Direct Manipulation

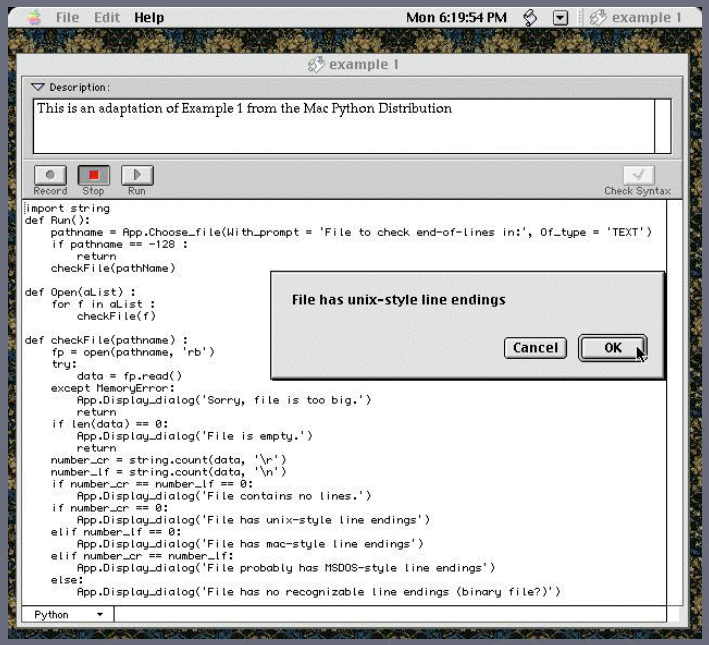
Human Computer Interaction

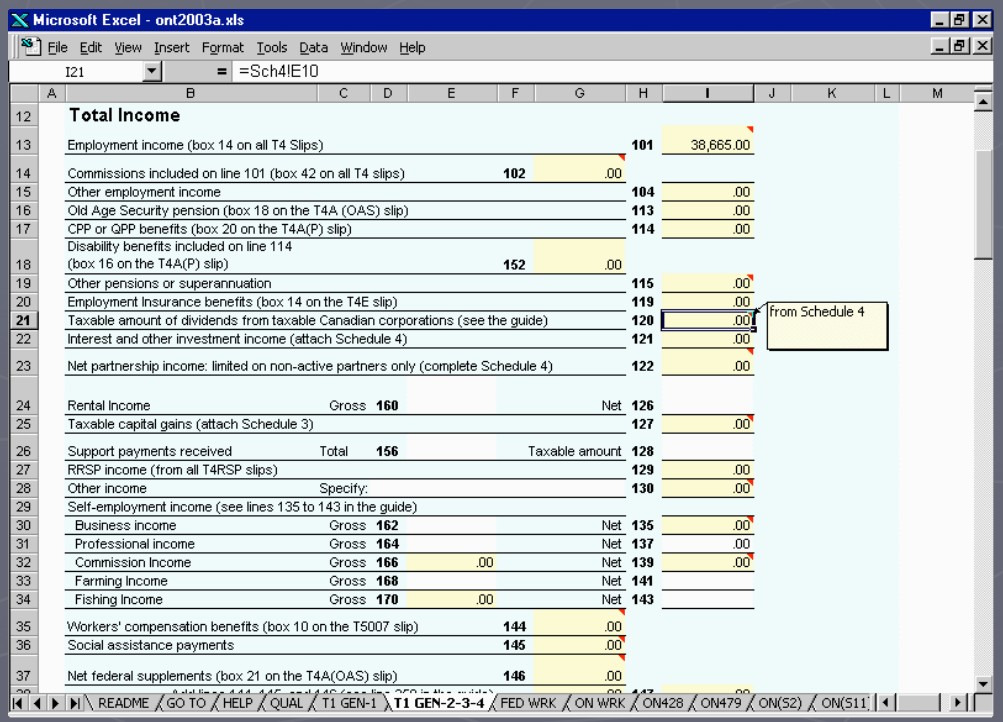
CIS 6930/4930

Section 4188/4186

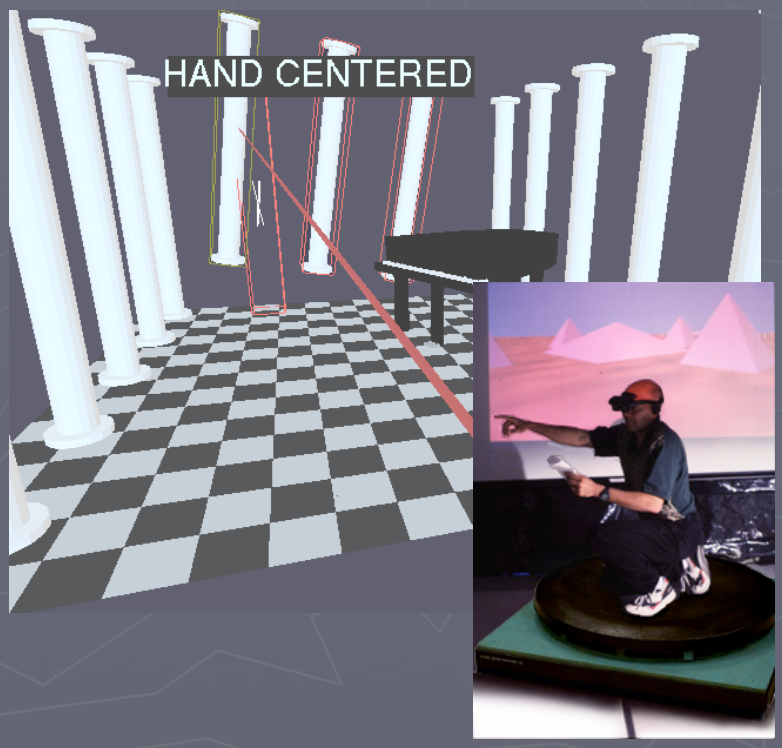
Introduction

- Interactive systems can produce reactions that non-interactive systems are less likely to produce
- Truly pleased user! They report…
  - Master of the interface
  - Competency of task performance
  - Ease of learning new and advanced features
  - Confidence of retention
  - Enjoyment
  - Eagerness to show to novices
  - Desire to explore





Direct Manipulation Interfaces



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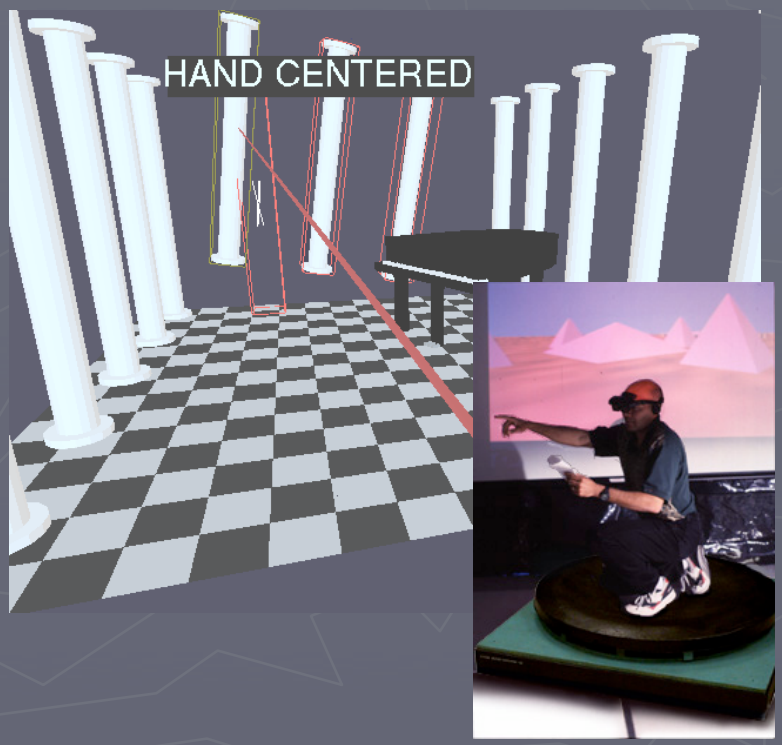

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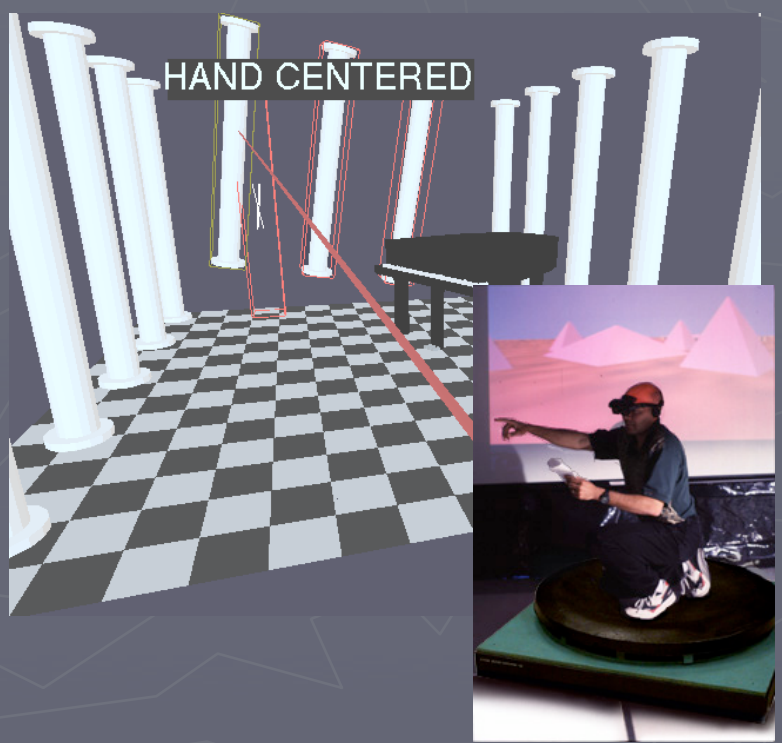

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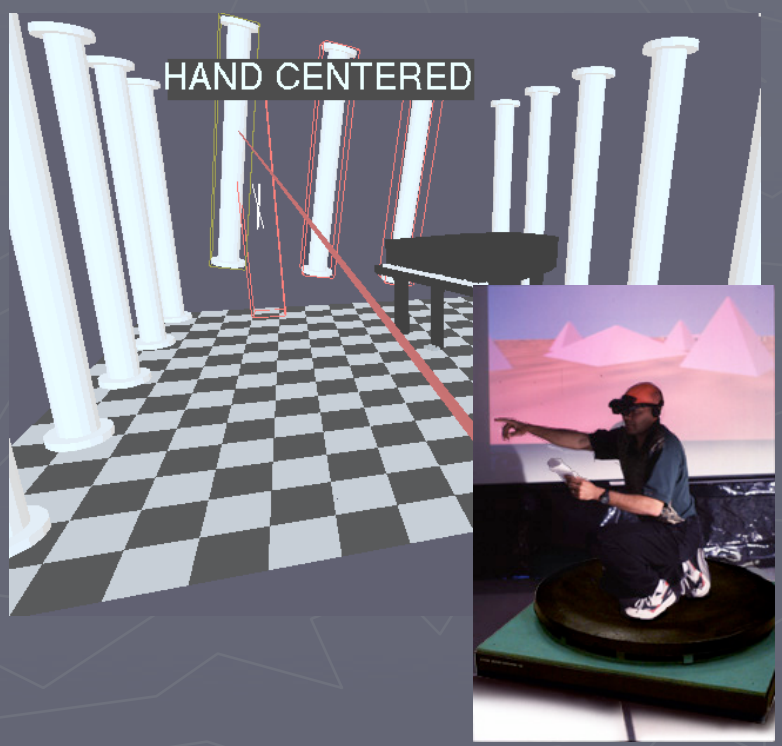

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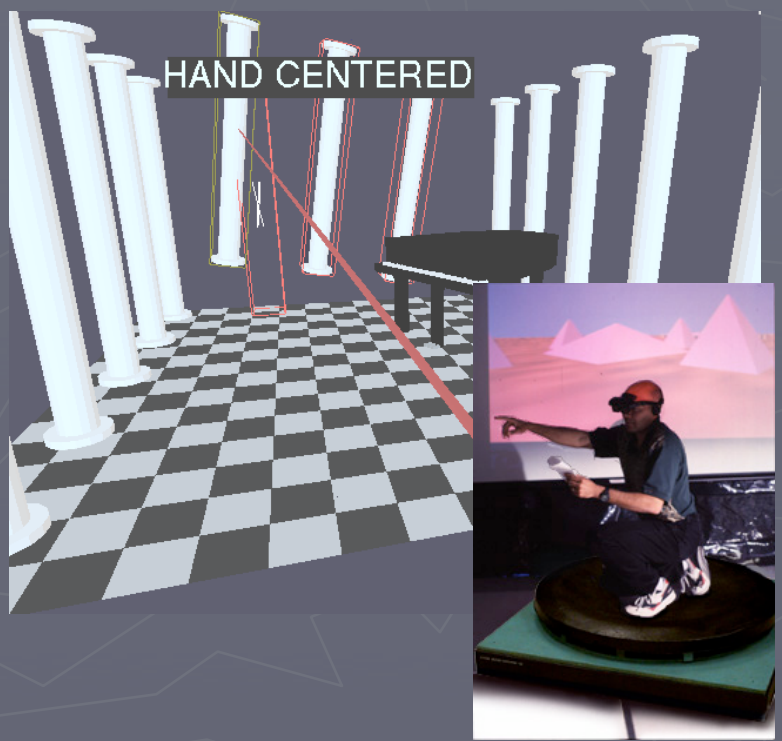

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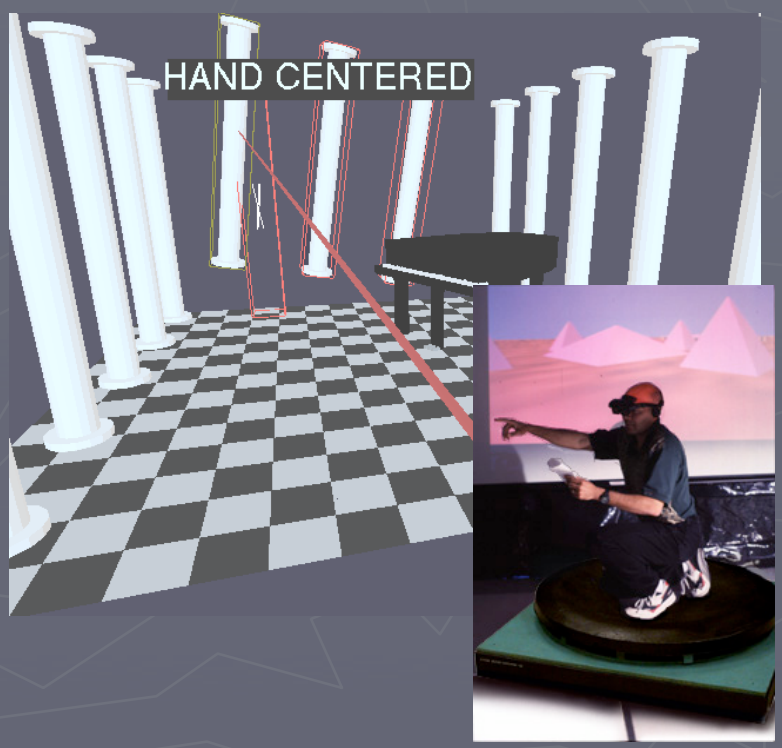

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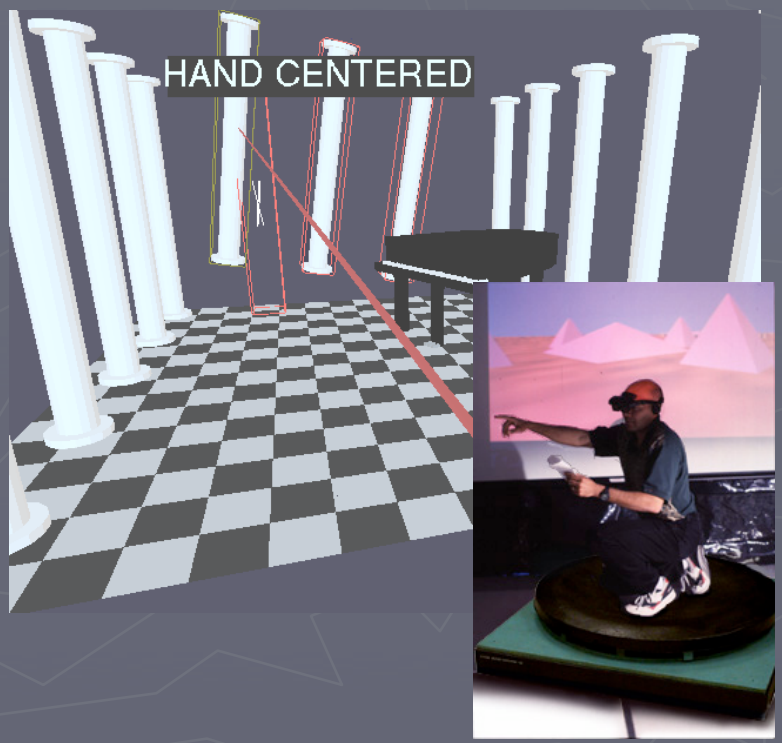

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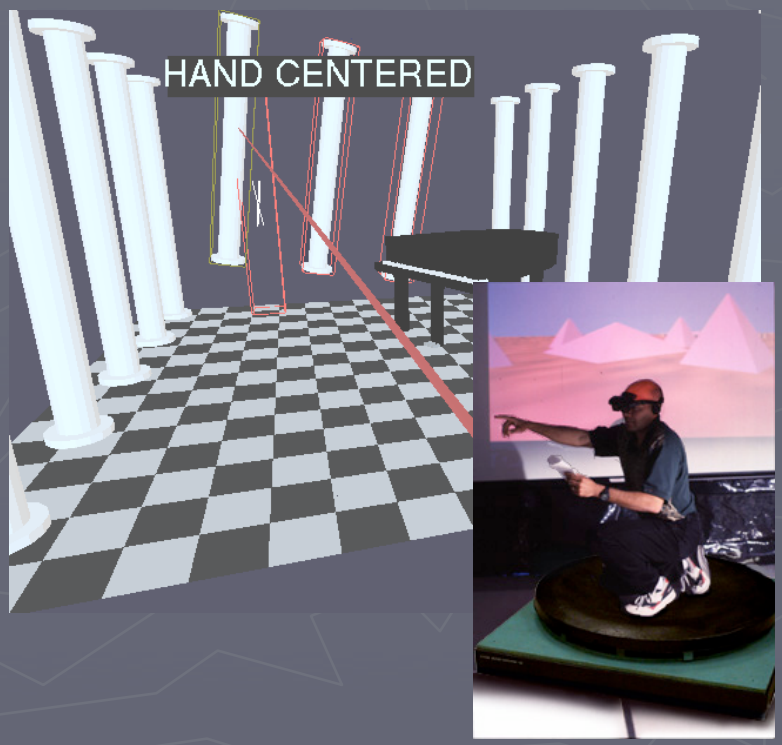

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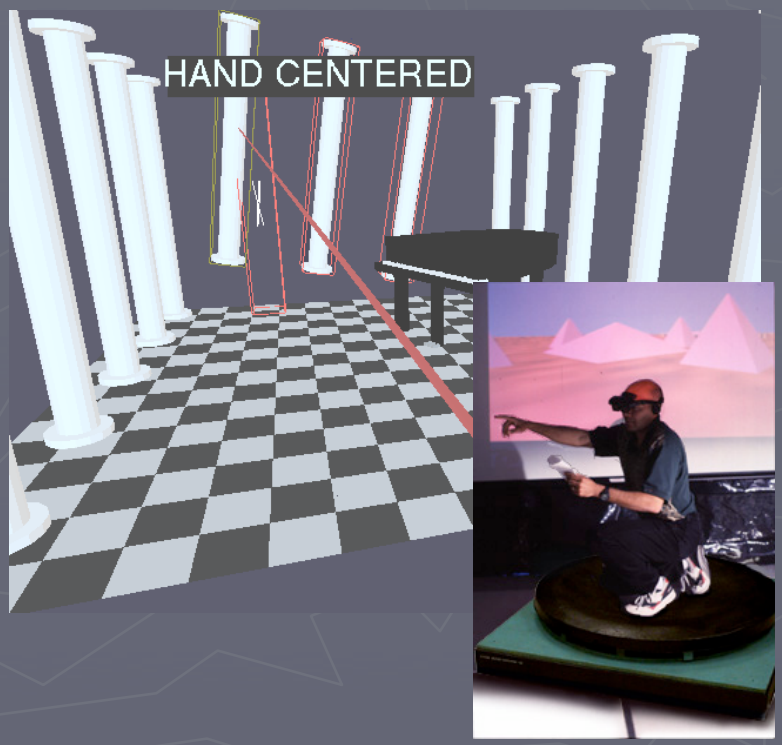
  - VR/AR (gestures, gloves, tracked devices)
  - 2D/3D what's the difference?

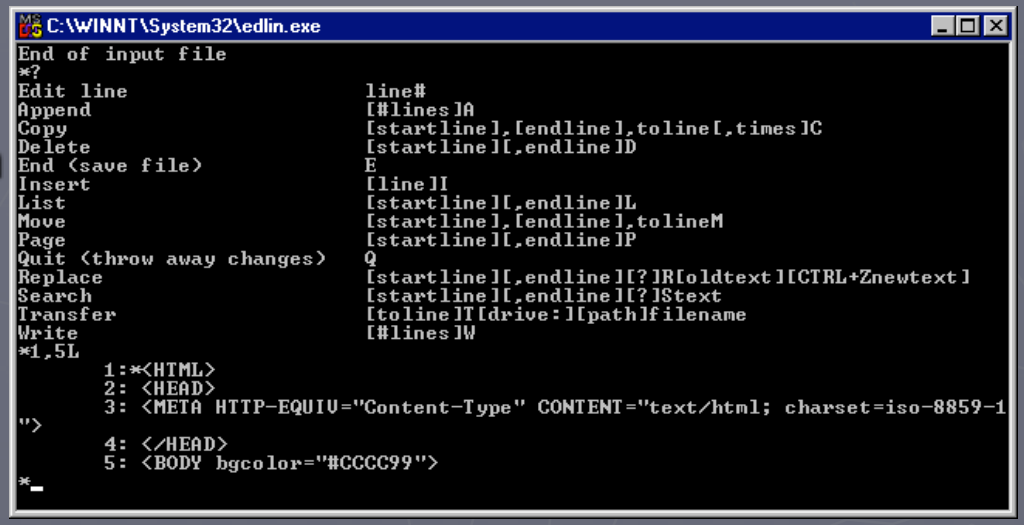


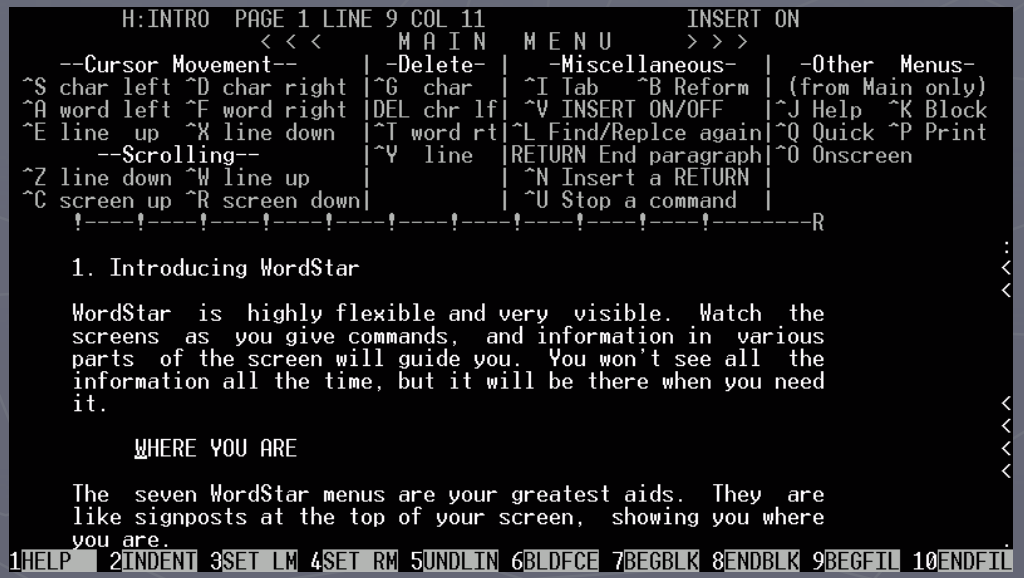
Direct Manipulation Examples

- Drive a car
- If you want to turn left, what do you do?
- What type of feedback do you get?
- How does this help?
- Think about turning left using a menu/text interfaces

Command-line vs. Display Editors vs. Word Processors

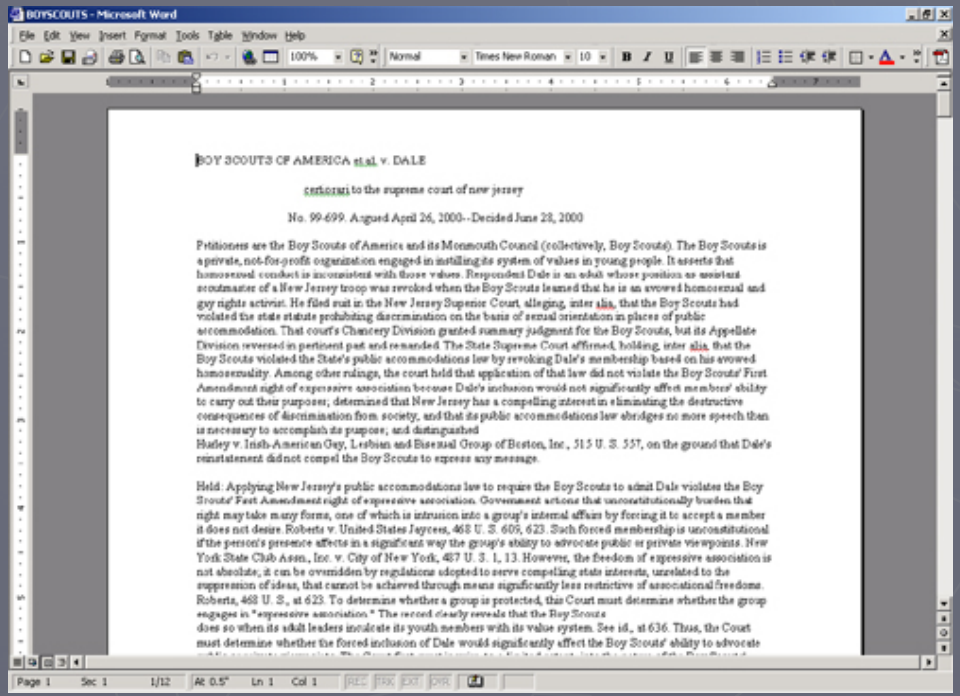
- Case Study: Word Processors:
  - Early 80s, only saw 1 line at a time
  - Editing was difficult
  - No global perspective
- Full-page Display Editors
  - 2D cursor control
  - Ex. WORDSTAR, emacs
- Researchers found:
  - Increased performance
  - Decreased frustration
  - Improved training
- What would be easier with command-line?





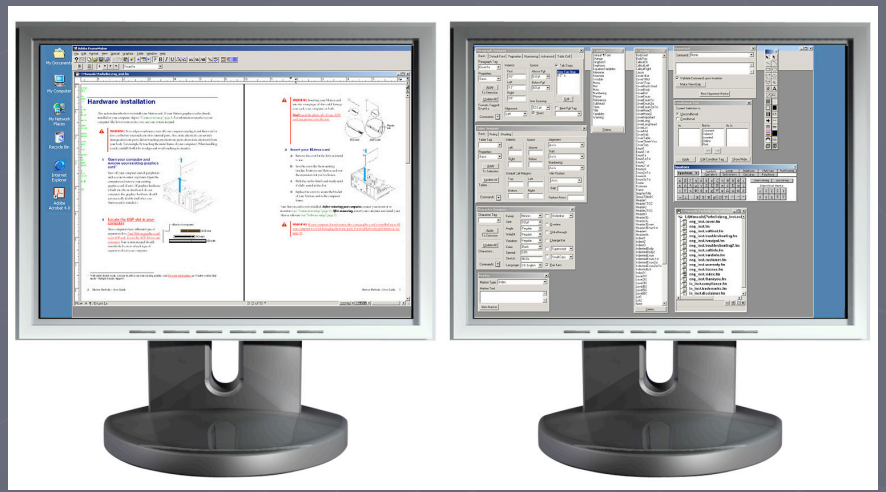
Command-line vs. Display Editors vs. Word Processors

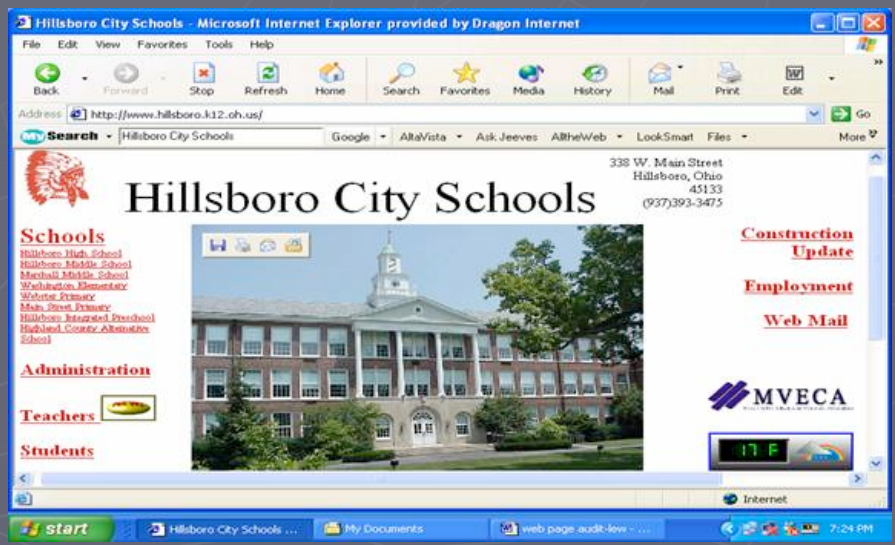
- Early 90s: What You See Is What You Get (WYSIWYG)
  - Word, Corel's WordPerfect, Lotus Word Pro
  - See a full page of text
  - Seen as it will appear
  - Cursor action is visible (attention focus)
  - Cursor motion is natural (arrow/ mouse vs. 'Up 6' – requires converting)
  - Labeled icons make frequent actions rapid (remind users of possible actions)
  - Immediate display of the results of an action
  - Rapid Response and Display (sense of power)
  - Reversible Actions (lowers anxiety)



Technical Results from Empirical Studies and Word Processors

- Integration of multimodal information – graphics, sound, animation, data, photos
- Desktop-publishing software
- Presentation software
- Hypermedia environments and the WWW
- Improved macro/templates facilities
- Spell/grammar checkers & thesauri



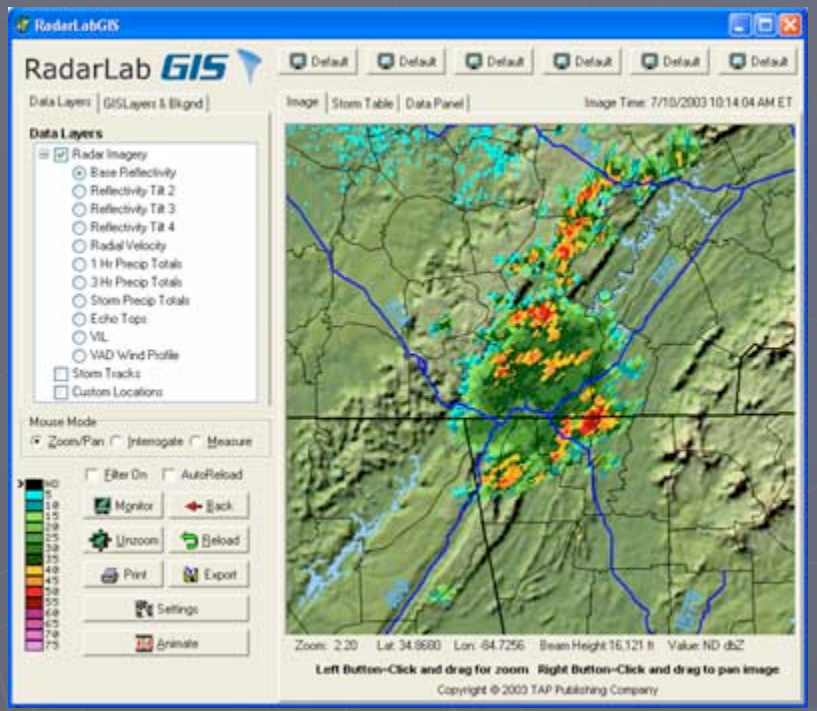


VisiCalc Spreadsheet

- 1979 – Dan Brickland (254 rows, 63 columns)
- Direct Manipulations
- Users like
  - Auto propagation of their actions
  - Alternate plans
  - Macros
- Others:
  - Lotus 1-2-3, Excel

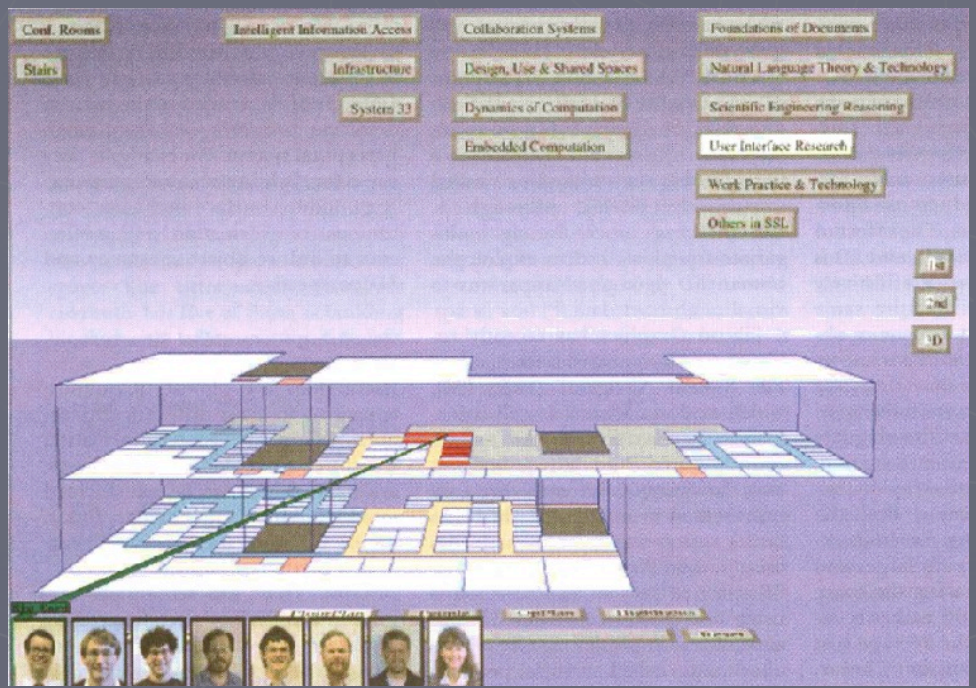
Spatial Data Management

- Geographical data visualization and interaction
- Direct Manipulations
  - Notion of using a joystick to navigate a map:
  - Idea: Nicholas Negroponte (MIT)
  - App: Spatial Data Management System (’80)
  - Zoom-in on ocean map and marker bouys



Spatial Data Management

- Others:
  - Xerox PARC Information Visualizer
    - Walkthrough
    - File directories, org charts, 2d info
  - ArcView – Current map viewer pg. 221
- Success: Designer is very important!
  - Icons, representations, understanding user needs.
  - Users typically enjoy the direct manipulation



What is the most successful app of Direct Manipulation?

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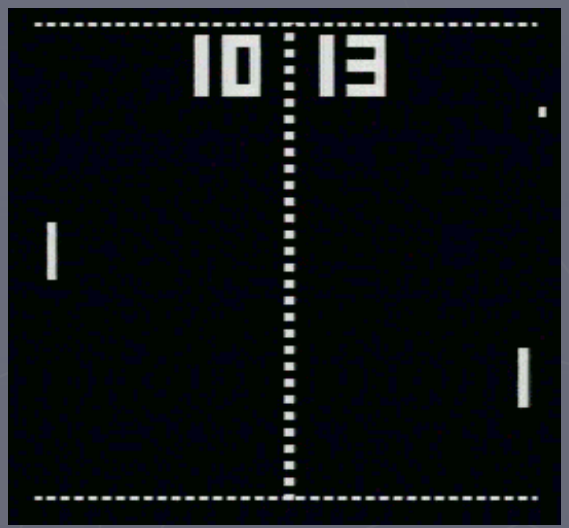
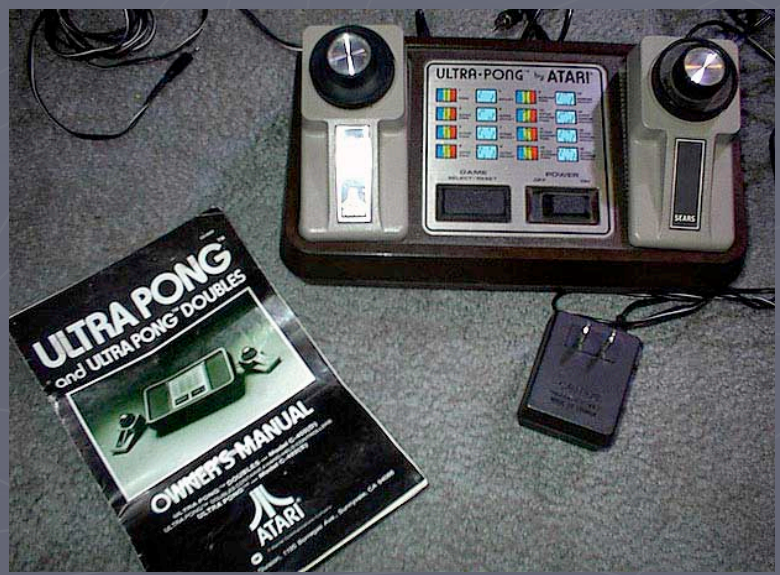
- Video Games
- PONG
  - Low learning curve
  - Mass appeal (which many current games don't have!)
  - Let's list a whole bunch of the most popular games
  - What are some commonalities?
- Direct Manipulations
  - Let's list them





Video Games

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  - Age

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- Think about designing for different platforms
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Video Games

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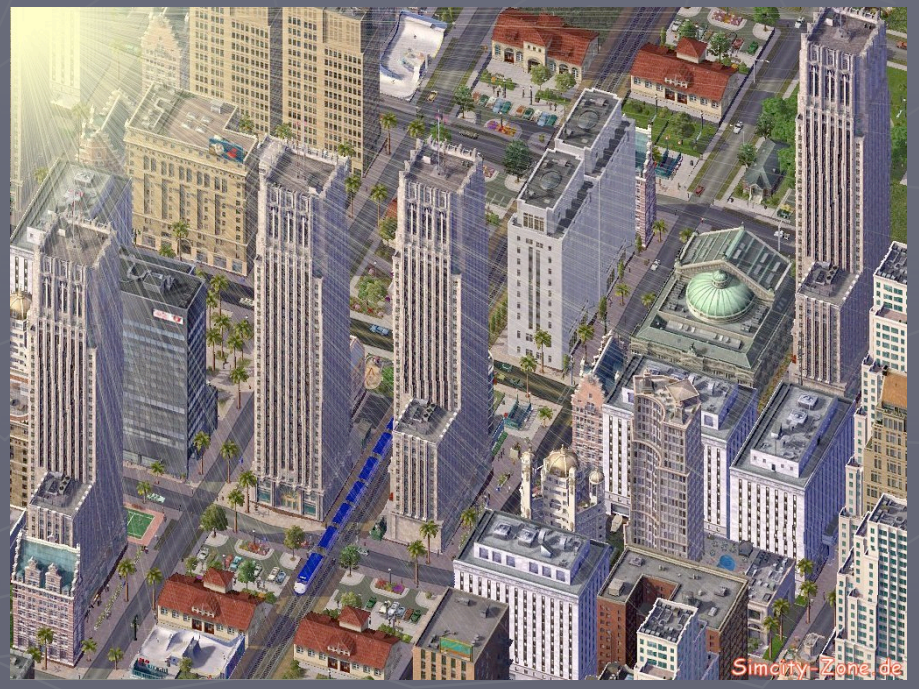

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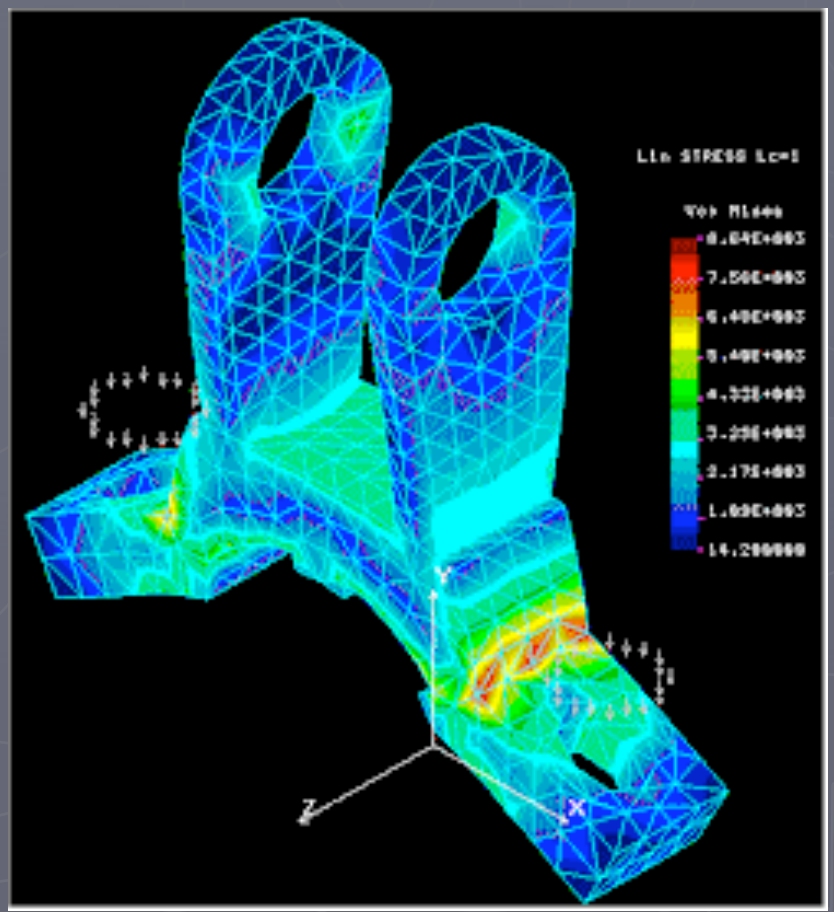
- Direct manipulation for education
  - SimCity
  - The Sims

Computer Aided-Design

- Extensively uses Direct Manipulation
- AutoCAD
- Structural engineer, landscaping, automobiles, etc.
- Change design and evaluate designs quickly
- Computer Aided Manufacturing (CAM)
- Allows many of the specification tools to be used for large designs (group review, etc.)
- Few complex commands
- Analogy/familiar designs important (don't change the terminology, etc.)



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  - **Study result:** task time (5.8 vs. 4.8 minutes), errors (2.0 vs. 0.8) (’87)

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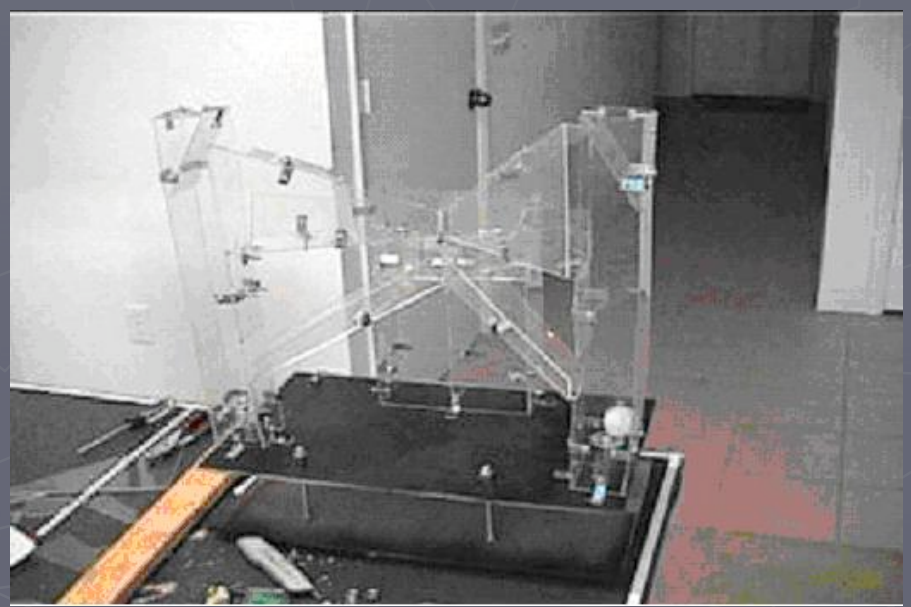
  - Improved productivity, reduced

Evolution of Direct Manipulation

- To create a good Direct Manipulation interface
  - Model reality well
  - Visual interface if possible
  - Know your users
- Aesthetic Computing
- Personal Finance (Quicken)
- Home design
- Robot programming (guide robots hand)



Evolution of Direct Manipulation

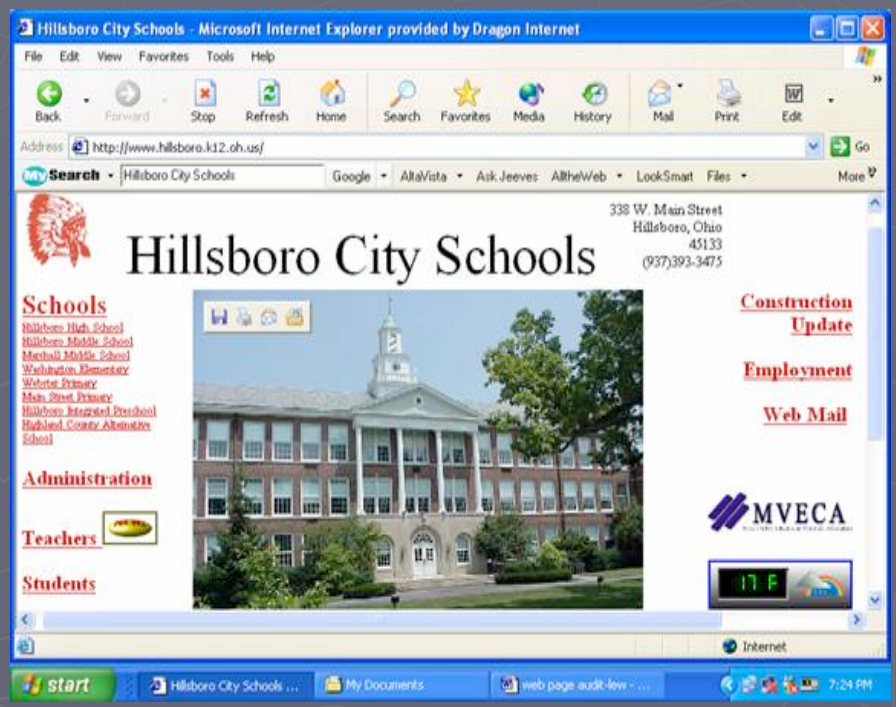
- **Future:**
  - VR/AR
  - Ubiquitous computing
  - Wearable computing
  - Tangible interfaces
- **Goals:**
  - Comprehensive
  - Rapid learning
  - Predictable actions
  - Appropriate feedback
- **Results:**
  - Retention
  - Learning
  - Lowered anxiety
  - Users feel empowered and satisfied

Thoughts on Direct Manipulation

- **Principle of virtuality** – users enjoy being able to manipulate some version of reality (Nelson ’80)
- **Principle of transparency** – UI disappears and allows user to apply intellect to task (Rutokwsiki ’82)
- Logical thinking (which engineers are good at) doesn’t always lead to good design (Heckel ’91)
- **Gulf of execution** and **gulf of evaluation** (Hutchins, Holland, and Don Norman ’86)
- Related to psychology literature on problem-solving and learning research
  - Ex. Use beads to teach math (better than abstract terms)
  - Why people like the abacus over calc, esp. for teaching

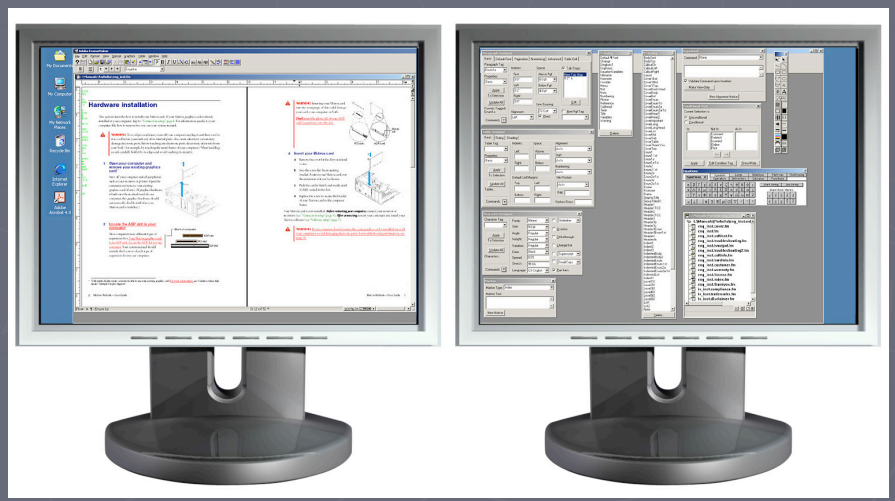
Direct Manipulation problems

- **Blind / Vision-Impaired** - If you develop **for** a visual interface, this group might be left out. Newer technologies help.
- **Screenspace**
  - Takes up plenty
  - Possible 'abuse'
  - Multiple pages can slow user down
  - Bad design is **amplified**
- **Detail** can be lost (graphs vs. tables)
- **Learning curve** – users must learn meaning of icons, etc. Different for novice vs. experienced users



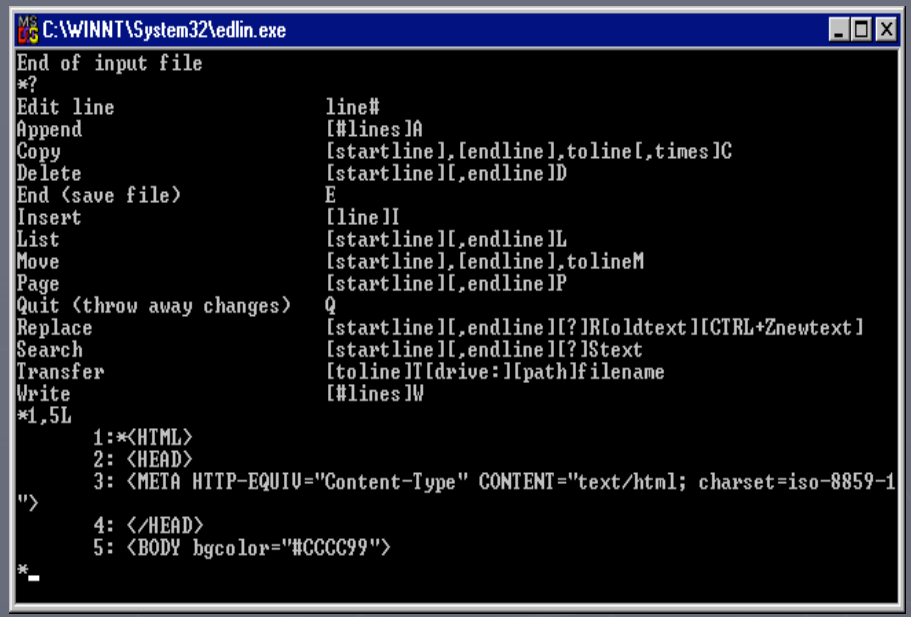
Direct Manipulation problems

- **Wrong conclusions** – graphs
- **Slow** for fast typists (moving hand to mouse is relatively slow)
- Poor for **some notations** (e.g. math)
- **Choosing** the right icons/ metaphors is difficult
- Requires:
  - Fast turnaround time (100ms or less)
  - Reversibility (undo)
  - Both can be hard to code
  - Difficult to do w/ HTML (better w/ Java or Flash)

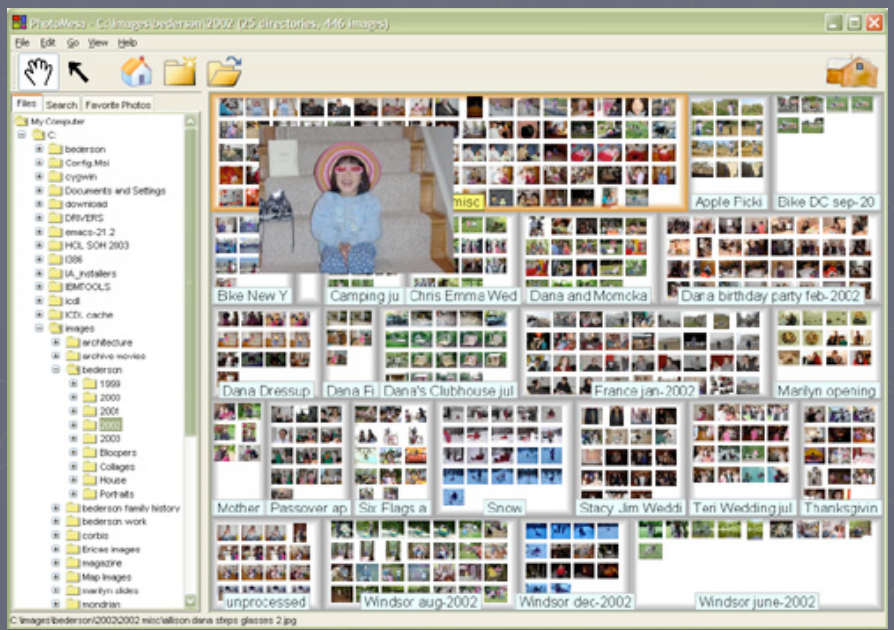


Direct Manipulation

- Advantages
  - Continuous visual representation of objects and actions of interest
  - Physical actions instead of syntax
  - Rapid, incremental, and reversible actions whose results are visible immediately
- Systems with Direct Manipulation **usually** have the following:
  - Novices can learn basic functionality quickly
  - Experts can work quickly to carry out a wide range of tasks
  - Intermittent users can retain concepts
  - Error messages are rarely needed
  - Immediate feedback if actions furthered or hampered goals
  - Less anxiety due to comprehension and reversibility
  - Gain confidence because users

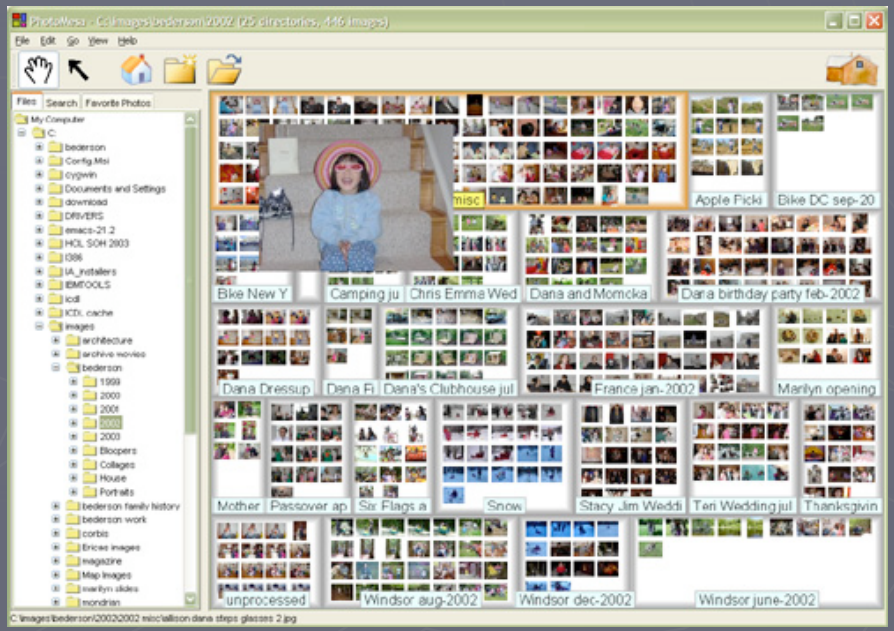


Object Action Interface approach to Direct Manipulation



Object Action Interface approach to Direct Manipulation

- **Ex:** organizing digital photos, stock portfolios
- What are the objects?
- What are the actions?



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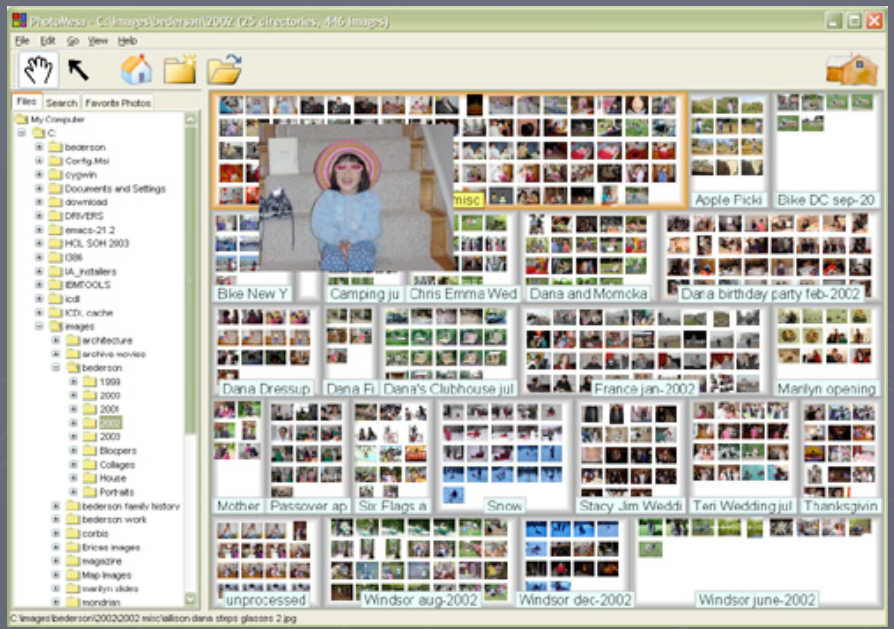

Object Action Interface approach to Direct Manipulation

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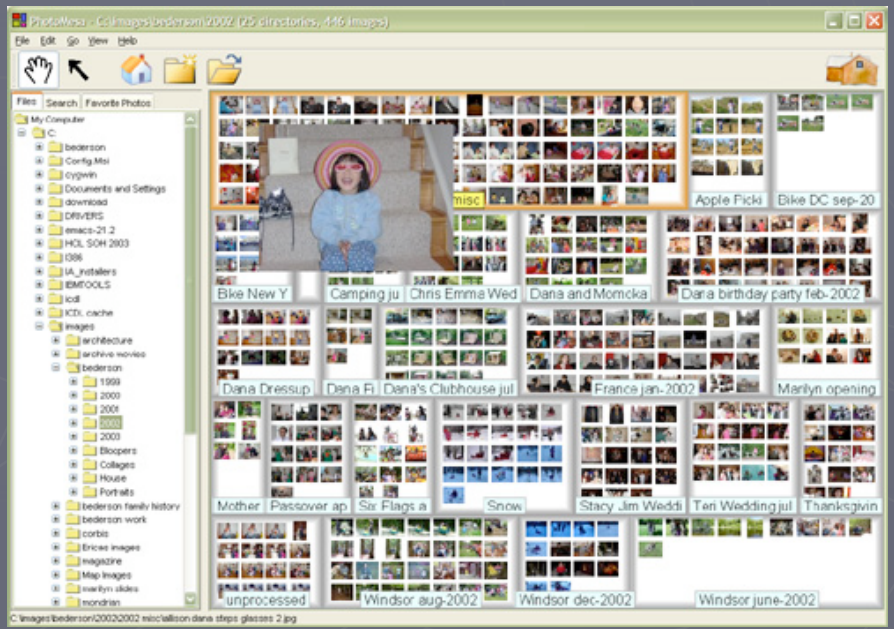
- What is the interface?
- Objects and actions are displayed close together



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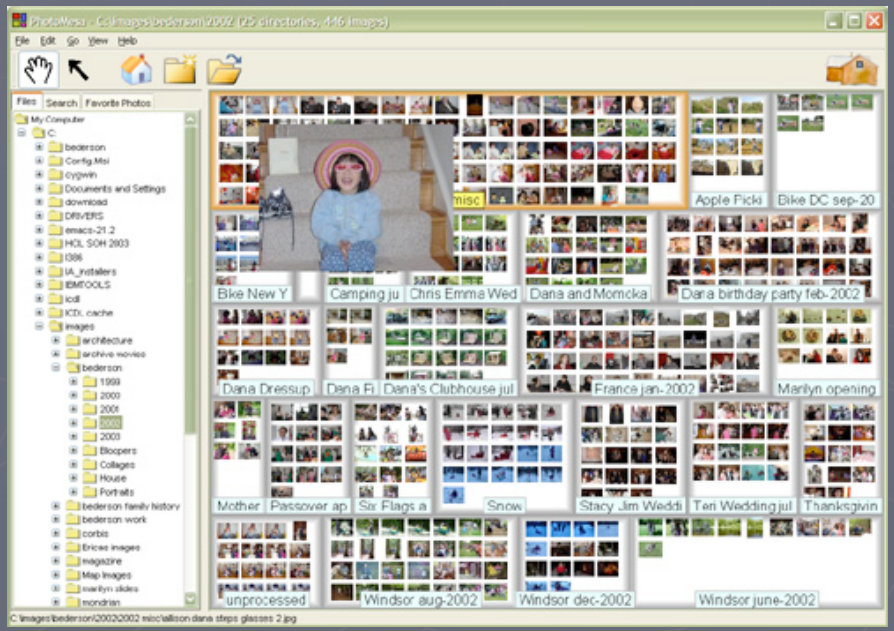
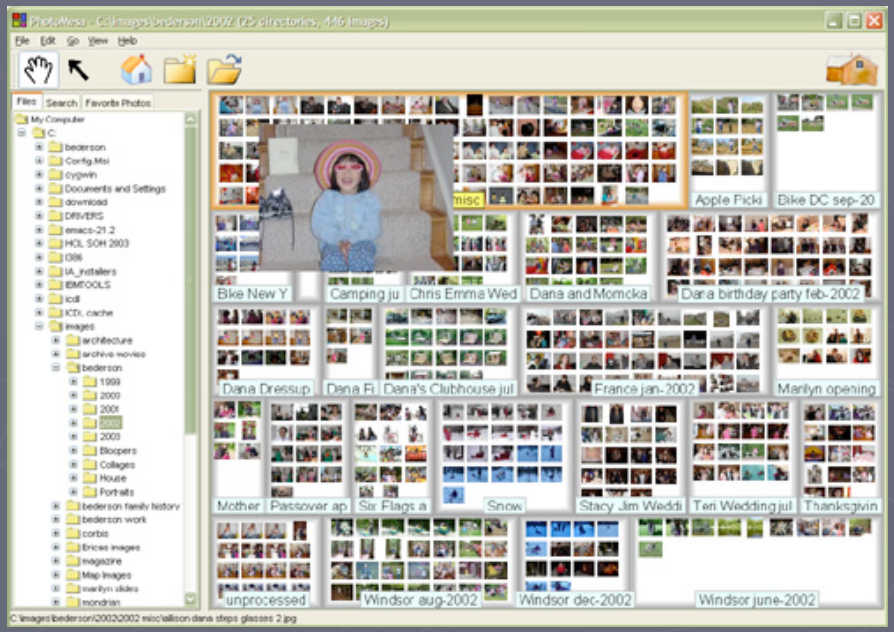
- **Ex:** organizing digital photos, stock portfolios
- What are the objects?
- What are the actions?
- What is the interface?
- Objects and actions are displayed close together
- Little need to break down into complex syntax



Object Action Interface approach to Direct Manipulation

- **Ex:** organizing digital photos, stock portfolios
- What are the objects?
- What are the actions?
- What is the interface?
- Objects and actions are displayed close together
- Little need to break down into complex syntax
- **Result:** Closeness of task domain to the interface domain reduces cognitive load and stress (stimulus-response compatibility in Human Factors research)

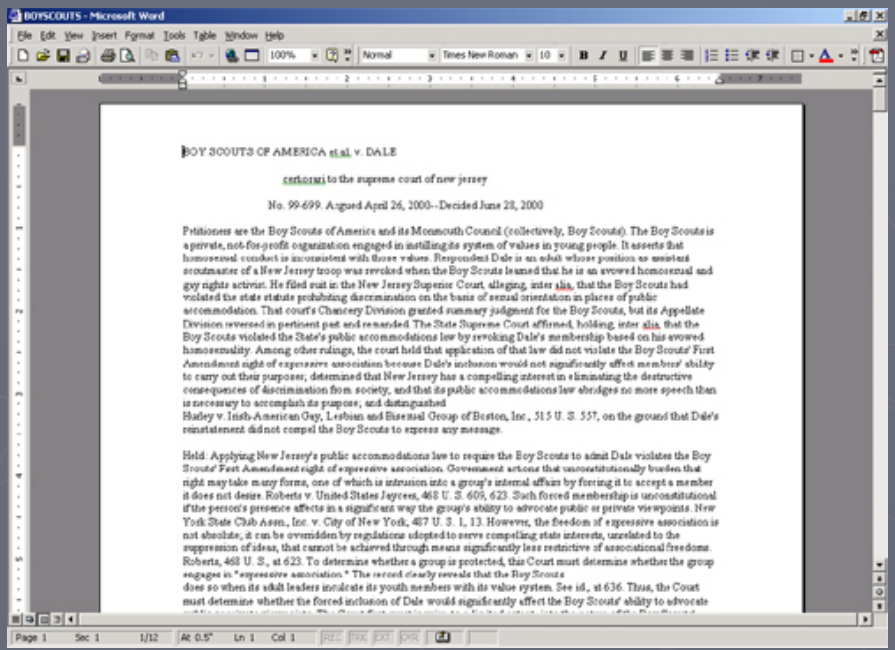


OAI and DM

- Actions are icons are more 'natural' (developed earlier) than language
- 7 to 11 yr old, can handle the DM approach (physical actions on an object)
  - Concepts of conservation and invariance
- 11+ is for formal operations (symbol manipulation)
  - Math, programming, languages
  - Children often link early math, etc. to objects
- Easier not only for kids but for everyone (Yet another example!)

Visual Thinking and Icons

- Visual Languages and Visual Thinking (Arnheim '72)
  - Data viz and symbol people Reaches out to the right-brained (look at all the users)
  - Shunned by many a left-brained
    - Read a paper by an algorithm/ theory person lately?
    - WIMP interfaces have that nickname for a reason
- No one style
  - People think differently
  - Should provide several if possible
- Depend on expected user base
  - Paint program (icons) vs. word processors (text menus)



Icon Design Considerations

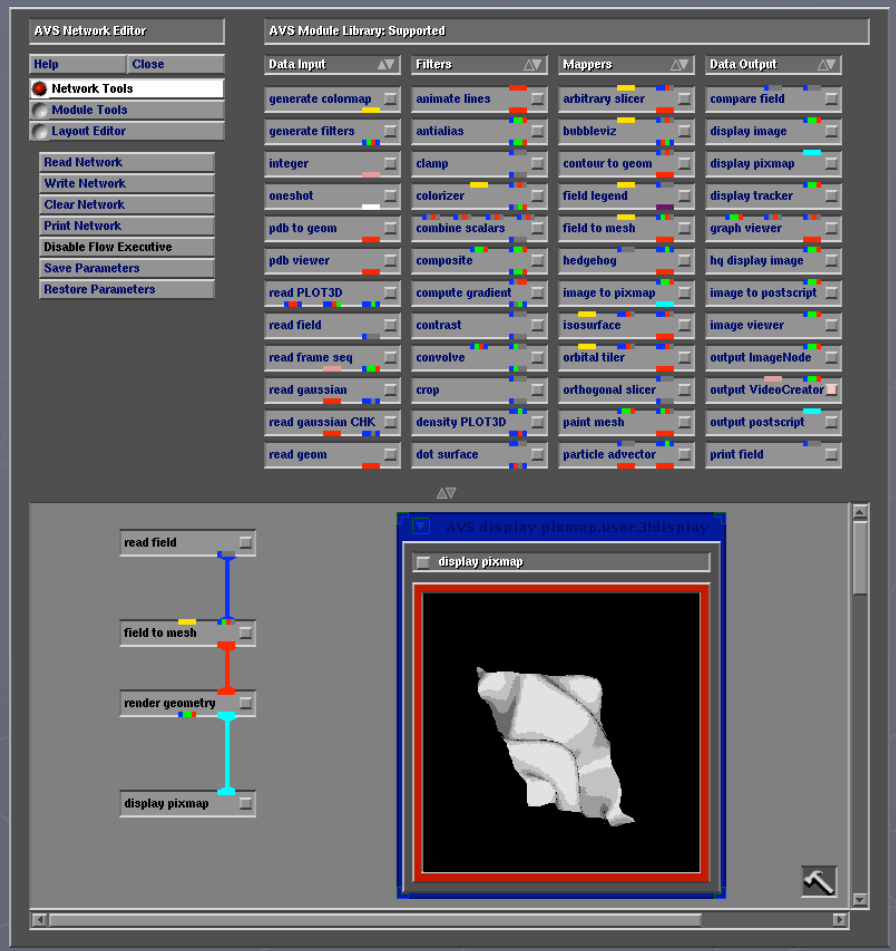
- Stand out from background and each other
- Limit the number
- 3D not necessarily good
- Familiarity (ex.)
- Selected icons should be easily found
- Animations, shadows, etc. help
- Dynamic icons (size changes, thumbnails, etc.)
- Interaction between icons

Icon Design Considerations

- Components of icons:
  - Lexical – brightness, color, blinking etc.
  - Syntatics – appearance and movements (lines, shape)
  - Semantics – object represented
  - Pragmatics – legibility, utility
  - Dynamics – receptivity to actions
- Adding multimodal or subtle affects helps users detect anomalies
  - Phone dialing
  - Hypothesis: Directories played a song when opened

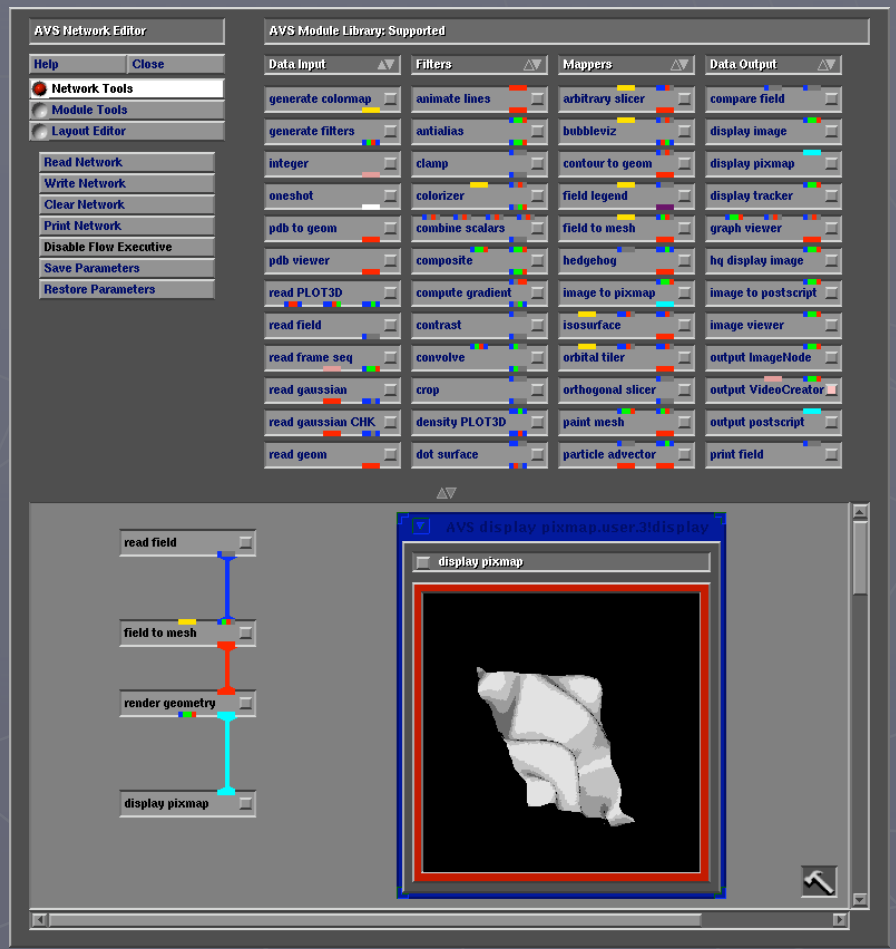
Direct Manipulation Programming

- Instead of just affecting a simulation/system with DM, how about programming with it?
- Alice, AVS, Car making robots
- Other examples of programming with DM?
  - Car radio presets
  - Movie camera tracks
  - Macros
- Systems observe the user and can replicate actions (chess)



Direct Manipulation Programming

- PITUI – programming in the user interface
  - Sufficient generality
  - Access to data structures and operators
  - Ease in programming and editing
  - Simplicity in execution and supplying arguments
  - Low-risk (low errors, reversibility, etc.)
- Cognitive-dimensions framework (Green and Petre '96)
  - Analyzes design issues
  - Viscosity – difficulty in making changes
  - Progress evaluation – execute partial programs
  - Consistency, hidden dependences, visbility, etc.
- Doesn't try to guess user's



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  - Making the interface simple (thus unnatural) often aids performance
    - Constrains movement
    - Limiting possible actions
  - Depends on application and goal of the user interface
    - Surgery simulation
    - Military simulation (general vs. soldier training)
    - Architecture, education, product design

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    - Video games

3D Interfaces

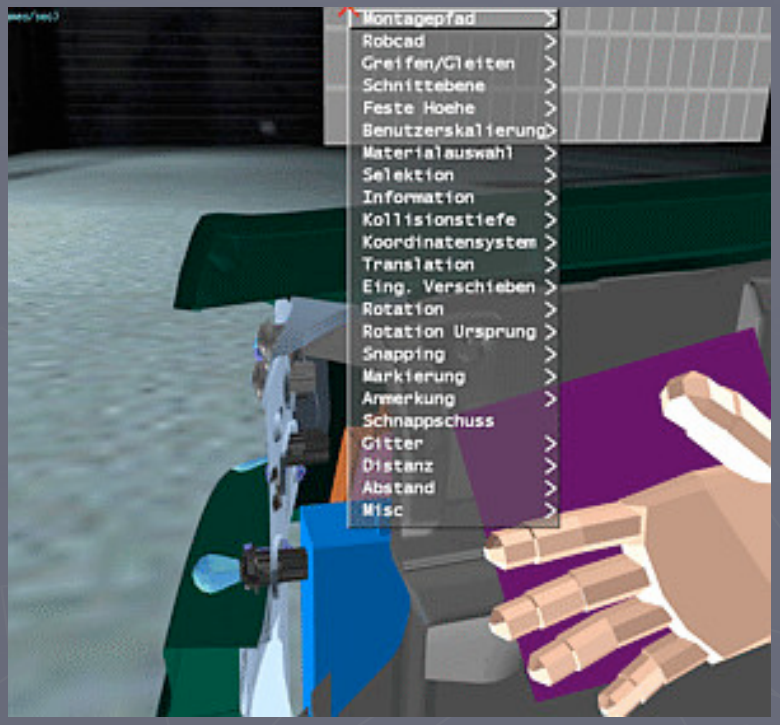
- What we really want are **enhanced** interfaces
- Give us powers we don't normally have
  - Flying, x-ray vision, teleportation, undo, etc.
- Be careful we don't become overzealous
  - Air traffic control 3D display
  - Library interfaces using a books on shelves (what is it good for? What is it poor for?)
- Hurts performance

Good 3D

- Social interfaces + 3D can be very powerful
  - MMORPG (EveQuest)
  - ActivedWorlds
  - The Sims Online
- Experiences
  - Art gallary
  - 3D Desktops (Mac's latest)
  - Office metaphors did not take off (BOB, Task Gallary)
  - 3D Webbrowsing. Sure you can arrange 16 web pages spatially, but why?
- Compromises to provide 3D interfaces might be undermine usability
  - Think RTS games
- Discussion: Is the interface holding back 3D?

3D Interfaces

- Use occlusion, shadows, perspective carefully
  - Improves use of spatial memory (Ark '98)
  - Distracting and confusing
- Minimize navigation steps
- Keep text readable (good contrast, 30 degree tilt max)
- Simple user movement (why lock to a floor?) Descent vs Quake

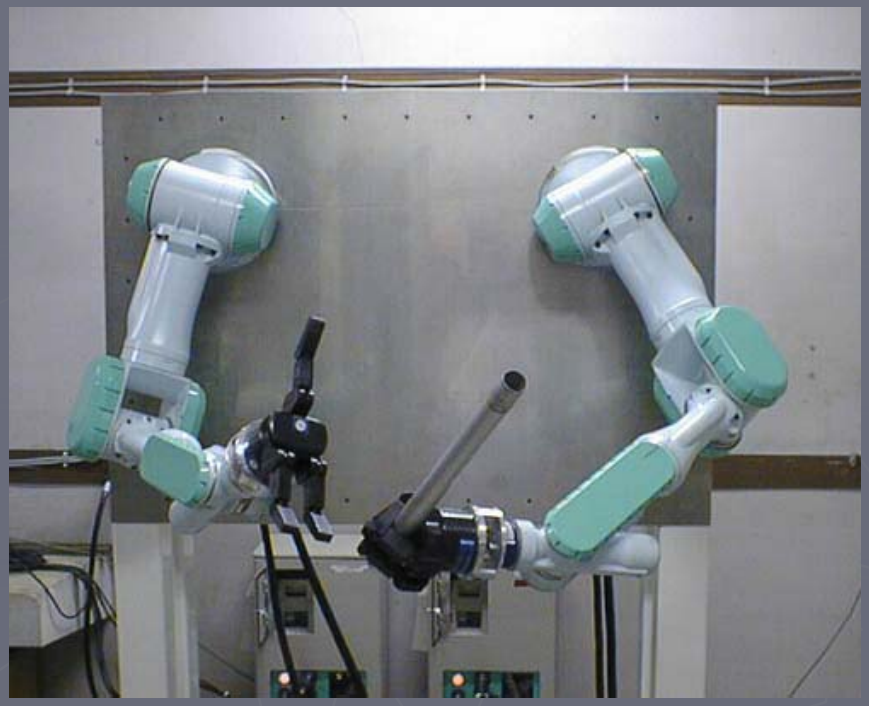


3D Interface Development

- Developments that show promise:
  - 3D sound
  - Stereo display (Ware and Frank '96)
  - Haptic feedback (mouse)
- 3D can help by:
  - Provide overviews to see big picture
  - Rapid teleportation (context shifts)
  - Zooming (aid disabled)
  - Multiple coordinated views (3dsmax)
  - 3D icons can represent abstract or recognizable concepts
- **Homework:** Find a UI to accomplish a 3D task. Describe the system, explain DM is applied. (Max 2 paragraphs)
  - Include a list of objects you can interact with
  - How it provides a global perspective
  - Feedback mechanism
  - Interaction mechanism (what does the user do to interact)

Teleoperation

- Combines:
  - Direct Manipulation
  - Process Control
- Human operators control physical processes in complex environments
- **Example applications:** Mars rover control, flying airplanes (Predator), manufacturing, medicine (surgery)
- **Supervisory control** (Sheridan '92)
  - Different levels of human control (automation)
- Direct Manipulation Issues
  - Adequate feedback (data quality, latency (transmission and operation delays), incomplete, interference)
  - Presence
  - Point and click or more natural interaction vs. typing



VR Interaction

- Trying to simulate reality or an experience
  - Training, Learning, Exploring
  - Expensive
  - Dangerous
  - Logistically Difficult
- Best interaction?
  - Flight simulators (they can cost $100 mil, but that's still a good deal!)
  - Why?
    - Why do video game flight sims not cut it? (only $40!)
- Okay, we have monitors that show 3D worlds, what else do we possibly need?