pattern of vibration when their bracelets are near one another.

Figure 4. The colour of the lamp changes every time we grasp the toy lamp.

Figure 5. RFID tagged Lego

Environment and Storytelling

In this application we explore the use of internet-connected objects to augment traditional tangible toys and mimick game interactions in the real world. Environmental elements such as lights or music can be automatically modified to create an immersive playing experience. For example, in Figure 3, a person is playing with multiple RFID tagged Lego pieces. If the player moves the Lego character towards the radio toy, the real radio in the room will turn on. We can also change the colour of the lights as well as turning on the heat. For example, in Figure 4 the Lego lamp has an embedded RFID tag, so every time we touch the lamp toy, the real light in the room will change colour.

In another application we explored the interactivity of toy characters by embedding RFID tags in multiple parts of the toy and detecting the gestures of the user's hand. The character comes alive and reacts to the child's actions such as shaking, rotation and holding by emitting certain sounds. For instance, we can imagine a Mr.Potato Head with one RFID tag located in the head and another one in the moustache, if the kid pulls off the moustache, Mr.Potato may complain about that. If the kid shakes the character, it will express motion sickness.

Implementation

Software

In conjunction with the bracelet, we have developed an Android application that pairs the bracelet with a smartphone via Bluetooth. This application has several pre-stored tags that are associated with different IDs. Each identifier is associated with certain predefined actions such as turning on the light or playing a sound on the smartphone. As is described in the Applications section, the bracelet can also be used with Internet-connected devices to enhance the game experience and modify the behaviour of the environment.

Every time the bracelet is next to a RFID tagged object (e.g. when the user is grasping or touching an object), the Android application receives real time information on how, when and how many times it has happened. An identifier associated to the tag as well as the times the object has been touched and the timing will be processed by the smartphone. At that moment, the sensor values from the bracelet will be analysed to recognize if the user is rotating, moving or shaking the hand and the smartphone application will trigger the action needed.

Hardware

The hardware expands on the TagMe project [15] by adding into the bracelet a vibrator motor for haptic feedback, a current amplifier for the antenna that increases the range of RFID tag detection up to 7cm, a gyroscope and an accelerometer sensor. The bracelet is wireless connected to a smartphone through a RN-41 Bluetooth module and it also has a SkyeModule M1-Mini TTL for the RFID reader capabilities. A triple-axis gyroscope (ITG-3200) and a triple-axis accelerometer (ADXL345) are embedded on top of the bracelet to recognize accelerations, movements and rotations of the wearer's hand.

Future Work

In the future we will allow children to configure their own games by programming the actions associated with a tagged object using the Scratch software. In terms of the prototype, we would like to incorporate a speaker into the bracelet as well as adding biosensors

to better understand the emotional state of the child as well as redesigning an ergonomic bracelet better adapted for kids.

Acknowledgements

References

[1]   Rideout VJ, Foehr UG, Roberts DF., Generation of M2 Media in the Lives of 8-18 Year Olds. A Kaiser Family Foundation Study (2010).

[2]   Fails, J. A., Druin, A., Guha, M. L., Chipman, G., Simms, S., & Churaman, W., Child's play: a comparison of desktop and physical interactive environments. In Proc. IDC 2005, ACM Press (2005) 48–55.

[3]   Flip: http://www.myfilip.com

[4]   Soler-Adillon, J., & Parés, N.,Interactive slide: an interactive playground to promote physical activity and socialization of children. Ext. Abstracts on CHI'09, ACM Press (2014) 2407-2416.

[5]   Ginsburg, K. R., The importance of play in promoting healthy child development and maintaining strong parent-child bonds. Pediatrics 2007, 119(1), 182-191.

[6]   Boswell, J., The Young Child and Music: Contemporary Principles in Child Development and Music Education. In Proc. MENC 1984.

[7]   Field, T. Touch. MIT Press 2003.

[8]   Ardiel, E. L., & Rankin, C. H., The importance of touch in development. Paediatrics & child health 2010, 15(3), 153.

[9]   Strife, S., & Downey, L., Childhood Development and Access to Nature A New Direction for Environmental Inequality Research. Organization & environment 2009, 22(1), 99-122.

[10] Collective, B. S. M., & Shaw, D., Makey Makey: improvising tangible and nature-based user interfaces. In Proc. TEI 2012, ACM Press (2012) 367-370.

[11] Antifakos, S., & Schiele, B., Bridging the gap between virtual and physical games using wearable sensors. In Proc. ISWC 2002, IEEE (2002) 139-140.

[12] Konkel, M., Leung, V., Ullmer, B., & Hu, C., Tagaboo: a collaborative children's game based upon wearable RFID technology. Personal and Ubiquitous Computing, 8(5), 382-384.

[13] Ryoko Ueoka, Hiroki Kobayashi, Michitaka Hirose, SoundTag: RFID based wearable computer play tool for children. Transactions on Edutainment III 2009

[14] Chung, K., Shilman, M., Merrill, C., & Ishii, H., OnObject: gestural play with tagged everyday objects. In Proc. UIST 2010, ACM Press (2010) 379-380.

[15] Benavides, X., Amores, J., & Maes, P., TagMe: an easy-to-use toolkit for turning the personal environment into an extended communications interface. Ext. Abstracts on CHI'14, ACM Press (2014) 2197-2202.

[16] Druin, A. (2009). Mobile technology for children: Designing for interaction and learning. Morgan Kaufmann.

[17] Kenneth P. Fishkin , Matthai Philipose , Adam Rea, Hands-On RFID: Wireless Wearables for Detecting Use of Objects, In Proc. of the Ninth IEEE International Symposium on Wearable Computers, p.38-43, 2005.

[18] Choi, Y., Tewell, J., Morisawa, Y., Pradana, G. A., & Cheok, A. D., Ring* U: a wearable system for intimate communication using tactile lighting expressions. In Proc. CACET, ACM Press (2014), p. 63.