Interacting with Technology

Lecture 5: Exploring spatial cognition with novel technologies

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Overview

Introduction & Lecture 1: Children, schools and technology

Lecture 2: Mobile technologies and sensors

Lecture 3: Mobile and tangible technologies for children

Lecture 4: Case study: Children and technology

Lecture 5. Exploring spatial cognition with novel technologies

Lecture 6: Aiding spatial cognition in children

Lecture 7: Evaluating 'in the wild'

Unit structure

1st part of course lectures

Topics include :

- Children and technology
- Space cognition
- Evaluating 'in the wild'
- Case studies

2nd part of course presentations by students

Please note 20 minute presentation, followed by 10 minutes of questions

Assessment

2 assessed courseworks:

- Presentation (20%)
- Report (80%)

Report

- Individually written
- The essay can address the same question as the oral presentation
- 2000-2500 words
- Refer to other presentations where possible.
- Deadline:12 noon Tuesday 18th May 2010

Space.
Can we simulate it effectively?

Spaces and Maps: Physical, Mental and Virtual

- Space
- The Cognitive Map
- Simulations of Space
- How real do simulations need to be?
- Presence

Theories of Space

Kant claims that "space and time are the very form of the human mind" (Ellis, 1991, p.xiii). Indeed everyday navigation and technological advances aiding exploration (flying, driving) involve complex spatial skill.

Space

- Physical space refers to the three dimensional, Euclidean world in which we live.
- Psychological space refers to the space of our perceptual experience, "any space which is attributed to the mind...and which would not exist if minds did not exist" (O'Keefe and Nadel, 1978, p.6-7).
- These two types of space overlap and interact with one another.
- We can also distinguish between virtual space and physical space, as virtual environments do not exist in the physical world.

Humans and animals must adopt strategies to gauge their constantly altering position within the environment if they are to successfully negotiate "that great God-given maze which is our human world" (Tolman, 1948, p. 208).

The Cognitive Map

McGee (1982) defined spatial orientation as

"the comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude for remaining unconfused by the changing orientations in which a configuration may be presented and the ability to determine spatial relations in which the body orientation of the observer is an essential part of the problem" (p.4).

3D

- We see our world in three dimensions. Although the retina in the eye is a flat surface and therefore the images it receives are two dimensional, distance cues enable some two dimensional images to be perceived as distant in a three dimensional world.
- Monocular depth cues include relative size, superposition/occlusion and relative height. Relative size refers to smaller objects being interpreted as further away than larger objects. Occlusion is the effect when one object obstructs another, causing the overlapping object to be perceived as being nearer. The relative height of similar objects can enable distance perception, for example, objects that are seen as higher in the image are perceived as more distant.

3D

The use of two eyes (binocular vision) has advantages for depth perception. Our two eyes enable us to see two slightly different images of an object and we use this disparity to calculate the object's orientation in space. The term stereopsis is used to explain how the brain adds depth from this disparity between the different images from the two eyes.

3D

Another type of depth cue arises from autonomous movement in space which appears to be crucial to the development of an effective internal spatial representation.

Gibson (1966) stated that as the observer moves through space, there is a flow of stimulation on the retinas, which leads to a better understanding of the three dimensionality of our world. "When the observer moves....the optic array becomes alive with motion" (Haber and Hershenson, 1973, p.332).

The form of the Cognitive Map

Tolman (1948) describes a "map control room" in the brain which stimuli enter and are "worked over" and "elaborated" into "a tentative, cognitive-like map of the environment" (p.192).

This "cognitive map" contains routes, paths and environmental relationships which are stored and can be used when responding to the environment. Thus accuracy of response to one's environment is intricately linked to the quality of the cognitive map formed.

The form of the Cognitive Map

- O'Keefe and Nadel (1978) drew a distinction between the "Taxon" system (routes) and the "Locale" system (places) in the build up of spatial knowledge.

  The "Taxon" system involves using a series of S-R-S (stimulus-response-stimulus) instructions. Navigation involves moving from one landmark to the next by aligning oneself in relation to the landmarks.

  The "Locale" system is a highly flexible system, based on the development and use of internal maps.

- O'Keefe and Nadel (1978) state that exploration is essential for the creation of internal spatial cognitive maps and in constantly up-dating them.

The form of the Cognitive Map

- Animal behavioural studies
- Most authors agree that humans carry spatial representations of their environment in their heads, yet there is constant debate concerning the type and content of these representations.
- Siegel and White (1975) suggest a three tiered process in the development of spatial knowledge: the use of landmarks, then the adoption of route knowledge allowing fairly simple wayfinding, and finally internal representations of space, allowing more sophisticated methods of navigation.

Landmarks, routes and maps

- Siegel and White suggest that landmarks may constitute "meaningful events" and the nervous system may be continually "taking pictures" of them.
- Routes are built up by connecting a series of landmarks. This strategy is egocentric (dependent on the body's location and direction of pointing in space) and is efficient as long as the links between successive turns are accurate.
- A cognitive map applies to the mental images that individuals build up as they become more familiar with their surroundings. This type of representation is allocentric (not dependent on the body's position in space or direction of regard) and thus is extremely flexible

Properties of cognitive map

- Pick and Lockman (1981) describe three properties of spatial maps: reversibility, transitivity and enabling detours.
- Lynch (1960) suggests that the cognitive map is a product of the number and type of landmarks and the number and type of past experiences one has had in a particular location.

Cognitive Map (contd.)

- Thorndyke and Hayes-Roth (1982) state three important points about spatial cognition.

Firstly, people build up their spatial knowledge from a variety of different sources: navigation through the environment, a wide variety of different forms of maps, verbal descriptions and photographs. The knowledge gained from each of these sources is integrated to form spatial knowledge.

Secondly, dependent on the knowledge they have, people use different methods when making spatial judgements.

Thirdly, the accuracy of any spatial judgement is dependent not only on the accuracy of spatial knowledge but also on the computations performed on this knowledge.

Virtual Environment (VE)

- Virtual environments (VEs) have as their core the simulation by computer of three dimensional space.
- The first defining feature of VEs is that they can be explored in real time with similar freedom to real world exploration.
- The second defining feature is that the user may interact with objects and events in the simulation.

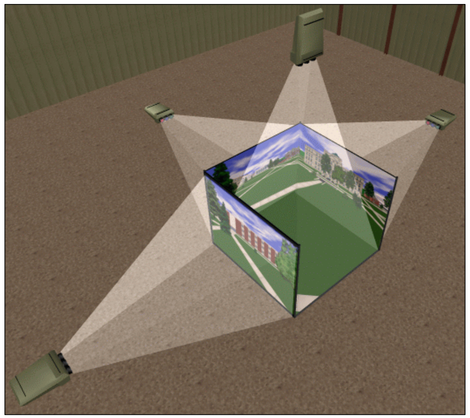
Application of VEs

- Research using VE’s has stemmed from:
  – Military
  – Space
  – Aviation
- VEs are now used in a wide variety of settings, including:
  – Education
  – Medicine
  – Building design
  – Applications for those with disabilities
  – …

NPSNET

Example VE

- Desktop use of VE



Training and Education

- Why use 3D environments for training
  - Take on different perspectives
  - Visualise 3D concepts
  - Interact in real time
  - Explore dangerous situations in safety
  - Independent rehearsal
  - Present realistic or abstract scenarios
  - Promote different learning styles and teaching methods
  - possess a high degree of flexibility

Training and Education

- Environments to train specific skills

- Important elements
  - safety, autonomy, repeated action enabled, reduction of clutter/noise, control..

Training and Education

- Health and safety routines and VR for workplace
  - practising emergency procedures in a variety of systems
  - simulators
  - Some examples: Learning about radioactivity, Product development, Training for disposal

Training and Education

- Social skills
  - E.g Autism
  - Independent rehearsal, taking others perspectives, safety, practicing behaviours
  - www.avirtualdayout.co.uk

Training and Education

- Phobias
  - Agrophobia, arachnophobia fear of flying…

www.equator.ac.uk

Training in VEs

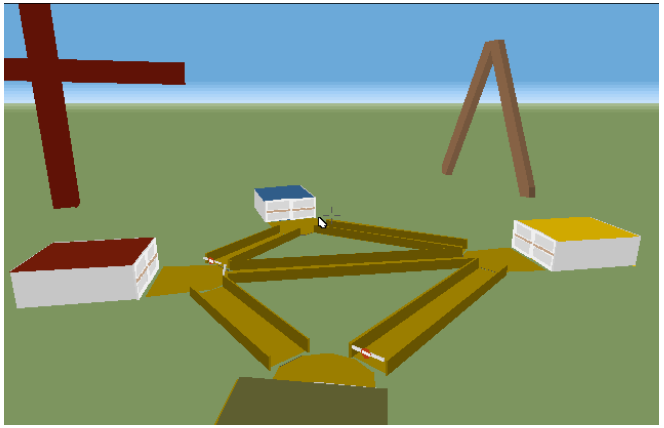
- Virtual environments are potential useful media for training spatial skills:
- Interactions with VEs reproduce similar visual-spatial characteristics to interactions with the real world
- Interactions with VEs can preserve the link between motor actions and their perceived effects (Regian, Shebilske and Monk, 1992). This may be primarily due to the three dimensionality of the display, which provides all of the transformations in the visual appearances of objects that would accompany real movements in space. In Gibson’s (1979) terms, the optical flow patterns that would be experienced in the course of real movements are maintained in the displayed environment.

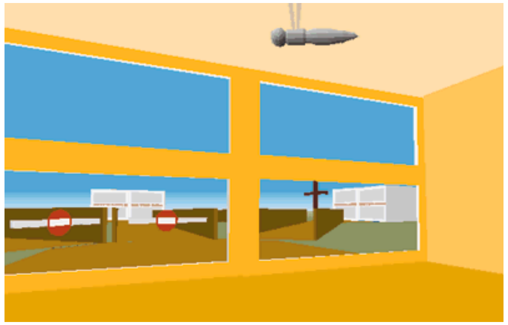
Training in VEs (contd.)

- VEs enable assessment of the internal spatial representations within the same mode as they were acquired. A user explores a VE and then can be tested on their spatial knowledge within this same environment using pointing tasks or route tests.
- easily adaptable, allows repeated viewing, and provides tight control of cues.
- they allow learning to take place without the danger of injury
- a high level of interactivity

Training and Education

- Virtual Environments are interesting tools for psychology research in spatial cognition, because they allow some control over testing spatial exploration
- Navigation and wayfinding
  - simulations of buildings
  - spatial orientation measures





- Understanding of spatial cognition has developed over the past 50 years
- Recent developments in computer graphics have allowed improved simulation of spatial environments
- These developments have in turn provided test beds for conducting research in how internal spatial representations are formed and as platforms for training spatial skills

Presence in VEs

- VEs consist of three-dimensional, interactive, computer generated worlds, running in real time.
- Often, interacting with these worlds provides a feeling of "presence" as every response has a consequence, and the egocentric viewpoint gives the illusion of looking from 'within' the virtual world.
- This may be true for more or less realistic technologies (e.g. head-mounted displays vs. 'desktop' VEs)

The overall experience - Presence

- A mental state where participant has the sense of being in the location specified by the displays - "being there"
- A fundamental goal of VR?
- Measuring presence
  - subjective presence
  - behavioural presence

See http://mitpress.mit.edu/journals/PRES/ps00734.pdf
http://www.cs.ucl.ac.uk/staff/A.Steed/papers.html

Factors that affect presence

- Immersion
- Mode of navigation
- Self-body image
- External disruptions
- Inconsistencies between the user's mental model of the world and its actual behavior
- Boredom and amount of activity

Suspension of Disbelief

- Desert Rain – a virtual reality performance uses two techniques to encourage suspension of disbelief
  - Traversable interfaces
  - Orchestration

  - See VIDEO
  - http://www.blasttheory.co.uk/work_desertrain.html

Traversable interfaces

- Virtual reality is an illusion
- Traversable interfaces enhance this illusion
  - for direct participants - designing the transition into an out of a virtual world
  - for observers - so that others appear to enter and leave a virtual world
- One option is to use a walk-through screen
  - the participant crosses into a specially designed antechamber
  - the observer sees them disappear into the image

Video of VE in use

Augmented reality

- Overlay the 3D world on the real world
  - dealing with complex machinery
  - revealing hidden objects
  - overlay scientific, engineering or strategic data
- May use:
  - see through head-mounted
  - tracked handheld displays
  - remote video views
- Requires tracking and registration

Real versus virtual?

- Can we ever truly simulate real space?
- Do we need to?
- How human can we make avatars?
- Will a multisensory approach (3D audio, haptics etc..) increase the feeling of presence?
- Has how we perceive space changed with the advent of new technologies such as in car navigation systems, personal digital assistants for wayfinding, hypertext, multi-user games?

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