PA198
Augmented Reality Interfaces

Lecture 5

Designing Augmented Reality Interfaces

Fotis Liarokapis
liarokap@fi.muni.cz

2nd November 2015

User Interface Design

What is User Interface Design?

- The process of designing effective and user friendly interfaces for software systems and applications
  - Applies in all computer science
  - Other disciplines as well
    - i.e. Hardware design

The User Interface

- Users usually judge a software application based on its interface rather than its functionality
  - A poorly designed interface can cause a user to make catastrophic errors
  - Poor user interface design is the main reason why so many software systems are never used

Many Types of Interfaces

- Command
- Speech
- Data-entry
- Form fill-in
- Query
- Graphical
- Web
- Pen
- Augmented reality
- Gesture

Graphical User Interfaces (GUIs)

- GUIs allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation
  - Opposed to text-based interfaces, typed command labels or text navigation
- GUIs can be found in hand-held devices and many applications exist
  - i.e. Augmented reality

GUI Characteristics

Characteristic	Description
Windows	Multiple windows allow different information to be displayed simultaneously on the user's screen.
Icons	Icons different types of information. On some systems, icons represent files; on others, icons represent processes.
Menus	Commands are selected from a menu rather than typed in a command language.
Pointing	A pointing device such as a mouse is used for selecting choices from a menu or indicating items of interest in a window.
Graphics	Graphical elements can be mixed with text on the same display.

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

GUI Advantages

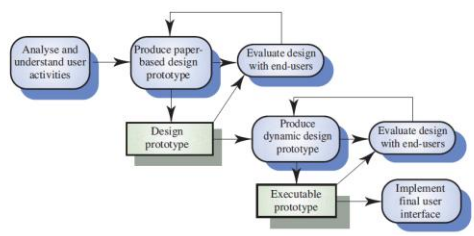
- They are easy to learn and use
  - Without experience can use the system quickly
  - Can switch quickly from one task to another
  - Can interact with several different applications
  - Information remains visible in its own window when attention is switched
- Fast, full-screen interaction is possible with immediate access to anywhere on the screen

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

User-Centred Design

- In user-centred design the needs of the user are paramount and where the user is involved in the design process
- User interface design always involves the development of prototype interfaces

User Interface Design Process



https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

User Interface Design Principles

- User interface design must consider the <u>needs</u>, <u>experience</u> and <u>capabilities</u> of the system users
  - Principles underlie interface designs although not all are applicable to all designs
- Designers should:
  - Be aware of people's physical and mental limitations (e.g. limited short-term memory)
  - Recognise that people make mistakes

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

User Interface Design Principles .

Principle	Description
User familiarity	The interface should use terms and concepts which are drawn from the experience of the people who will make most use of the system.
Consistency	The interface should be consistent in that, wherever possible, comparable operations should be activated in the same way.
Minimal surprise	Users should never be surprised by the behaviour of a system.
Recoverability	The interface should include mechanisms to allow users to recover from errors.
User guidance	The interface should provide meaningful feedback when errors occur and provide context-sensitive user help facilities.
User diversity	The interface should provide appropriate interaction facilities for different types of system user.

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Design Principles

- User familiarity
  - The interface should be based on user-oriented terms and concepts rather than computer concepts
    - i.e. An office system should use concepts such as letters, documents, folders etc. rather than directories, file identifiers, etc.
- Consistency
  - The system should display an appropriate level of consistency
  - Commands and menus should have the same format, command punctuation should be similar, etc.
- Minimal surprise
  - If a command operates in a known way, the user should be able to predict the operation of comparable commands

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Design Principles .

- Recoverability
  - The system should provide some resilience to user errors and allow the user to recover from errors
    - This might include an undo facility, confirmation of destructive actions, 'soft' deletes, etc
- User guidance
  - Some user guidance such as help systems, on-line manuals, etc. should be supplied
- User diversity
  - Interaction facilities for different types of user should be supported
    - i.e. Accessibility

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

User-System Interaction

- Two problems must be addressed in interactive systems design
  - How should information from the user be provided to the computer system?
  - How should information from the computer system be presented to the user?
- User interaction and information presentation may be integrated through a coherent framework such as a user interface metaphor

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Interaction Styles

Interaction Styles

- Direct manipulation
- Menu selection
- Form fill-in
- Command language
- Natural language

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Pros and Cons

Interaction style	Main advantages	Main disadvantages	Application examples
Direct manipulation	Fast and intuitive interaction Easy to learn	May be hard to implement. Only suitable where there is a visual metaphor for tasks and objects.	Video games CAD systems
Menu selection	Avoids user error Little typing required	Slow for experienced users. Can become complex if many menu options.	Most general-purpose systems
Form fill-in	Simple data entry Easy to learn Checkable	Takes up a lot of screen space. Causes problems where user options do not match the form fields.	Stock control, Personal loan processing
Command language	Powerful and flexible	Hard to learn. Poor error management.	Operating systems, Command and control systems
Natural language	Accessible to casual users Easily extended	Requires more typing. Natural language understanding systems are unreliable.	Information retrieval systems

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Direct Manipulation Advantages

- Users feel in control of the computer and are less likely to be intimidated by it
- User learning time is relatively short
- Users get immediate feedback on their actions so mistakes can be quickly detected and corrected

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Direct Manipulation Disadvantages

- The derivation of an appropriate information space model can be very difficult
- Given that users have a large information space, what facilities for navigating around that space should be provided?
- Direct manipulation interfaces can be complex to program and make heavy demands on the computer system

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Menu Systems

- Users make a selection from a list of possibilities presented to them by the system
- The selection may be made by pointing and clicking with a mouse, using cursor keys or by typing the name of the selection
- May make use of simple-to-use terminals such as touch screens

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Menu Systems Advantages

- Users need not remember command names as they are always presented with a list of valid commands
- Typing effort is minimal
- User errors are trapped by the interface
- Context-dependent help can be provided
  - The user's context is indicated by the current menu selection

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Menu Systems Disadvantages

- Actions which involve logical conjunction (and) or disjunction (or) are awkward to represent
- Menu systems are best suited to presenting a small number of choices
  - If there are many choices, some menu structuring facility must be used
- Experienced users find menus slower than command language

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Command Interfaces

- User types commands to give instructions to the system
  - i.e. UNIX
- May be implemented using cheap terminals
- Easy to process using compiler techniques
- Commands of arbitrary complexity can be created by command combination
- Concise interfaces requiring minimal typing can be created

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Command Interfaces Disadvantages

- Users have to learn and remember a command language
  - Unsuitable for occasional users
- Users make errors in command
  - An error detection and recovery system is required
- System interaction is through a keyboard so typing ability is required

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Command Languages

- Often preferred by experienced users because they allow for faster interaction with the system
- Not suitable for casual or inexperienced users
- May be provided as an alternative to menu commands
  - i.e. Keyboard shortcuts
- In some cases, a command language interface and a menu-based interface are supported at the same time

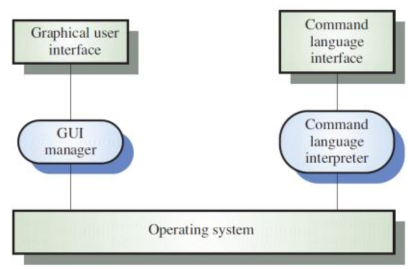
https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Natural Language Interfaces

- The user types a command in a natural language
- Generally, the vocabulary is limited and these systems are confined to specific application domains
  - i.e. Timetable enquiries
- NL processing technology is now good enough to make these interfaces effective for casual users
  - But experienced users find that they require too much typing

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Multiple User Interfaces



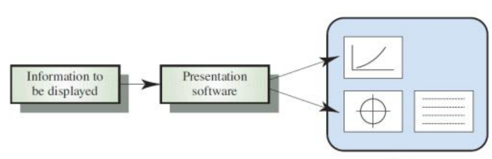
https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Information Presentation

- Information presentation is concerned with presenting system information to system users
- The information may be presented directly (e.g. text in a word processor) or may be transformed in some way for presentation (e.g. in some graphical form)
- The Model-View-Controller approach is a way of supporting multiple presentations of data

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Information Presentation .



https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Types of Information

- Static information
  - Initialised at the beginning of a session
    - Does not change during the session
  - May be either numeric or textual
- Dynamic information
  - Changes during a session and the changes must be communicated to the system user
  - May be either numeric or textual

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

Information Display Factors

- Is the user interested in precise information or data relationships?
- How quickly do information values change?
- Must the change be indicated immediately?
- Must the user take some action in response to a change?
- Is there a direct manipulation interface?
- Is the information textual or numeric? Are relative values important?

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

AR Interfaces

Introduction to AR Interfaces

- Browsing Interfaces
  - Simple (conceptually!), unobtrusive
- 3D AR Interfaces
  - Expressive, creative, require attention
- Tangible Interfaces
  - Embedded into conventional environments
- Tangible AR
  - Combines TUI input + AR display

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

Browsing Interfaces

- 2D/3D virtual objects are registered in 3D
  - “VR in Real World”
- Interaction
  - 2D/3D virtual viewpoint control
- Applications
  - Visualization, training


State, et al. 1996

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

3D AR Interfaces

- Virtual objects displayed in 3D physical space and manipulated
  - HMDs and 6DOF head-tracking
  - 6DOF hand trackers for input
- Interaction
  - Viewpoint control
  - Traditional 3D user interface interaction
    - Manipulation, selection, etc


Kiyokawa, et al. 2000

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

Tangible Interfaces

- Dangling String
  - Jeremijenko 1995
  - Ambient Ethernet monitor
  - Relies on peripheral cues
- Ambient Fixtures
  - Dahley, Wisneski, Ishii 1998
  - Use natural material qualities for information display

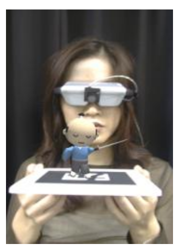
Augmented Surfaces and Tangible Interfaces

- Basic principles
  - Virtual objects are projected on a surface
  - Physical objects are used as controls for virtual objects
  - Support for collaboration

Digital Desk. 1993

Tangible AR

- AR overcomes limitation of TUIs
  - Enhance display possibilities
  - Merge task/display space
  - Provide public and private views
- TUI + AR = Tangible AR
  - Apply TUI methods to AR interface design



Space Multiplexed vs. Time Multiplexed

- Space-multiplexed
  - Many devices each with one function
    - Quicker to use, more intuitive, clutter
    - Real Toolbox
- Time-multiplexed
  - One device with many functions
    - Space efficient
    - Mouse

Tangible AR: Tiles (Space Multiplexed)

- Tiles semantics
  - Data tiles
  - Operation tiles
- Operation on tiles
  - Proximity
  - Spatial arrangements
  - Space-multiplexed

Tiles, 2001

Tangible AR: Time-Multiplexed Interaction

- Use of natural physical object manipulations to control virtual objects
  - Catalog book:
    - Turn over the page
  - Paddle operation:
    - Push, shake, incline, hit, scoop

Interface Design Path

- Prototype Demonstration
- Adoption of Interaction Techniques from other interface metaphors **Augmented Reality**
- Development of new interface metaphors appropriate to the medium **Virtual Reality**
- Development of formal theoretical models for predicting and modeling user actions **Desktop WIMP**

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

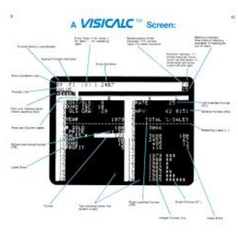
Interface Metaphors

- Designed to be similar to a physical entity but also has own properties
  - e.g. desktop metaphor, search engine
- Exploit user's familiar knowledge, helping them to understand 'the unfamiliar'
- Conjures up the essence of the unfamiliar activity, enabling users to leverage of this to understand more aspects of the unfamiliar functionality
- People find it easier to learn and talk about what they are doing at the computer interface in terms familiar to them

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

Example: The Spreadsheet

- Analogous to ledger sheet
- Interactive and computational
- Easy to understand
- Greatly extending what accountants and others could do



Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

Why was it so good?

- It was simple, clear, and obvious to the users how to use the application and what it could do
- "it is just a tool to allow others to work out their ideas and reduce the tedium of repeating the same calculations."
- Capitalized on user's familiarity with ledger sheets
- Got the computer to perform a range of different calculations in response to user input

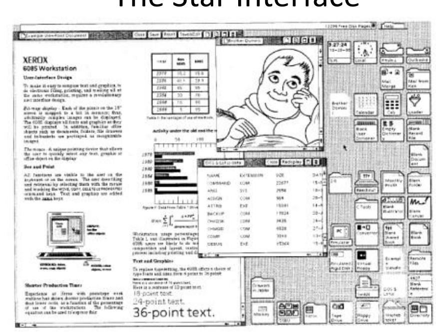
Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

Another Classic

- 8010 Star office system targeted at workers not interested in computing per se
- Spent several person-years at beginning working out the conceptual model
- Simplified the electronic world, making it seem more familiar, less alien, and easier to learn

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

The Star Interface



Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

Benefits of Interface Metaphors

- Makes learning new systems easier
- Helps users understand the underlying conceptual model
- Can be innovative and enable the realm of computers and their applications to be made more accessible to a greater diversity of users

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

Problems with interface metaphors (Nielson, 1990)

- Break conventional and cultural rules
  - i.e. Recycle bin placed on desktop
- Can constrain designers in the way they conceptualize a problem
- Conflict with design principles
- Forces users to only understand the system in terms of the metaphor
- Designers can inadvertently use bad existing designs and transfer the bad parts over
- Limits designers' imagination with new conceptual models

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

AR Design Principles

- Interface Components
  - Physical components
  - Display elements
    - Visual/audio
- Interaction metaphors

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

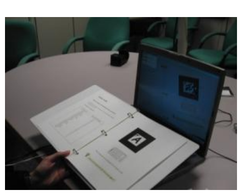
Tangible AR Design Principles

- Tangible AR Interfaces use TUI principles
  - Physical controllers for moving virtual content
  - Support for spatial 3D interaction techniques
  - Time and space multiplexed interaction
  - Support for multi-handed interaction
  - Match object affordances to task requirements
  - Support parallel activity with multiple objects
  - Allow collaboration between multiple users

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

The MagicBook

- Design Goals:
  - Allows user to move smoothly between reality and virtual reality
  - Support collaboration



Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

MagicBook Features

- Seamless transition between Reality and Virtuality
  - Reliance on real decreases as virtual increases
- Supports egocentric and exocentric views
  - User can pick appropriate view
- Computer becomes invisible
  - Consistent interface metaphors
  - Virtual content seems real
- Supports collaboration

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

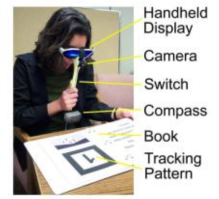
MagicBook Collaboration

- Collaboration on multiple levels:
  - Physical Object
  - AR Object
  - Immersive Virtual Space
- Egocentric + exocentric collaboration
  - Multiple multi-scale users
- Independent Views
  - Privacy, role division, scalability

Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

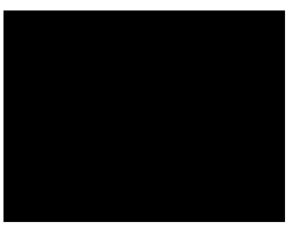
MagicBook Technology

- Reality
  - No technology
- Augmented Reality
  - Camera – tracking
  - Switch – fly in
- Virtual Reality
  - Compass – tracking
  - Press pad – move
  - Switch – fly out



Billinghurst, M. COSC 426: Augmented Reality, Sep 5th, 2012.

MagicBook Video



https://www.youtube.com/watch?v=tNMljw0F-aw

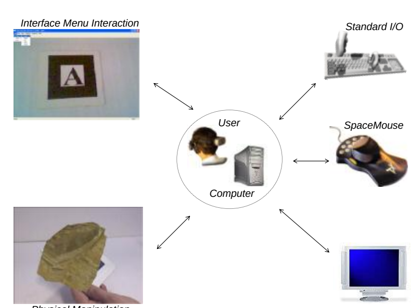
Generic AR Interface

Layers of the AR Interface

AR Applications	
Interface framework	
Interaction algorithms	
Audio algorithms based on OpenAL API	
Visual algorithms based on OpenGL API	
ARToolKit tracking Libraries	Vision SDK Video Libraries
Windows OS	
Libraries and Drivers (Graphics and Sound Card, Video Camera, etc)	

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

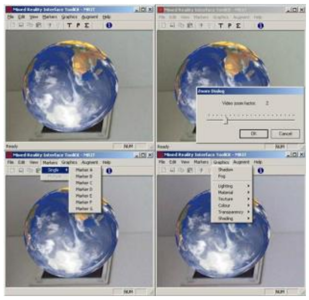
Interactions



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Interface Visualisation Capabilities

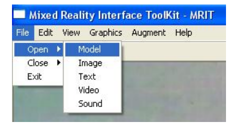
- Visualisation
  - 3D models
  - 3D text
  - 3D sound
  - Videos
  - Pictures



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

GUI Environment

- The GUI consists of a
  - Menu
  - Toolbar
  - Status bar
  - Dialog boxes



- Allows participants to have the same access to the augmented virtual information as they have had using standard interaction techniques

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Some Algorithms

Multiple Augmentation Algorithm

```
Detect camera position
Check the video stream and perform video operations
    if predefined marker is detected in the scene
        Check the available rendering modes
            if 3D model
                Parse a 3ds file and render the 3D model
                Cast shadows and reflections using lighting information
            if Image
                Turn off lighting effects and scale image frame
                Render the image as a static texture
            if Video
                Determine the size of video and decompose into frames
                Render frames as normal images
            if Text
                Parse and ASCII text file
                Render in orthographic or perspective mode
            if Sound
                Read and place sounds into the real environment
                Play multiple sound files in loop until stopped by the user

    Delete from memory
Loop continuously until stopped by the user
```

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Tracking Multiple Markers

Check the image plane for markers

if one or more marker cards are detected
- The transformation matrix between the cameras coordinates and the marker is computed
- The transformation is then stored to the marker array,
- Transformation is compared with the 3D array (which holds transformations for each pattern detected)

if the marker card and the camera stays in static position
- if all markers are in direct view without obstructions virtual information is superimposed
- else if at least one marker card is in direct view and the others are not, then again the virtual information can still be augmented

else if the marker or the camera moves,
- Virtual information is superimposed again

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Textual Augmentation Algorithm

```
Initialise the graphics view for the textual augmentation
Translate the position data in X, Y, Z
Check the font colour
    Assign a new colour when appropriate
Disable OpenGL lighting and texturing functionality
Specify the raster position for pixel operations
If text file is selected by the user
    Check if string exists
        Read string continuously until stopped by user
            Read line by line
            Specify the raster position
            Check the size of the array
                Draw Bitmap when string is found
            Otherwise
                Specify the raster position
    Close the reading operation
```

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

3D Sound Generation

```
initialize OpenAL variables
Load the wave file(s) into different types of buffers

for all the specified sound buffers
    Generate new sound sources and buffers
    Store the wave file into the new buffers
    Assign the sources into buffers
    Unload the wave file(s)
    Specify the pitch
    Specify the gain

for each sound source
    Assign the position, velocity and orientation

Read and invert the transformation matrix
Define a distance model
Assign camera position, velocity and orientation to the listener
```

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

SpaceMouse Interaction

```
Read Event from hardware device
    if Translation button
        if Tx is positive then Translate forward in X axis
        if Tx is negative then Translate backward in X axis
        if Ty is positive then Translate forward in Y axis
        if Ty is negative then Translate backward in Y axis
        if Tz is positive then Translate forward in z axis
        if Tz is negative then Translate backward in Z axis
    if Rotation button
        if Rx is positive then Pitch right in X axis
        if Rx is negative then Pitch left in X axis
        if Ry is positive then Yaw right in Y axis
        if Ry is negative then Yaw left in Y axis
        if Rz is positive then Roll right in Z axis
        if Rz is negative then Roll left in Z axis
    if Scaling button
        if S is positive then Scale up by a predetermined factor
        if S is negative then Scale down by a predetermined factor
    if Lighting button
        Ambient Lighting is turned on/off
    if Ground button
        A virtual ground drawn to occlude the marker card is turned on/off
    if Clipping button
        An invisible plane that clips the AR scene is turned on/off
    if Reset button
        Initialise the transformations to default values
```

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Magic Book Algorithm

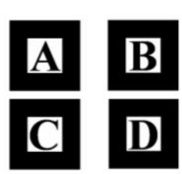
```
If user selects multiple objects button in 'AR Learning Book'
    A list of objects is assigned to an array of markers
    VRML models are downloaded into a local directory through XML
    Textures are downloaded into the same local directory
    Each virtual object is assigned to a specific marker page
    Lighting conditions and other transformations are initialised
    User can alter lighting conditions and other transformations depending on object
    All VRML objects and textures are deleted when user changes view
```

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Designing Markers

Square Marker Cards

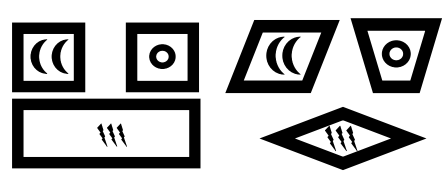
- The easiest solution
- Will work out well for assignment



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Other Shapes Markers

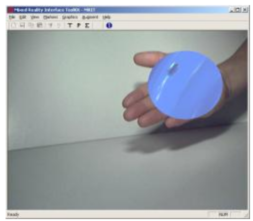
- There are limitations with the number of square markers that can be designed



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Hand Markers

- Does not work very well with ARToolKit

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Tracking & Calibration

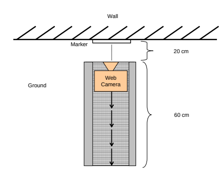
Measuring ARToolKit's Tracking Error

- In wide area applications, the positioning accuracy of ARToolKit is not very robust
- In distances between 1m and 2.5m the error in the x and y values increases proportionally with the distance from the marker
- Calculate error in distances ranging between 20 cm and 80 cm under normal lighting conditions

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Measuring ARToolKit's Tracking Error .

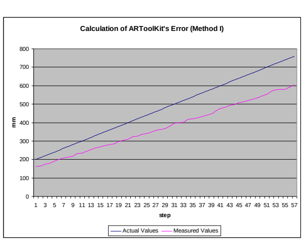
- The optimal area, which contains the least error, is the one that is perpendicular to the marker card
- A rigid path is set so that the camera can not loose its direction while moving backwards
- Numerous measurements of the location of the web camera in a local co-ordinate system



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Measuring ARToolKit's Tracking Error ..

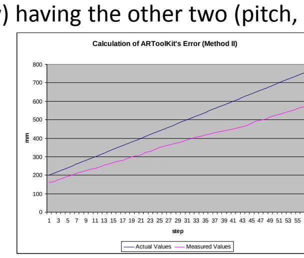
- Error is proportional to the distance



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Measuring ARToolKit's Tracking Error …

- Camera facing the marker at variable angle (yaw) having the other two (pitch, roll) stable



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Measuring ARToolKit's Tracking Error ....

- Differences in the error produced from the experiments compared with the actual values

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Calculating Camera Parameters

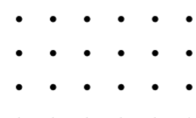
ARToolKit's Calibration Method

- ARToolKit provides two software tools called calib_dist and calib_param that can be used to calculate these camera properties
  - calib_dist is used to measure the lens distortion and the image centre point
  - calib_param is used to compute the focal length of the camera

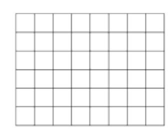
Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

ARToolKit's Calibration Method .

- In calib_dist program, an image of a pattern 6x4 dots spaced equally apart is used



Camera calibration for lens distortion

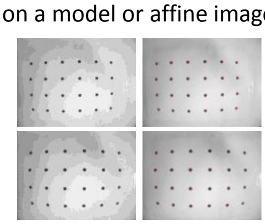


Camera calibration for focal length

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

KLT Tracking Method

- A feature-based vision method is known as the KLT (Kanade-Lucas-Tomasi) algorithm based on a model or affine image changes



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

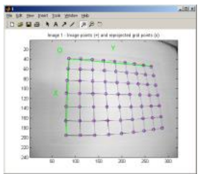
Camera Calibration Toolbox for Matlab

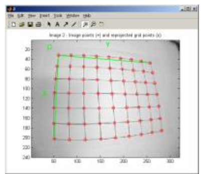
- Offers an automatic mechanism for counting the number of squares in each grid
- All calibration images are searched and focal and distortion factor are automatically estimated

	Estimated focal (pixels)	Estimated distortion factor (kc)
Image 1	201.2503	-0.2
Image 2	224.1415	-0.2
Image 3	231.7859	-0.2
Image 4	114.2254	-0.055
Image 5	265.8596	-0.28
Image 6	211.5925	-0.2

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

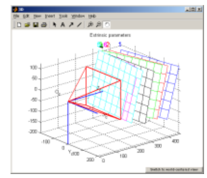
Calibration Without Lens Distortion

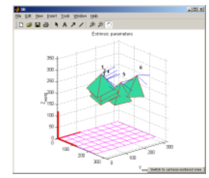




Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

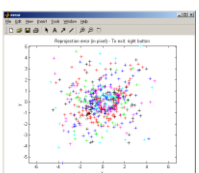
Calculation of Extrinsic Parameters



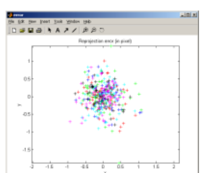


Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Error Calculation of Extrinsic Camera Parameters



Initial Error



Corrected Error

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Case Studies

Learning Requirements

- The potential benefits of AR applied to HE include:
  - Visualisation of the theoretical parts in 3D
  - Practical exploration of the theory
  - Effective collaboration and discussion amongst the participants

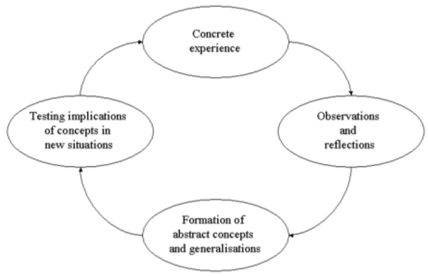
Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Learning Requirements .

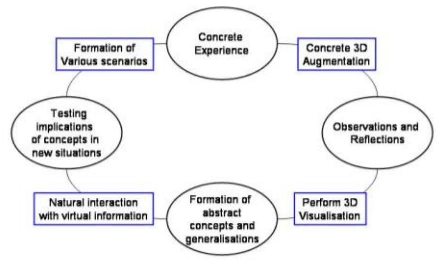
- An ideal AR system must include at least the following requirements
  - Be simple and robust
  - Provide the user with clear and concise information
  - Enable the teacher to input information in a simple and effective manner
  - Enable easy interaction between users
  - Make complex procedures transparent to the user
  - Be cost effective

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Kolb's Learning Cycle



Enhanced Learning Cycle using AR



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

Design of Teaching Material

- Off-line process and consists of:
  – A set of distinctive marker cards - this is the link between the real and the digital information;
  – Digital information - is the digital information including pictures, 3D models, textual descriptions, video animations and auditory information;
  – Educational tutorials - consist of a number of predefined learning scenarios which combine theory and practice at the same time

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

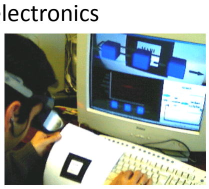
Tutorials Generation

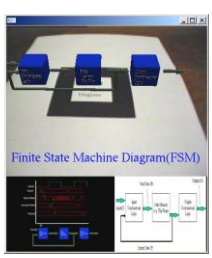
- Theoretical tutorials
  – Most important parts of the theory are described through visual and auditory means of augmentation having limited user interaction
- Practical tutorials
  – Based on the theory, students have to use the specific set of marker cards to describe a simple but complete process using collaborative interaction techniques
- Assessment tutorials
  – 3D graphical representations of theoretical and practical issues are assessed in a semi-automatic way based on all the proposed types of human-computer interactions

Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

First Prototype: MARIE

- Initial prototype for AR in education
- Focused on teaching electronics

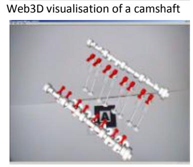


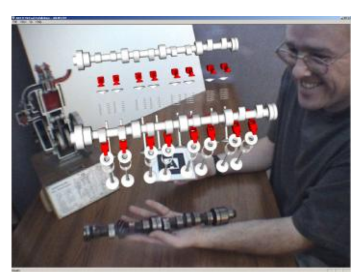


Liarokapis, F., Petridis, P., Lister, P.F., White, M. Multimedia Augmented Reality Interface for E-Learning (MARIE), World Transactions on Engineering and Technology Education, UICEE, 1(2): 173-176, 2002. (ISSN: 1446-2257)

Second Prototype: Wed3D & AR


Web3D visualisation of a camshaft

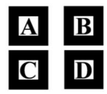

Augmentation of a camshaft


Pilot user experiencing an AR learning scenario, University of Sussex

Liarokapis, F., Mourkoussis, N., White, M., Darcy, J., Sifniotis, M., Petridis, P., Basu, A., Lister, P.F. Web3D and Augmented Reality to support Engineering Education, World Transactions on Engineering and Technology Education, UICEE, 3(1): 11-14, 2004. (ISSN: 1446-2257)

Design of Teaching Material

- Create appropriate markers
- Create material
- Link together



Liarokapis, F., Augmented Reality Interfaces - Architectures for Visualising and Interacting with Virtual Information, Sussex theses S 5931, Department of Informatics, School of Science and Technology, University of Sussex, Falmer, UK, 2005

University of Sussex

- Application in Informatics
- Goal:
  - Understand the computer

Liarokapis, F., Anderson, E. Using Augmented Reality as a Medium to Assist Teaching in Higher Education, Proc. of the 31st Annual Conference of the European Association for Computer Graphics (Eurographics 2010), Education Program, Norrkoping, Sweden, 4-7 May, 9-16, 2010. (ISSN: 1017-4656)

City University

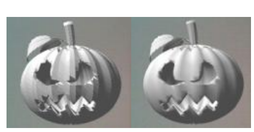
- Application in Geography and GIS
- Goal:
  - Understand GIS in London

Liarokapis, F., Anderson, E. Using Augmented Reality as a Medium to Assist Teaching in Higher Education, Proc. of the 31st Annual Conference of the European Association for Computer Graphics (Eurographics 2010), Education Program, Norrkoping, Sweden, 4-7 May, 9-16, 2010. (ISSN: 1017-4656)

Video City University

Coventry University

- Application in Computer Graphics
- Goal
  - Understand basic principles in CG



Liarokapis, F. Augmented Reality Interfaces for Assisting Computer Games University Students, Bulletin of the Technical Committee on Learning Technology, IEEE Computing Society, 14(4): 7-10, October, 2012. (ISSN: 2241-3766)

Evaluation

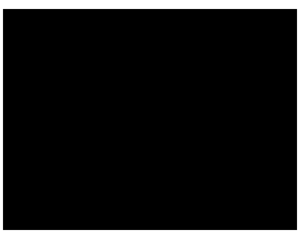
- Very useful tool
- Need some time to adapt
- Teacher can combine different learning approaches
  - i.e. Activity Lead Learning

Some Videos

BaekAR Video

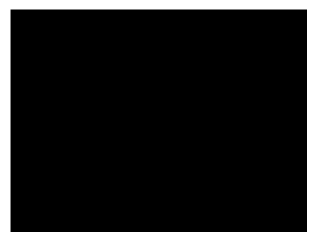
https://www.youtube.com/watch?v=ZyZMdymlwms

IKEA Video



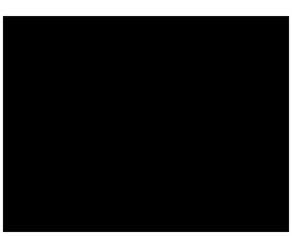
https://www.youtube.com/watch?v=ohDaowN1KYY

3D User Interface Design Video



https://www.youtube.com/watch?v=B4GVWk3L9hE

Multi-Players Learning Video



https://www.youtube.com/watch?v=jqE-EmIhGw4

Assignment Tips

Assignment

- Make use of an AR API to create an educational game
  - i.e. ARToolKit
- Implementation in C/C++/C sharp
- Emphasis will be given on the interaction and visualisation techniques
  - Not on tracking!
- Deadline end of the term

Details

- The game should be focused on indoor environments
  - Not mobile!
- The topic is focused on designing a game/tool to assist students to learn computer graphics
- Visualisation
  - All types of multimedia information can be superimposed
- Tracking
  - Single or multiple markers

Visualisation

- ARToolKit main platform
- Graphics in ARToolkit C++ version is not well supported
- Can wrap it with other applications
- Develop tools for handling different media
  - Text, sound, 3D, images, video

Content

- Best to find it online
- Loads of resources
- Might need to make small adjustments
- Don't model things from scratch, no time!

Markers

Tracking

- Don't need to create new tracking methods
  - Just select the best one from the examples presented in the lab
- But think of the presentation
  - Single
  - Multiple
  - Combination

Interaction

- Need to determine requirements and user needs
- Take other constraints into account
  - i.e. Time, hardware
- Also will depend on suitability of technology for activity being supported

Report Structure

- Title page
- Contents
- Abstract (or summary) (1/2 page)
- Introduction (1 page)
- Background theory (3-5 pages)
- Methodology and results (5-10 pages)
- Conclusions (1 page)
- References
- Appendices

Questions