

# Augmented Reality II

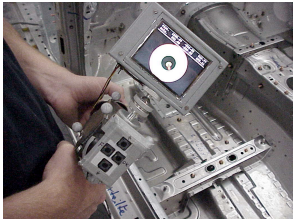
User Interfaces:  
Direct Manipulation

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# Reminder

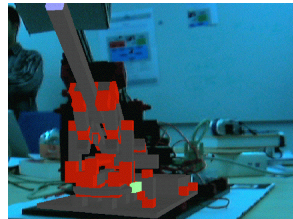
## AR-Examples



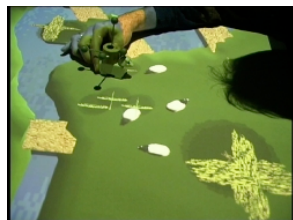
- PAARTI (stud welding)
  - heARts (Minimally invasive surgery)



- Fatamorgana (car design)



- FixIT (diagnosis of machine malfunctions)
  - STARS (plant maintenancs)



- SHEEP (collaborative process control)
  - CAR (rapid prototyping of UI functionality)

# Literature

- Ben Shneiderman, “Designing the User Interface, Strategies for Effective Human-Computer Interaction”, Addison Wesley.  
(Chapter 6)

# Outline

- Examples
- Explanations
- Visual Thinking and Icons
- Programming
- Virtual Environments

# 1. Examples

# 1. Examples

The ultimate direct manipulation: Driving a car...

- Scene directly in front window
- Performance of actions common cultural knowledge

Slightly less real: Air traffic control...

- Visible representative of air space
- Brief virtual data blocks attached to planes
- Controllers move track ball to point at specific planes and to perform actions

# 1. Examples

Manipulation of virtual data:

- Texts: WYSIWYG
- Tables: VisiCalc
- Maps: Spatial data management
- Simulations: Video games
- 3D Models: CAD

# 1.1 WYSIWYG



# 1.1 WYSIWYG

“What you see is what you get” (vs. line-oriented editors)

- Display full page of text
- Display document in the form that it will appear at the end
- Show cursor action to the user
- Control cursor motion through physical means (mouse)
- Use labelled icons for actions
- Display results of actions immediately
- Provide rapid response and display
- Offer easily reversible actions

HOW ABOUT LATEX???

# 1.1 WYSIWYG

By now: word processors as integrated toolchests

- Multi-media
- Desktop-publishing software (high-quality output)
- Slides
- Hypermedia environments
- Improved macro facilities
- Spell checkers, thesauri
- Grammar checkers
- Document assemblers

## 1.2 VisiCalc

“Instantly calculating electronic worksheet”  
[Dan Bricklin, Harvard Business School]

- Simulation of an accountant’s spreadsheet
- “It jumps”
- Integration with
  - graphics,
  - 3D representations,
  - multiple windows,
  - database features

# 1.3 Spatial data management

Exploit the concept of spatial representations

- Use geographic maps [Negroponte]
  - Picture of the globe
  - Organizational chart of a company
  - Travel information
  - Production data
  - Schedules
- Travel through complex information spaces (*I-spaces*) by mouse selection and zoom
- System success depends on designers' skill in choosing geometric metaphors (icons, graphical representations and layouts) that correspond naturally to the (semantics of the) data.

## 1.4 Video Games

- PONG
- Missile Command
- Donkey Kong
- Pac Man
- Tempest
- TRON
- ...

## 1.4 Video Games

- Minutes of basic instruction
- Hours of training to become an expert

## 1.4 Video Games

- Commands are physical actions (button presses, joystick motions, knob rotations)
- Results are shown on the screen
- No syntax to remember!
- Continuous score keeping +display
  - positive reinforcement (objective feedback)
  - no annoying subjective positive feedback (“hypocratic”)

## 1.4 Video Games

Educational games (“edutainment”)

- SimCity
- Myst, Riven
- DOOM (?)

Limits to the lessons that can be learned from  
games



# 1.4 Video Games

## - Limits to Edutainment -

### Game players

- seek entertainment
- focus on the challenge of mastering the UI
- random events are seen as a challenge

### Application users

- focus on the task
- resent too many playful distractions
- prefer predictable behavior

# 1.5 CAD

Application areas:

- automobiles
- electronic circuits
- architecture
- aircraft design
- slide layout

## 1.5 CAD

- Capacity to manipulate the object of interest directly
- Generate multiple alternatives rapidly
- Basic strategy:
  - Eliminate the need for complex commands
  - visual overview facilitates problem solving by analogy (screen representation similar to real environment)
- Problem: 3D picking

## 1.6 In General...

Holy grail: find an appropriate representation or model of Reality!

- Jump to visual language
- Metaphors:
  - stack of cards: sets of addresses, phone numbers, events, ... (HyperCard stacks)
  - checkbook maintenance (Quicken)
  - web-based reservations (airline reservations)
  - master-slave robot teaching

## 2. Explanations of Direct Manipulation

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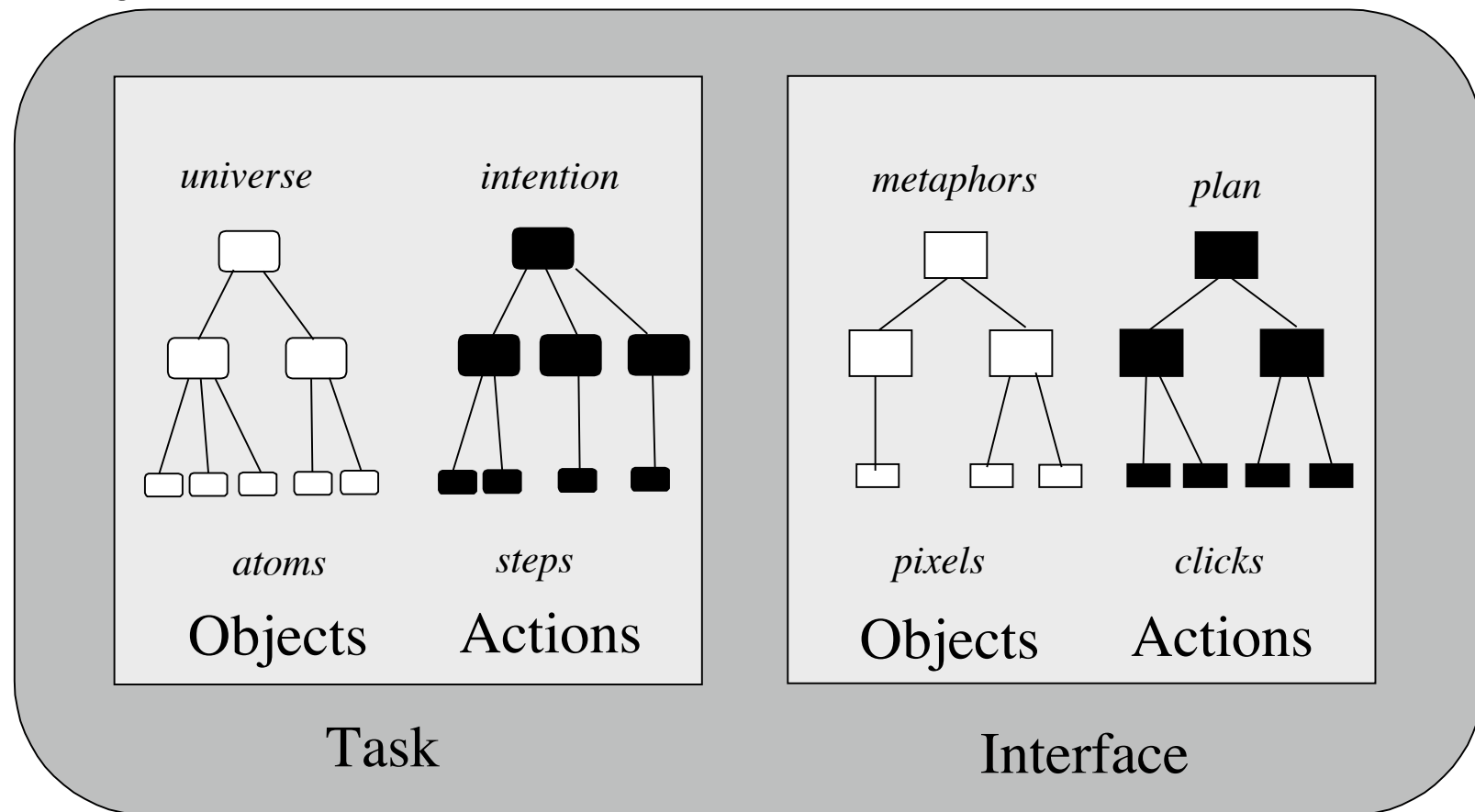
- [Nelson 80]: “Principle of virtuality”  
a representation of reality that can be manipulated
- [Rutkowski 82]: “Principle of transparency”  
user can apply intelligence directly to the task; the tool seems to disappear
- [Heckel 91]: Problem solving styles of
  - Engineers: logical symbolic sequential left-brain
  - Users: visual artistic all-at-once right-brain
- [Hutchins 86]: Feeling of involvement directly with a world of objects rather than communicating with an intermediary
- Direct manipulation breeches
  - Gulf of execution
  - Gulf of evaluation

## 2.1 Problems with Direct Manipulation

1. Spatial/visual representations very spread out.
2. Users must learn the meaning of components of a visual representation.
3. Visual representation may be misleading (incorrect conclusions about permissible actions: over-/underestimation of the functions of a computer-based analogy).
4. Experienced typists are faster with the keyboard than with the mouse.

# 2.2 OAI Model Explanation of Direct Manipulation

(Object-Action Interface Model [Shneiderman])





## 2.2 OAI Model Explanation of Direct Manipulation

Three main principles of direct manipulation:

1. Continuous representation of the objects and actions of interest with meaningful visual metaphors
2. Physical actions or presses of labeled buttons instead of syntax
3. Rapid incremental reversible operations whose effect on the object is visible immediately

## 2.2 OAI Model Explanation of Direct Manipulation

- Stimulus-response compatibility
- TASK objects and actions dominate users' concerns. With direct manipulation, the closeness of the task domain to the interface domain is visible.
- INTERFACE actions at high level in the tree. Little need for mental decomposition of the tasks

## 2.2 OAI Model Explanation of Direct Manipulation

- Psychologists know:
  - People grasp spatial relationships and actions faster when they are given visual (rather than linguistic) representations
- 4 stages of development [Piaget]
  - sensorimotor (birth - 2 years)
  - preoperational (2-7 years)
  - concrete operational (7-11 years)
    - ... physical actions on an object become comprehensible
    - ... children acquire concept of conservation/invariance
  - formal operations (11 years and more)
    - ... children start using symbol manipulation to represent actions,

direct manipulation  
interfaces



### 3. Visual Thinking and Icons

# 3. Visual Thinking and Icons

CMD-line interfaces for

- logical
- linear
- text-oriented
- left-brained
- compulsive
- rational

programmers

WIMP (windows, icons, mouse, and pull-down menu) interfaces for

- artistic
- right-brained
- holistic
- intuitive

users

# 3. Visual Thinking and Icons

Text vs. Graphics: ICONS...

- Design requirements for icons
  - small (to save space)
  - high resolution (to be distinct)
- Task-dependent
  - stay visual in a visually oriented task (drawing)
  - stay textual while working on a tex document

# 3. Visual Thinking and Icons

## Icon-specific guidelines

- Represent object/action in a familiar/recognizable manner
- Limit number of icons
- Make icon stand out from its background
- 3D icons: eye-catching but also distracting
- Make icons easily distinguishable (esp. selected vs. unselected icons)
- Harmonious families of icons
- Design animation of icon movement
- Icons to show progress of complex actions
- New concepts to describe combinations of icons

# 3. Visual Thinking and Icons

Semiotics: Levels of icon design [Marcus 92]:

- Lexical: machine generated marks (pixels, shape)
- Syntactics: appearance, movement
- Semantics: object representation; concrete vs. abstract, part vs. whole
- Pragmatics: overall legibility, utility, memorability, pleasure of use
- Receptivity to clicks: highlighting, dragging, combining



# 4. Direct Manipulation Programming

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Goals:

- Programming physical devices by direct manipulation
- Macro facilities for GUIs (as for command languages)

[Myers]: “demonstrational programming”

- User demonstrates a certain pattern of actions
- System automatically recognizes and instantiates patterns; creates appropriate macros

# 4. Direct Manipulation Programming

Five challenges of *Programming In The UI* (PITUI)

1. Sufficient computational generality
2. Access to appropriate data structures and operators
3. Ease in programming and in editing programs
4. Simplicity in invocation and assignment of arguments
5. Low risk (high probability of bug-free programs)

Goal of PITUI:

- Allow users easily and reliably to repeat automatically the actions that they can perform manually in the UI.

# 4. Direct Manipulation Programming

Cognitive dimensions framework [Green]

- Help analyze design issues of visual-programming environments
- Aspects of an API that affect its usability

# 4. Direct Manipulation Programming

Cognitive dimensions framework: Some of the dimensions

1. abstraction level
2. learning style
3. working framework
4. work-step unit
- 5. progressive evaluation** (capacity for execution of partial programs)
6. premature commitment
7. penetrability
8. API elaboration
- 9. API viscosity** (difficulty of making changes)
10. consistency
11. diffuseness / terseness
12. hidden dependencies
13. visibility and juxtaposibility

# 5. Virtual Environments

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Examples:

- Flight simulator
- Evolution of 3D architectural design
  - 3D models
  - monitor .. wall-sized display .. HMDs
  - animated viewer motions
  - user-controlled motions (treadmill .. trackers)
  - connected rooms
  - “looking at” .. “being in”

# 5. Virtual Environments

## “Looking at”

- air-traffic control
- regular TV experience
- regular theater
- look at a patient
- *exo-centric view*  
(*pursuit*)

## “Being in”

- architectural visualization
- movies on large screens
- Living Theater “be-ins”
- be in a patient (minimally  
invasive surgery)
- *ego-centric view*  
(*compensation*)



# 5. Virtual Environments

- Artificial reality [Krueger 91]  
VideoPlace, VideoDesk: large screens + full-body movement
- CAVE [Cruz-Neira 93]
- Telepresence: non-physical motions
  - remote direct manipulation, remote vision
  - escape reality
  - psychological treatments (e.g. fear of heights)

# 5. Virtual Environments

Requirements according to OAI model:

- rapid select of actions by pointing, gesturing
- incremental, reversible control
- immediate display feedback (for sense of causality)
- simple interface objects and actions (directly related to task domain)
  - surgeon's instruments
  - interior designer: window stretching tool, room painting tool, ...
  - navigation: overview maps

## 5. Virtual Environments

Alternative to immersive environments:

*Desktop (fishtank) virtual environments*

- “looking at” standard displays
- user-controlled exploration of real places, scientific visualization, fantasy worlds
- on high-performance workstations
- web-based presentations (VRML)

## 5. Virtual Environments

Alternatives to immersive virtual environments:

- *Augmented Reality*: Semitransparent mixture of virtual and real for the current viewpoint of a user [Feiner 93, Mizell and Caudell]
- *Situational Awareness*: palmtop computer with location sensors to control the display [Fitzmaurice 93]

# 5. Virtual Environments

Technical requirements to preserve the sense of “being in”

- Visual display: field of view, resolution, coarse vs. detailed images at different speeds of user motions, smooth transitions
- Head-position sensing: high precision (< 1 degree), rapid (< 100 msec), eye tracking
- Hand-position sensing: accuracy, standard gestural vocabulary [Bryson 96], finger positions, knees, arms, legs
- Force feedback (haptic)
- Sound input and output
- Other sensations: vibrations, tilting, throbbing, smell (olfactory)
- Cooperative and competitive virtual reality

