Is There Any Real Virtue In Virtual Reality?
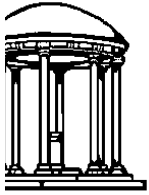
- **What?**

- **Why?**

- **So What?**

Fred Brooks
University of North Carolina
Chapel Hill
April 21, 1998

Hope — Sutherland's 1965 Vision

1. Display as a window into a *virtual world*

2. Improve image generation until the picture
    in the window *looks real*

3. Computer maintains world model in *real time*

4. User *directly manipulates* virtual objects

5. Manipulated objects *move realistically*

6. Immersion in virtual world via *head-mounted display*

7. Virtual world also *sounds real, feels real*

Hype

- *Wall Street Journal* Article 1990

- Pack journalism feeding frenzy—
  "GEE WHIZ!"

- 1990 "Hip, Hype, Hope" panel
  - Unprofessional panel selection
  - Designed to wow, not to inform

How Tell Hope Without Hype?

- **Necessity—AI example**

- **Honest, accurate status reports**

- **Warts and all**

- **Sober futures**

- **A lily needs no gilding—
  the plain truth is exciting enough.**

Virtual Worlds Research

The Research Challenge:

"Look real, sound real, feel real, interact realistically"

The Scientific Questions:

1. Can we make virtual worlds systems good enough?

2. If so, so what?
   Can we do anything demonstrably useful with them?

What *Is* Virtual Reality?

Realities essential to my broad definition:

Real time — viewpoint changes as head moves

Real space — 3-D worlds, whether concrete or abstract

Real interaction — direct manipulation of virtual objects

Not essential to the broad *definition*, in my view:

Head-mounted display

Sound display

Force display

Our Hope—Mind-Machine Systems

Thesis:

$$IA > AI$$

We want

powerful *mind-machine* systems,

with close coupling

between mind and machine,

both ways.

Virtual Reality — It Almost Works

- Swimming due to lag

- Poor resolution — user legally blind

- Narrow field of view

- Limited model complexity

- Poor registration with real world

- Bad ergonomics

- Tethered ranging

- Tedious model-building

How To Make VR Work?

Faster

Prettier

Any
Virtual-
World
System

Handier

Realer Modeling
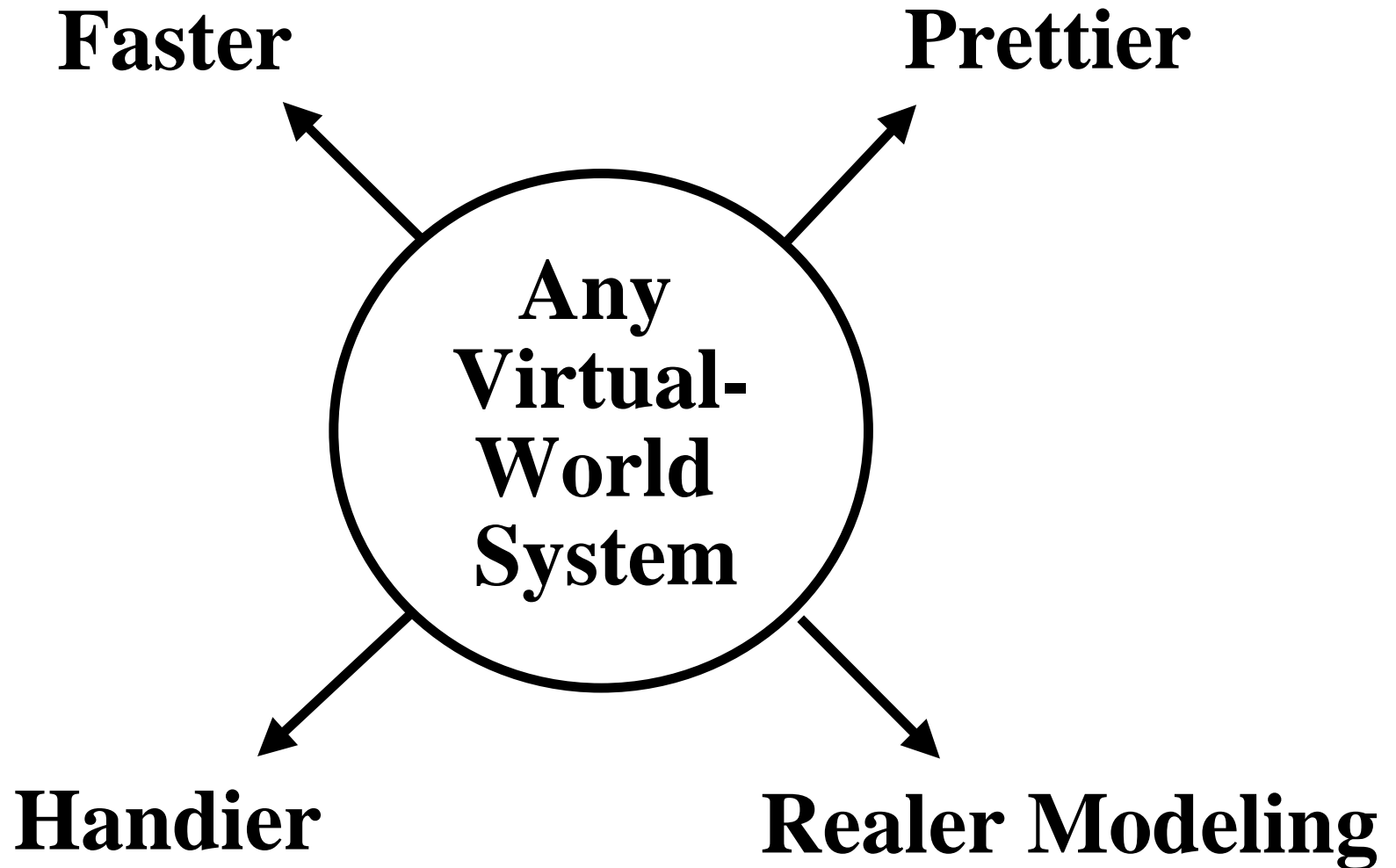
Hardware for VR

Image Generation — Speed, textures, low latency

   UNC PixelFlow: 1997, 45 M textured, shaded polys/sec

   Image-warping as a really new approach

Image Delivery — See-through, resolution, wide angle;

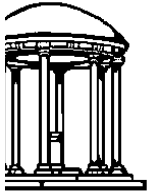   **Flip-down glasses; Projectors with seamless edges**

Head, Hand Tracking — Lag, range, precision

   UNC optical ceiling tracker — 18' x 24', 0.3 mm, 0.3°

Virtual Feeling — Fidelity, speed, low mass

   PHANToM 4-degree-of-freedom arm, 1000 hz, 1 mm.

Can We Do Anything Useful With It?
Applications Testbeds

Computer scientists are toolsmiths.

Driving problems

Spatial Design: submarines, process plants, buildings
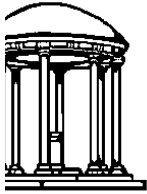
Medical Imaging and Reconstruction
  Image-guided surgical procedures: e.g. breast biopsies, laparosco
  Radiation treatment planning
  Telemedical consultation

Molecular Structure: protein, nucleic acid fitting, folding, docking

Scanning Probe Microscopes: Nanomanipulation

Real Virtues of Virtual Reality

What have we proved so far?

Presence — Everyone *feels* as if present; no one is fooled

Perception — Aids formation of accurate 3-D world models

Participation — Personal control aids perception
                         Rotation of molecules
                              The hand that rocks the cradle...

                    Direct manipulation facilitates tasks
                         Molecule fitting, folding, docking
                         13:1 speedup on fitting

Force display significantly speeds molecular docking task
                              Speedup bounded by x2
Flight simulator experience

Hot Open Questions

How to get lag down to acceptable levels?

Head-mounted displays versus screens with head-tracking?

How to render massive models (> 1 M polygons) in real time?

How best to interact with virtual worlds?

- **Manipulation**

- **Locomotion**

- **Wayfinding**

How to make model worlds efficiently?

- **Models of existing world**
- **Models of non-existing worlds**

The Future

The technologies will get there.

Entertainment—of course; not as hard technically

Vehicle simulation

Molecular structure

Medicine

- Surgical planning
- Psychiatry

Architectural design and spatial arrangement

Microscopy

Training—especially industrial and military

?

UNC Faculty Team

Virtual Environments P.I.'s—Fred Brooks, Henry Fuchs
    Project Manager—Mary Whitton
    Tracking—Gary Bishop, Vern Chi, Fuchs
    See-Through Display—Bishop, Chi, Fuchs

Geometry and Algorithms—Dinesh Manocha, Ming Lin

Pixel-Planes, Pixel-Flow P.I's—Henry Fuchs, John Poulton
    Hardware—Poulton, Nick England
    Software— Anselmo Lastra

Applications
    Medical—Fuchs, Stephen Pizer, Brooks
    Nanomanipulator—Russell Taylor, Chi, Brooks
    Spatial Design—Brooks, Manocha, Lin
    Molecular Structures—Mary Whitton, Brooks

Thanks for Support

Main project support:

> **DARPA**
> **NIH National Institute for Research Resources**
> **NSF CISE**
> **NSF-ARPA Center for Computer Graphics**
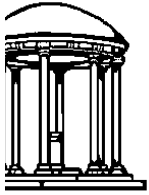> **and Scientific Visualization**
> **Army Research Office**
> **Office of Naval Research**
> **Alfred P. Sloan Foundation**

Student fellowships:

> **Division, IBM, Link, Silicon Graphics, NSF**

Real Virtues of Head-Mounted Display (versus stereo on big screens)?

Postulated virtues:

- **Intuitive control of kinetic depth effect — a biggie**
  Head-*tracking,* not display, gives this.

- **Intuitive navigation of 3-space — hard to realize**

- **Disbelief cues from surroundings blanked out**

- **Perhaps best way to do surgery**

Real virtues: Limited proof so far

Vices:

- **Narrow field of view, but ...**

- **Low resolution, but ...**

FPB - 4/21/98

What Can We Really Do Well Now?

- Vehicle simulators: aircraft, ships, trucks, cars
- Microscope control
- Molecular structure visualization
- Design review of structures
- Entertainment
- Stage sets
- Demos

Faster

- **Frame rate = scene complexity**
- **Textures**
- **Lag**
  - **Passmore's numbers: need 25ms, 15ms**
  - **Prediction accuracy gain 5-10x, *if <80ms***
  - **Inertial sensors are 2-3x of that**
  - **Error goes as $(p\omega)^2$**
- **Algorithms**
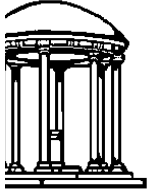- **Hardware**
- **Modeling physics**

Prettier

- **Resolution**
- **Color saturation**
- **Textures**
- **Lighting**
- **Anti-aliasing**
- **See-through and registration**
- **Sound**
- **Force**

Handier

- **Tracking range**
- **Ergonomics**
  - **Weight**
  - **Moment of inertia**
  - **Balance**
  - **Umbilical cords**
  - **Motion sickness**
- **Interaction devices**
- **Interaction modes**

Realer Models

- **Model engineering**
- **Model-building tools**
    - **Build in 3-D**
    - **Inside virtual space**
    - **Image-based modeling**
    - **Progressive truthfulness**
- **Model libraries**
- **Modeling physics**
    - **Motion**
    - **Sound**
    - **Force**