MOBILE PLATFORMS FOR PLAYFUL LEARNING AND INTERACTION

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ABSTRACT

In this paper, we present two mobile platforms in an interactive learning context for children. The first system is the BlueCube, a wirelessly networked tangible computer using acceleration sensors built into a cube, the second is a modern mobile phone with Bluetooth capabilities and J2ME support. Both devices use different input modalities for the same task: a supportive and general learning platform. We present the hardware platform built for the BlueCube and the system architecture. The goal of this work is to compare the impacts of both systems on the experience and learning success. We conclude by giving an outlook on the evaluation of the presented system in a real school.

KEYWORDS

Mobile Learning Platform, Tangible Devices, Cube, Mobile Phone

1 INTRODUCTION

Embedding small sensor nodes into everyday objects has brought up a variety of new user interfaces. Exploiting the technological capabilities of augmented artifacts allows researchers from various fields, especially human computer interaction and design, to create exciting user experiences.

In this paper, we report on two user interfaces for providing an exciting learning experience to children of various ages: the BlueCube, a cubic interface with displays and embedded sensor and processing node, and an application running on a mobile phone. Both communicate over a local Bluetooth network with the same central database. This setup can easily be created in a classroom where one computer is equipped with a Bluetooth dongle and then routes the requests to a question database not accessible by the pupils.

1.1 Concept and Motivation

Limiting the interaction space for applications to classic GUI based-interaction is unsuitable for young children as key presses and mouse movements do not account for their desire to be active. This can have negative impact on the usage of a learning system and can result in a drift of attention. It is especially challenging to create an atmosphere that attracts children and makes them want to use a system. Playfulness in the interaction and mobility are two aspects that can increase the children's engagement with supportive learning systems. Traditional desktop-based interaction also seems awkward in a kindergarten or preschool scenario. Even specially designed multimedia systems with audio-visual feedback often fail to foster interaction and concentration. Also, children will always prefer a system that allows for more fun during usage. Especially for younger children, research has shown that motivation, interest, and fun play especially important roles in the success of learning. This domain creates special needs for applications that leave the standard computer desktop setting which is often seen as boring and not addressing the need for physical engagement as well as offering few possibilities for collaboration.

Novel user interfaces have been enabled by advances in the base technologies such as sensor nodes and RF communication. In the case of the BlueCube (see Section 2), the embedded sensor node allows for integration in a small everyday object. Mobile phones as computationally powerful embedded and networked platforms incorporate communication capabilities that enable mobile usage in the living room, in the classroom and even while traveling. Also, even youngest children are already familiar with mobile phones.

The learning system presented allows for fun, mobility and more interactivity than traditional learning systems. The goal of this work is to compare the influence of the interaction modality (handling a tangible user interface versus joystick or key pad input) on the learning success and the motivation of the children.

1.2 Related Work

There are a lot of learning applications on mobile phones available today. This paper does not want to provide another one for the sake of giving a better or different application but uses it to compare the type of interaction and results with a tangible device we call the BlueCube. According to constructivist learning theories, children learn while exploring and actively being engaged in problem solving activities [Piaget, 1953]. Recent neuro-scientific research suggests that some kinds of visual-spatial transformation (e.g., mental rotation tasks, object recognition, imagery) are interconnected with motor processes and are possibly driven by the motor system. [O'Malley 2007] gives an extensive overview of current xxx

The cube as a 3D object has been studied by Sheridan, suggesting a description of possible manipulations of the cube, based on action, description and events, which potentially provides a framework for the design of gesture-based interaction techniques [Sheridan, 2003]. The concept of using the affordances of a sensor augmented cube as a learning toy has been presented in Terrenghi et al. [Terrenghi, 2006] with a focus on the design and conceptual foundations.

A first working prototype has been presented in the demo program of UbiComp 2005. The rich feedback from the discussion with the conference participants motivated a complete redesign of the platform. Technical issues (e.g. limited bandwidth) have been readdressed. Also, interactional changes have been incorporated from the findings from our work on gestural input for human computer interaction [Kranz, 2006]. Output modalities have also been enriched for better user feedback.

2 BLUECUBE

The iterations mentioned above resulted in the BlueCube system. It comprises the whole user interface for the interactions with the learning system in a single object. It is a cube with an edge length of 8 cm, a comfortable weight of approximately 500 g, and rounded corners. Each of its 6 faces features a full color, high resolution display with a backlight that can be switched on and off programmatically. The cube as an interaction device can communicate with a PC via a Bluetooth connection. This enables two modes of using the system. In single question mode, questions are sent to the device one by one and the result of each question is sent back to the database. In packet mode, a whole set of questions is sent to the mobile device and saved locally as well as the results that can be sent back to the database later. This allows for 'online' learning e.g. during classes and also for 'offline' learning, e.g. homework or assignments. The rich set of potential questions has been described in our previous work [Terrenghi, 2006]. The size was chosen to allow teenagers to grasp the platform with one hand, while smaller children can conveniently use both hands. This is a design decision taken after initial results with the DisplayCube [Kranz, 2005].

The user's interaction with the system is based on a question shown on the display that currently faces upwards while the other displays show one correct and four wrong answers. Following the affordance of the cube, users turn it in a way that the display with the answer they want to give is on top. The selection of the answer is confirmed by briefly shaking the cube. This eliminates the need for any additional buttons or other input technologies on the cube. Without going into details about the recognition algorithm, it should be noted that this is not trivial due to the need to distinguish the different ways people shake the cube from movements such as rotations, translations, or unintended shakings (occurring while the user tries to find the correct answer, moves the cube from one hand to the other or to other users). The algorithm can also be used to adjust the physical effort needed to choose between the answers to prevent users form 'testing' all answers instead of thinking. Of course, false answers given are also saved in the system. A correct answer will trigger the next question, if available, to be displayed in place of the given answer and the process is repeated.

The BlueCube platform (see Fig. 1a) is an example of a perceptive user interface that explicitly uses the human capabilities like motor skills and gesture input. It consists of a low power embedded microcontroller board with wireless communication capabilities and several built-in sensors and actuators. The sensor board provides an interface to six 128x128 pixels color displays, an acceleration sensor and several ball switches. The 3-axes acceleration sensor is mainly used to detect gestures like shaking. The nine differently oriented ball switches determine the orientation in 3D space (i.e. which display is on top). The cube also features a Bluetooth transceiver for data transmission. The complete set of hardware is fitted into the cube and affixed to the housing. This provides stability during interaction. For the housing, we experimented with different materials which have influence on the user. We already created prototypes with housings made out of wood, steel, and plastic from a 3D printout. The latest cube is made from FIMO. FIMO is a kind of clay used by children to make small objects like jewelry. After the modeling of the housing, it is baked in an oven. The size and weight of the light material does not change during this process which makes it a suitable prototyping material for user interfaces in ubiquitous computing. Also, we could observe that everyone who held the cube found the feeling of the material to be nice and pleasant. Stability is sufficient to account for the cube to fall down during usage as it remains slightly flexible. The hardware of the BlueCube is depicted in Fig. 1a.

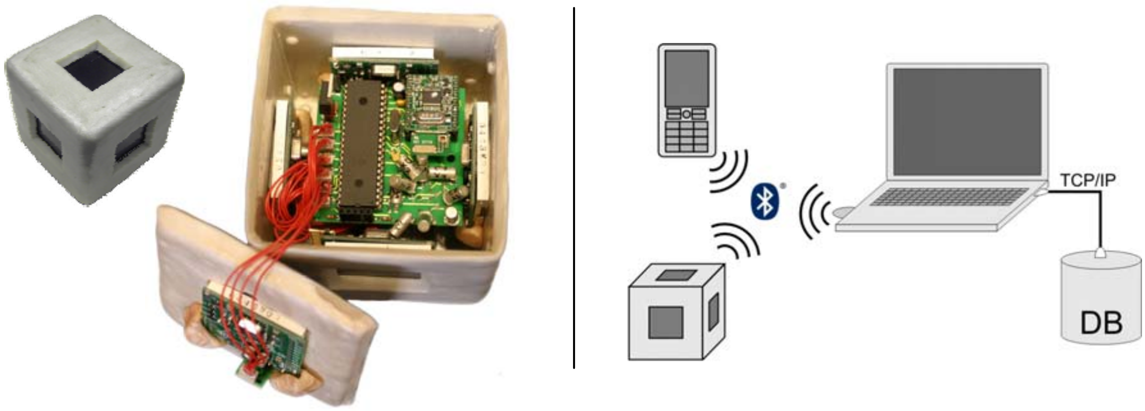

Fig. 1a: BlueCube: All electronics are unobtrusively integrated within the housing. The system is lightweight due to the material chosen for the housing so as little strain as possible is put on the user during interaction.
Fig. 1b: Visualization of the communication flow within the system. The tangible devices use Bluetooth to communicate with a PC that presents a graphical user interface for the database on which questions as well as usage data are stored.

3 MOBILE PHONE

The mobile phone software is implemented using Java Mobile Edition (J2ME). Therefore any phone supporting MIDP 2.0 and Bluetooth can be used to run the application. The wide spread of mobile phones among the population provides broad access to the system without the need to buy new hardware. In order to maximize compatibility with different phones, only standard elements were used for the graphical interface. The appliance is built as a multiple choice test using a list of possible answers. Interaction is based on common input techniques using the keys of the phone. Communication with the PC works similar to the cube and questions are written to the record store of the phone.

Considering the evaluation of the systems, mobile phones offer clear advantages. Firstly, the form factor of the mobile phone is similar to the BlueCube and therefore enables similar scenarios of use. This allows us to focus on differences caused by the different interaction modalities. Secondly, mobile phones allow easily conducting user studies as many pupils have modern or even the “latest” mobile phones. Using standard software elements enables us to use existing hardware during a longer field study. Also, using devices that the user already is fond of instead of a new device is supposed to increase the acceptance of the software.

4 INFRASTRUCTURE

Both presented devices can store data like sets of questions. However, teachers should be able to easily operate the system. Therefore, a database with a graphical user interface is developed platform independently in Java. It is provided to comfortably manage users (pupils, teachers) and store as well as modify sets of questions (e.g. per type of class or age of pupils). In addition, the learning progress of each user can be analyzed. The database in the back-end is implemented on a standard PC using MySQL. Besides the mere data, information about how often a question was answered wrongly or correctly by each user is also saved. This enables learning based on the well proven file card system where the repetition of questions depends on how often they were answered correctly. The system on the PC also manages data transmission between the database and the mobile devices via Bluetooth including the selection of questions for the next learning session which can be done automatically by the index card system as well as user controlled, e.g. according to topics or the last time a question was brought up. The data flow is visualized in Fig. 1b.

5 USE CASES AND NEXT STEPS

The system can be used to train any kind of data that can be interrogated in multiple choice tests. Obvious domains are vocabulary and mathematical tasks but also historical dates, technical terms, and picture-word associations. Children can objectively check their progress themselves any time they want or need to. Still, teachers or parents are able to control the learning progress and analyze results. In contrast to a normal computer, the cube's restriction to the learning appliance avoids distraction. In classrooms, our system provides an opportunity for children to exercise simultaneously. Each pupil may learn at his or her own pace. The teacher can pay attention to those who need help while the other pupils are occupied and will not become bored. As we saw in early tests, the mobile nature of the devices also fosters collaboration between children.

We are currently setting up a user study with children of various ages in a school to compare learning success using the BlueCube to the phone and to traditional learning methods. Aspects that potentially influence the learning progress like the interface and its playfulness as well as the impact of novelty effects will be under special examination. We believe that the affordances of the cubic user interface will contribute to the learning task. The study will take place in a classroom within a local school. Here, the initial capabilities will be tested before the study. Then three children will be given a mobile phone running the learning application and three children will be handed a BlueCube. The other children in the class will use traditional learning methods. The teacher will then introduce new vocabulary in a foreign language. After two weeks, the learning results of the children will be measured during a school test. This allows judging the motivational factors of the user interfaces as well as the usability aspects of the system itself. We hope to be able to verify our assumption that the two mobile learning systems improve motivation and learning success. We also conjecture that the interaction with the cube will be preferred by the pupils and even stronger effects on the learning experience and its results can be observed.

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