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Modular robotics as a tool for education and entertainment

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Abstract

We developed I-BLOCKS, a modular electronic building block system and here we show how this system has proven useful, especially as an educational tool that allows hands-on learning in an easy manner. Through user studies we find limitations of the first I-BLOCKS system, and we show how the system can be improved by introducing a graphical user interface for authoring the contents of the individual I-BLOCK. This is done by developing a new cubic block shape with new physical and electrical connectors, and by including new embedded electronics. We developed and evaluated the I-BLOCKS as a manipulative technology through studies in both schools and hospitals, and in diverse cultures such as in Denmark, Finland, Italy and Tanzania.

Keywords: Constructionism; Developing countries; Educational robots; Educational technology; Entertainment robots

1. Introduction

Miniaturisation of computing makes it possible to employ new educational practises and revolutionise programming through the use of technological components. With the development of physical, intelligent building blocks (e.g., neural building blocks; see Lund, 2003b), it is investigated how it may become possible to 'program by building' (a research subject also referred to as physical programming). Construction with intelligent building

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blocks results not only in the development of a physical structure, but also in the development of a functionality of the physical structure. So construction of functionality can happen with physical building blocks that each contains computational processing and communication. After the basic development of the first hardware realisations, we worked on applying our I-BLOCKS technology in the fields of psychology, education and interaction design. We believe that the I-BLOCKS are important tools for constructionism, since they allow easy, hands-on manipulation with both physical and functional structures, e.g. for "playing" with cognitive tasks.

Other researchers (e.g., Ishii & Ullmer, 1997) have presented haptic and tangible interfaces where physical objects are coupled with digital representations. Any change in the physical arrangement is recognized and interpreted as a controlling action for the digital counterpart, e.g. as in the navigational blocks (Camarata, Gross, & Johnson, 2002) that provide visitors of a virtual museum with a direct manipulation experience using physical blocks to navigate a data space. Also, the Tangible Computation Bricks (McNerney, 2001) are physical building blocks augmented with embedded micro-processors that implement a programming language for scientific exploration. However, different from the I-BLOCKS presented here, in McNerney's implementation, building blocks can only stack in one dimension, and they allow only for sequential control. Whereas this may be suitable in some cases, in other cases a more general approach allowing two- or three-dimensional construction and parallel control may be suitable, see I-BLOCKS experiments below. Indeed, in this paper we will also focus on the technological development towards 3D building possibilities.

Most of the currently available prototypes of tangible interfaces share the characteristic to specify a computation that is performed by a target system. In a sense the tangible interface is still separated by any produced output either in the physical or in the virtual world. However, with the I-BLOCKS technology, we try to take a step forwards with regards to other existing implementations of building blocks, developing building devices able to simultaneously perform computations and to act as output devices of the intended functionality. They are not control systems but both input and output devices that are constructed by the users. Therefore, the I-BLOCKS objective is to develop a concept of seamless interface to manipulate physical objects (the building blocks and the constructions obtained assembling them), to build conceptual structures (the meaning associated to each block, e.g. a math block, word block), and to compose actions (combination of output blocks like motors, LEDs, loudspeakers). Manipulating I-BLOCKS do not only mean constructing physical or conceptual structures but composing actions for building complex behaviours. During our work, we have succeeded in refining the studies in both schools and hospitals, and in diverse cultures such as in Denmark, Finland, Italy and Tanzania. We have also found, that some technological developments are necessary to provide the seamless interface and creative construction possibilities, e.g. the new connection mechanism and the possibility for authoring the contents of the individual I-BLOCKS as presented here.

2. I-BLOCKS

I-BLOCKS are hardware building blocks, which are currently embedded in LEGO Duplo® bricks. The electronics and connectors have been designed so as to facilitate communication and power sharing between I-BLOCKS when these are physically connected.