ConnectUs: A New Toolkit for Teaching about the Internet of Things

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Figure 1. A CodeMe cube

CHI'16 Extended Abstracts, May 07-12, 2016, San Jose, CA, USA
ACM 978-1-4503-4082-3/16/05.

Abstract
The emerging Internet of Things (IoT), through which vast amounts of everyday objects are becoming embedded with computing and networking capabilities, is rapidly changing the way society uses and experiences technology. Despite this, children do not systematically learn about IoT in schools. This demonstration will showcase ConnectUs, a new IoT toolkit, which can be used to introduce children to a variety of IoT concepts, and provide users with the opportunity to design their own IoT system.

Author Keywords
Tangible interfaces; ubiquitous computing; playful learning; Internet of Things; ConnectUs; CodeMe.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
The emerging Internet of Things (IoT), through which vast quantities of everyday objects are becoming embedded with computing and networking capabilities, is changing the way society uses and experiences technology. Despite this, much of computing education in schools is still restricted to traditional approaches like teaching programming on desktop computers. While

Figure 2. Children interact with CodeMe cubes

these methods remain important for computational literacy, in order to prepare learners for the coming of what has been termed the "new industrial revolution" [3], it is necessary for computing education to converge with advances in technology, and to expose the next generation to both conceptual knowledge of and hands-on experience with IoT.

Due to IoT's novelty and lack of a clear definition, literature on best practices for teaching about IoT has only recently started to develop. Recently, efforts have been made to make explicit the concepts underlying IoT [1], and several IoT courses have emerged at university level (e.g., [2,8]).

However, as many of the concepts underlying IoT, such as embedded programming and distributed systems [1], are very abstract and technically advanced, the question remains as to how to lower the entry level for learning about and exploring IoT technologies, especially for young audiences.

Our research examines how the precursors to such technically advanced IoT concepts can be conveyed to children without requiring experience with programming and communication protocols. Our approach is to develop a tangible toolkit to explore and instantiate IoT concepts with. This is supported by previous research on playful learning with tangible technologies which has shown that tangible interfaces can help children with learning abstract concepts (e.g. [7,10,11]), as well as the educational theories of constructivism and constructionism which advocate learning through doing (e.g., [5,6]).

We are currently developing and testing a toolkit called CodeMe (Figure 1), which consists of a number of interactive sensing and actuator cubes. Bluetooth has been added to the latest version enabling several cubes to be wirelessly connected. We call this latest version ConnectUs, to indicate how the cubes can be connected with each other in order to allow users to specifically discover and explore IoT concepts.

In particular, we have developed activities that can be carried out using ConnectUs to convey core systems thinking themes, including interdependence, feedback loops, and emergent behaviours in a system (e.g., [9]), which are conceptual precursors to more advanced IoT concepts like distributed computing and networking protocols. The aim is that getting children to experience and think about these themes in an engaging, interactive, and non-intimidating way will spark further curiosity about IoT, and provide them with a basis from which to learn more complex IoT concepts.

In this demonstration, the audience will have the opportunity to interact with ConnectUs, and explore one of the recently developed activities, which showcases various ways in which IoT objects can be interdependent.

The CodeMe Toolkit

The original CodeMe toolkit consists of interactive sensing cubes (Figure 2) designed to ease new learners into exploring coding and electronics, as well as to encourage creative crafting and tinkering.

The CodeMe cubes are embedded with a variety of sensors, light displays, and Bluetooth technology. Whereas tangible interfaces are often created to be purpose-specific, an exciting feature of the CodeMe

cubes is that they are rather designed as general-purpose building blocks. Each cube functions as a self-contained interface, but can also be wirelessly connected to other cubes, smartphone or tablet interfaces to build increasingly complex functionality. The result is a toolkit that is extensible to an unlimited variety of activities.

Based on the educational theory of constructivism (e.g., [5,6]), which advocates learning by actively engaging with the world, the toolkit is designed to be discovery based, social, and linked to the real world. Through these factors, the toolkit lends itself to sharing, tinkering and creativity.

The Demonstration

The demonstration will consist of a set of hands-on user activities with the ConnectUs cubes, demonstrating those in ongoing workshops carried out with children. Through the activities, the audience will explore the concept of interdependence between wirelessly interconnected objects. Specifically, the task will be to figure out and manipulate the ways in which multiple interconnected cubes are interacting with each other—for example, how do light displays change on the cubes when both cubes are tilted in a specific direction, as opposed to when one is tilted?

8 CodeMe cubes, interconnected via Bluetooth, will be laid out for the audience. Audience members will be encouraged to collaborate in pairs.

During the first activity, the audience will be able to explore individual cubes and their sensor/actuator mappings. The direction in which the cube is tilted, for example, will alter the LED matrix display, while covering the light sensor will produce yet another LED effect.

In the second activity, the concept of interdependence will be introduced through Bluetooth connections between the cubes. For example, tilting two cubes simultaneously will produce different light patterns than tilting one individually. In pairs, participants will have to decrypt the mappings between the sensors of the interconnected cubes, in order to successfully complete a round of a digital Simon Says game.

Lastly, using a tablet GUI, the audience will be able to creatively design their own IoT system. Participants will be able to change which specific cubes are connected to one another, and alter what will happen to the light displays on each cube when specific conditions are met. For example, participants will be able to specify in which directions both cubes must be tilted in order to elicit a desired animation on the LED matrices. The demonstration activities will last between 2 and 5 minutes.

The demonstration hopes to inspire discussion about tangible technologies, methods for design of playful learning experiences, as well as concepts underlying systems thinking and IoT.

Relevance to the CHI Audience

The demonstration is relevant to IoT programming, tangible interfaces and educational technologies, all of which receive ongoing interest in the CHI community. The demonstration will also be of interest to those who curious about the concepts underlying systems thinking, network connectivity and the Internet of Things.

Acknowledgements

The authors would like to thank Phil Stenton (BBC Research and Development) for his contributions to the ideas presented in this work.

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