Communication Theory

Lecture 3:
Tangible Technologies for Learning

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Aims

• To introduce the concept of tangible computing

• To outline why the use of tangible technologies might provide benefits for learning
“…an attempt to bridge the gap between cyberspace and the physical environment by making digital information (bits) tangible.” (Ishii and Ullmer, 1997 p. 235)
What are Tangible Interfaces?

Some tangible interfaces consist of relatively simple and cheap technologies (e.g., barcodes, sensors).

Other tangible interfaces are still in the early stages of development and involve more sophisticated uses of video-based image analysis or robotics.
What are Tangible Interfaces?

http://www.media.mit.edu/groups/gn/projects/animalblocks/
http://www.sics.se/kidstory/
http://www.ioe.stir.ac.uk/CACHET/
http://web.media.mit.edu/~kimiko/projects.htm
Tangible interfaces
Potential of Tangible Interfaces

• Tangible technologies are part of a wider body of developing technology known as ‘ubiquitous computing’ in which computing technology is so embedded in the world that it ‘disappears’.

• Tangible interfaces may be of significant benefit to education by enabling, in particular, younger children to play with actual physical objects augmented with computing power.

• Research from psychology and education suggests that there can be real benefits for learning from tangible interfaces. Such technologies bring physical activity and active manipulation of objects to the forefront of learning.
From GUIs to TUIs

GUI – Graphical User Interface
TUI – Tangible User Interface

• Digital spaces traditionally manipulated with simple input devices (keyboard and mouse), which are used to control and manipulate (usually visual) representations displayed on output devices such as monitors, whiteboards or head mounted displays.

• What has become known as ‘tangible interfaces’ attempt to remove this input-output distinction and try to open up new possibilities for interaction that blend the physical and digital worlds (Ullmer & Ishii, 2000).

• Tangible interfaces emphasise touch and physicality in both input and output.
Range of Applications

• Applications range from rehabilitation, for example, tangible technologies that enable individuals to practise making a hot drink following a stroke (Edmans et al., 2004) to urban planning with physical manipulation of models of buildings (Underkoffler and Ishii, 1999).

• Examples here will focus on learning, particularly childrens’ learning
Why may tangibles aid learning?

- Historically children have played individually and collaboratively with physical items (building blocks, jigsaws..) and have been encouraged to play with physical objects to learn a variety of skills.
- Montessori believed that playing with physical objects enabled children to engage in self-directed, purposeful activity. She advocated children’s play with physical manipulatives as tools for development.
- Resnick extended the tangible interface concept for the educational domain in the term ‘Digital Manipulatives’ (Resnick et al., 1998). These are familiar physical items with computational power aimed at enhancing children’s learning.
Why may tangibles aid learning?

- Familiar objects (building bricks, balls) are physically manipulated to make changes in an associated digital world, capitalizing on people’s familiarity with their way of interacting in the physical world (Ishii & Ullmer, 1997).

- In relation to learning, such tangibles are thought to provide different kinds of opportunities for reasoning about the world through discovery and participation.

- Tangible-mediated learning also has the potential to allow children to combine and recombine the known and familiar in new and unfamiliar ways encouraging creativity and reflection (Price et al., 2003).
Conceptual Frameworks

• A number of frameworks explore the interactional properties of tangible technology for control of representations and for mappings between forms of representations (physical and digital).

Example Frameworks:
Ullmer and Ishii - concepts of control and representation
Koleva et al – build on this notion
Holmquist et al.’s concepts of containers, tokens and tools
Fishkin’s concepts of embodiment and metaphor
Conceptual Frameworks

Although researchers have used different terminologies and structured the design space in different ways, each of the frameworks is an attempt to deal explicitly with the interaction metaphors embodied in

(i) the manipulation (operation) of tangible devices
(ii) the mappings between forms (appearance) of physical and digital representations.
Physical Manipulatives for Learning

- physical action is important in learning – children can demonstrate knowledge in their physical actions (e.g., gesture) even though they cannot talk about that knowledge
- concrete objects are important in learning – e.g., children can often solve problems when given concrete materials to work with even though they cannot solve them symbolically or even when they cannot solve them ‘in their heads’
- physical materials give rise to mental images which can then guide and constrain future problem solving in the absence of the physical materials
- learners can abstract symbolic relations from a variety of concrete instances
- physical objects that are familiar are more easily understood by children than more symbolic entities
Tangible Interfaces and Digital Manipulatives

- allow for parallel input (e.g., two hands) improving the expressiveness or the communication capacity with the computer
- take advantage of well developed motor skills for physical object manipulations and spatial reasoning
- externalise traditionally internal computer representations
- afford multi-person, collaborative use
- physical representations embody a greater variety of mechanisms for interactive control
- physical representations are perceptually coupled to actively mediated digital representations
- the physical state of the tangible embodies key aspects of the digital state of the system
Case Studies

1. Digitally augmented paper and books

2. Phicons: The use of physical objects as digital icons

3. Digital manipulatives

4. Sensors and digital probes
Digitally augmented paper and books

- *Listen Reader* (Back, et al., 2001) is an interactive children’s storybook, which has a sound track triggered by moving one’s hands over the book.

- A more familiar, commercially available system, is *LeapPad®*

- Paper++ was aimed at providing digital augmentation of paper with multimedia effects.

- *MagicBook* (Billinghurst & Kato, 2002). This employs augmented reality techniques to project a 3-D visual display as the user turns the page.
Phicons

• Microsoft ActiMates™, starting in 1997 with Barney™

• The CACHET project (Luckin et al, 2003) explored the use of interactive toys (DW™ and Arthur™) in supporting collaboration.

• Storymat (Ryokai & Cassell, 1999) is a soft interactive play mat that records and replays children stories.

• In the KidStory project RFID tags were embedded in toys as story characters (Stanton et al, 2001).

• Chromarium is a mixed reality activity space that uses tangibles to help children experiment and learn about colour mixing (Rogers et al, 2002)
Digital manipulatives

• LEGO/Logo robotics construction kit (Resnick, 1993) children can create Logo programs to control LEGO assemblies.

• Programmable Bricks (Resnick et al, 1996). These bricks contain output ports for controlling motors and lights and input ports for receiving information from sensors (e.g., light, touch, temperature).

• Crickets (Resnick et al., 1998) much smaller and more powerful processors and with a two-way infrared capability. Crickets have been used, together with an accelerometer and coloured LEDs to create the BitBall – a transparent rubbery ball. BitBalls have been used in scientific investigations with undergraduates and children in learning kinematics.

• Curlybot (Frei et al, 2000) is a palm-sized dome-shaped two-wheel toy that can record and replay physical motion.
Sensors and digital probes

- Flashlights or torches have been used to interact with a display. As users collaboratively shone their flashlights on the sand it burned a virtual hole through the surface to reveal images beneath, telling the history of Nottingham Castle (Fraser et al., 2003).

- I/O Brush (Ryokai et al., 2004) is a drawing tool for young children aged four and over. The I/O Brush is modelled on a physical paintbrush but in addition has a small video camera with lights and touch sensors embedded inside it.

- The SENSE project (Tallyn et al., 2004) has been exploring the potential of sensor technologies to support a hands-on approach to learning science in the school classroom.
References


References


References


