ELBlocks - An Interactive Semantic Learning Platform for Tangibles

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Abstract

This paper describes and discusses work in progress. With Tangicons and SpelLit we have developed tangible learning games using physical Sifteo Cubes. From this idea we evolved to a web-based platform running the games on mini-tablets. The new approach we introduce in this contribution focuses on Electronic Learning Blocks (ELBlocks), which integrate with our semantic repository, the Network Environment for Multimedia Objects (NEMO) hence interconnecting with all applications and devices of the Ambient Learning Spaces (ALS) research platform.

1 Introduction

Developed in a co-design process with children, *Tangicons* is a non-competitive learning game, which initially ran on comprehensible and graspable physical cubes. The objective is to engage preschool or primary school children in scenarios to foster cognitive skills and social interaction for problem solving combined with fine or gross motoric skills in a physical environment (Winkler et al., 2011; Hahn et al., 2012; Scharf et al., 2012). While Tangicons focus on algorithmic thinking processes, another learning application called *SpelLit* supports learning to read and write for children at the age of preschool or their first years in primary school (Winkler et al., 2013; Winkler et al., 2015). Both games have been designed for group activities, which is decisive for our evaluation approach (Winkler et al., 2014; Wendel et al., 2013). Engaging children in deep learning can be accomplished with joy and fun by serious games (Prensky, 2003; Ritterfeld et al., 2009).

The previous versions of Tangicons and SpelLit were based on the technology of Siftables (Merrill et al., 2007) and the discontinued Sifteo Cubes. Switching to a web-based approach, we opened the platform for mobile devices of all kinds, only a browser and an Internet connection are required. Therefore, we were able to use mini-tablets (XO-Tablet) for our latest studies.

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The evaluation results from learning games running on the Sifteo Cubes are surprisingly different from those with the use of mini-tablets. A possible explanation is that whenever a game requires a certain sequence of placement of either Sifteo Cubes or mini-tablets, tangibles can be placed next to each other and calculate their position and neighbors through their sensor data. Using mini-tablets, this is not possible due to technical restrictions. With the use of tangibles, children are able to interact with physical items representing elements from the games. Our findings show that children had to be an average of nearly two years older to be able to comprehend the interaction with the mini-tablets compared to physical blocks.

Starting from this observation, we continue to develop both Tangicons and SpelLit in a web-based approach while putting the technology back into tangibles again. Therefore, we are currently developing *Electronic Learning Blocks* (ELBlocks), which are tangibles that feature web-based technology. We assume it has a positive effect on the children's performance during the learning games that they can take a hold of the ELBlocks even with their small hands. For example, whilst running children have to carry a tablet with both hands whilst an ELBlock can be carried easily in one hand only. Being able to combine small graspable elements representing parts of the virtual program by placing real world objects together, physical and mental activities have to be interlinked. With the development of ELBlocks, children will again have the physical experience the program's logic through the placement of several small physical devices. Thus, with our work in progress we focus on evaluating our hypothesis that small graspable devices make a difference in learning games. Our research may also provide insights for investigating possible correlations of movements and learning.

Although the ELBlocks are web-based, the games take the relative position of each block into consideration. ELBlocks present more technical capabilities than Sifteo Cubes. This has been achieved by connecting the ELBlocks to our *Network Environment for Multimedia Objects* (NEMO), which features a semantic data and program-logic repository interconnecting applications and devices of the *Ambient Learning Spaces* (ALS) platform (Winkler et al., 2014a). ALS create mixed realities, in which body and space are extended by digital systems. With the connection of the ELBlocks to NEMO we not only have the opportunity to further develop a semantic context for our learning games and connect to other devices and applications from ALS, but we are also able to conduct detailed statistical analyses of all interactions with the devices, applications and systems within ALS.

2 ELBlocks in Detail

ELBlocks are graspable media, so-called *tangibles*. With an individual IP-address assigned, they become a part of the Internet of Things. Apart from the sensors, a touch-screen display as well as a speaker provide input and output capabilities.

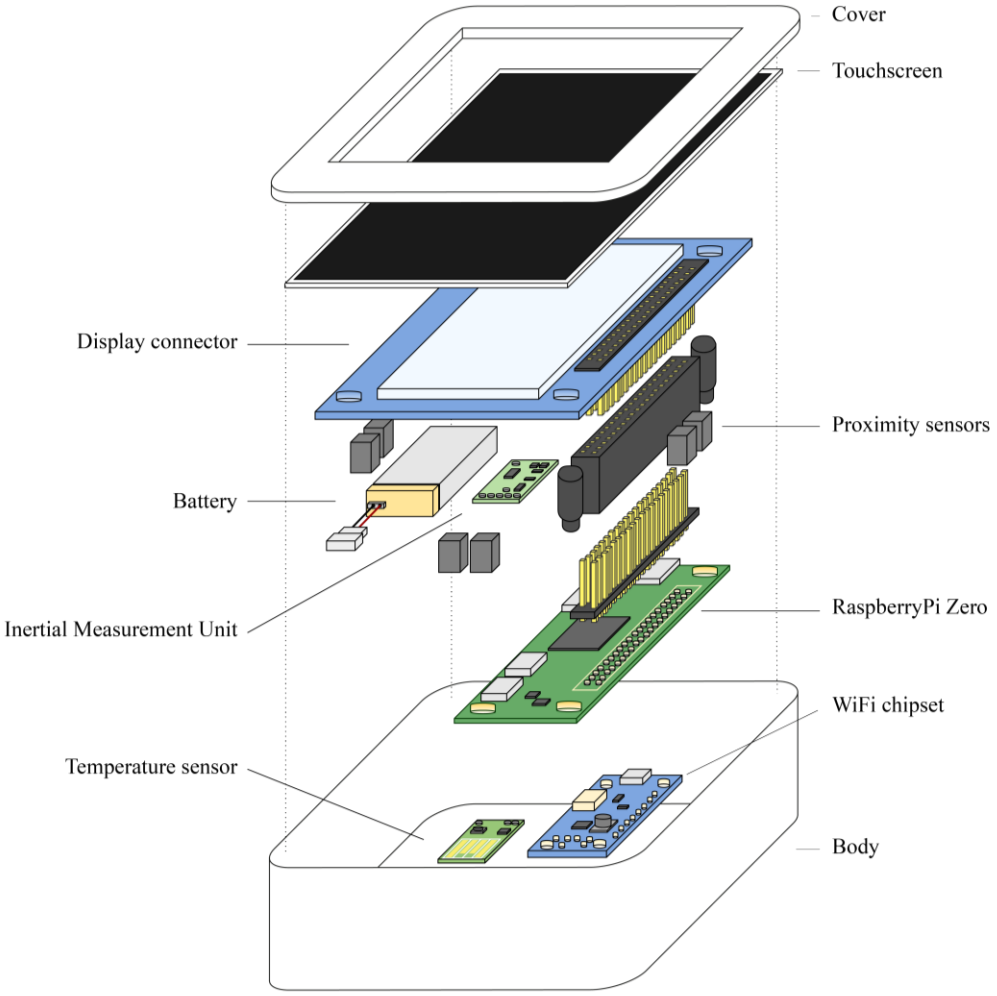

Figure 1: Explosion drawing of an ELBlock.

2.1 Hardware

Equipped with motion, temperature and proximity sensors, which are connected to the computing core of the ELBlock, a Raspberry Pi Zero, each block connects to a wireless network independently through a Wi-Fi chipset. To be able to identify an ELBlock and its neighbors in a relative position to each other, radio-frequency identification (RFID) and near-field communication (NFC) receivers and emitters are fitted into each block. Sensor data is captured in nine axes from the Inertial Measurement Unit (IMU), supplied in triples by the accelerometer, gyroscope, and magnetic compass. By these data an Attitude Heading Reference System (AHRS) can be driven providing even more possibilities of interactions. AHRS is most commonly used when controlling aircrafts or model-piloting, giving

information on the roll-pitch-yaw angle, acceleration and heading. With AHRS more detailed information on any movement is available allowing more complex calculations. Each ELBlock is also equipped with a 2.4-inch display with a square-resolution of 240x240 pixels. Application content will be displayed in a web-based interface (see figure 2) which can be used in touch interactions.

Figure 2: Sketch of the screens of our application Tangicons using ELBlocks.

2.2 Software

Each ELBlock securely connects to a local instance of NEMO through a standard network connection. NEMO has been developed for Ambient Learning Spaces and provides a web-service-based API abstracting authentication, semantic data storage and various services interconnecting ALS applications, featuring an extendable module for application code. Here the game logic resides, which processes all data generated by human interaction with an ELBlock and computes what to display on any of the ELBlocks on the network, executing the respective callback method of the blocks.

Apart from its own semantic storage, the powerful NEMO backend connects to the increasing space of Semantic Web and currently supports more than twelve types of semantic databases. Therefore, the game logic implemented for ELBlocks has access to all data of the local NEMO instance and virtually any data on the Semantic Web. This implies many possibilities for any developer of learning games, not alone through the variety of data available from the Semantic Web. The game's logic may also access information on the user such as the current context, in which the user interacts with any application or device from ALS, as well as the user's capabilities or usage history. As NEMO was not specifically designed for ELBlocks, it provides even more functionality, e.g. a narrative component for storytelling.

Like Tangicons and SpelLit, ELBlocks are being developed in a co-design process. Most importantly we involve children in the design process. This participation leans to requirements closer to the needs and interests of children.

3 Roadmap for Evaluations and Further Development

The primary subject of evaluation is the question, whether or not there is a measureable difference in our observations of children participating in learning games on ELBlocks in contrast to learning games provided on mini-tablets. This may also lead to first answers to

the question of how graspable media influence interaction of children in general as well as in contexts of educational games.

In our roadmap for development we focus on the evaluation of the positive effects we observe from our approach using ELBlocks with regard to tangible media and learning games, also described in our related work (Winkler et al., 2014). Through NEMO we are able to collect statistical data of each user interaction, its context and the relation to the current state of the game. We are looking forward to undermining our hypothesis with suitable studies derived from this data. The question, whether the intermission of cognitive learning processes by running physically as part of the game (Winkler et al., 2014) has an effect on learning, we also like to answer. Additionally, the suitability for children from different class of age, the difficulty level or intermissions of the game without physical activity in comparison with sessions of physical activity can now be analyzed quantitatively. Even long-term evaluation without direct observation of the participants is now possible, as NEMO collects all data in the background automatically.

4 Summary and Outlook

In an ongoing development we engineer ELBlocks as elements of the Internet of Things. Connected to our multimedia repository NEMO, learning games can be implemented with the use of semantically and contextualized content provided by NEMO. ELBlocks are small, simple to interact with and made for the hands of children. Because we host the data and the game's logic in NEMO, we are able to log detailed statistical data of the children's interactions with the learning games. SpelLit and Tangicons on the ELBlocks are valuable systems for the evaluation of contemporary didactic concepts in a mix of both physical and digital environments particularly for children at the age of preschool or primary school.

From the work we describe new system and game concepts arise. With NEMO we are able to track interaction, movement and the state of the game giving even more possibilities for new studies. Not only can this technology be employed in ELBlocks, but in other smart toys (Berta et al., 2016) or *SmartPlushies* as we call them, which are fantasy creatures in plush toys somewhat coming to life within ALS through the technology hidden inside.

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