Data Visualization and Exploration via Virtual Reality - An Overview

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Virtual Reality (VR)

- Three-dimensional
- Immersive
- Interactive
- Multi-sensory
- Viewer-centered
- Computer generated environments
- Technology to build such environments

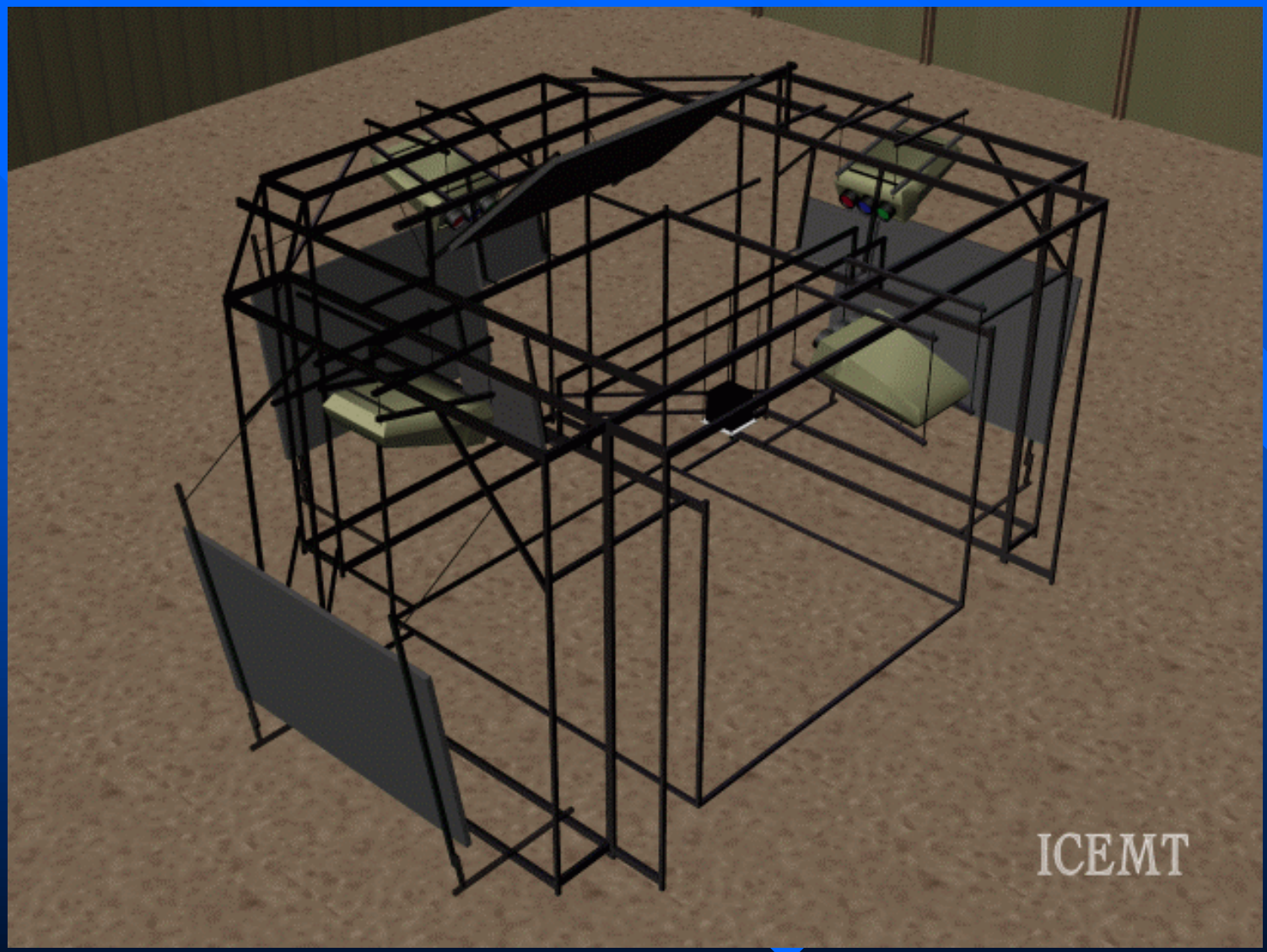
VR History

- Ivan Sutherland (1965): Ultimate Display
- Ivan Sutherland (1968): Sword of Damocles (HMD)
- Thomas Zimmerman (1985): DataGlove
- Fake Space Labs: BOOM (1989)

CAVE Concept

- A projection-based immersive VR system
  - Silicon Graphics-based with 8 to 12 processors
  - RE^2 or RE Infinity graphics engines
  - CRT-based projection system
  - Stereographics Crystal Eyes shutter glasses
  - Head tracking
  - Usually 3 to 6 wall cube
- CAVE originally developed at U. Illinois, Chicago (Cruz-Neira et al., 1992)


ICEMT


ICEMT

Immersive Projection Technology (IPT)

- User is visually immersed in VR environment
- HMD, BOOM
- CAVE, C2, C6, and many clones
- MiniCAVE
- Responsive Workbenches

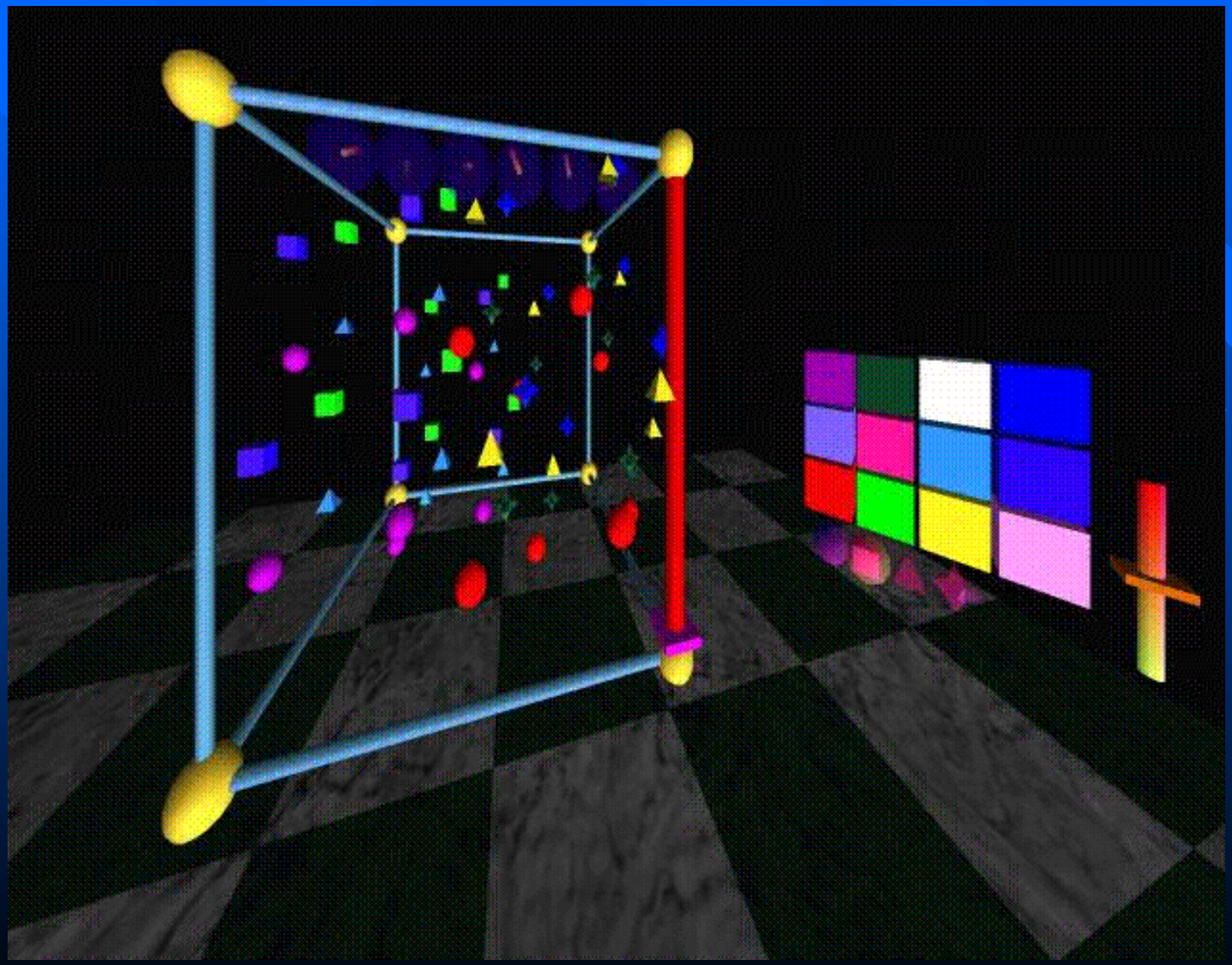
Data Visualization via VR

- C2 - Iowa State University
- MiniCAVE - George Mason University
- Virtual Data Visualizer - Georgia Tech & Delft Technical University (van Teylingen et al., 1997)
- VR on the Web via VRML - University of South Carolina (Rossini & West, 1998)

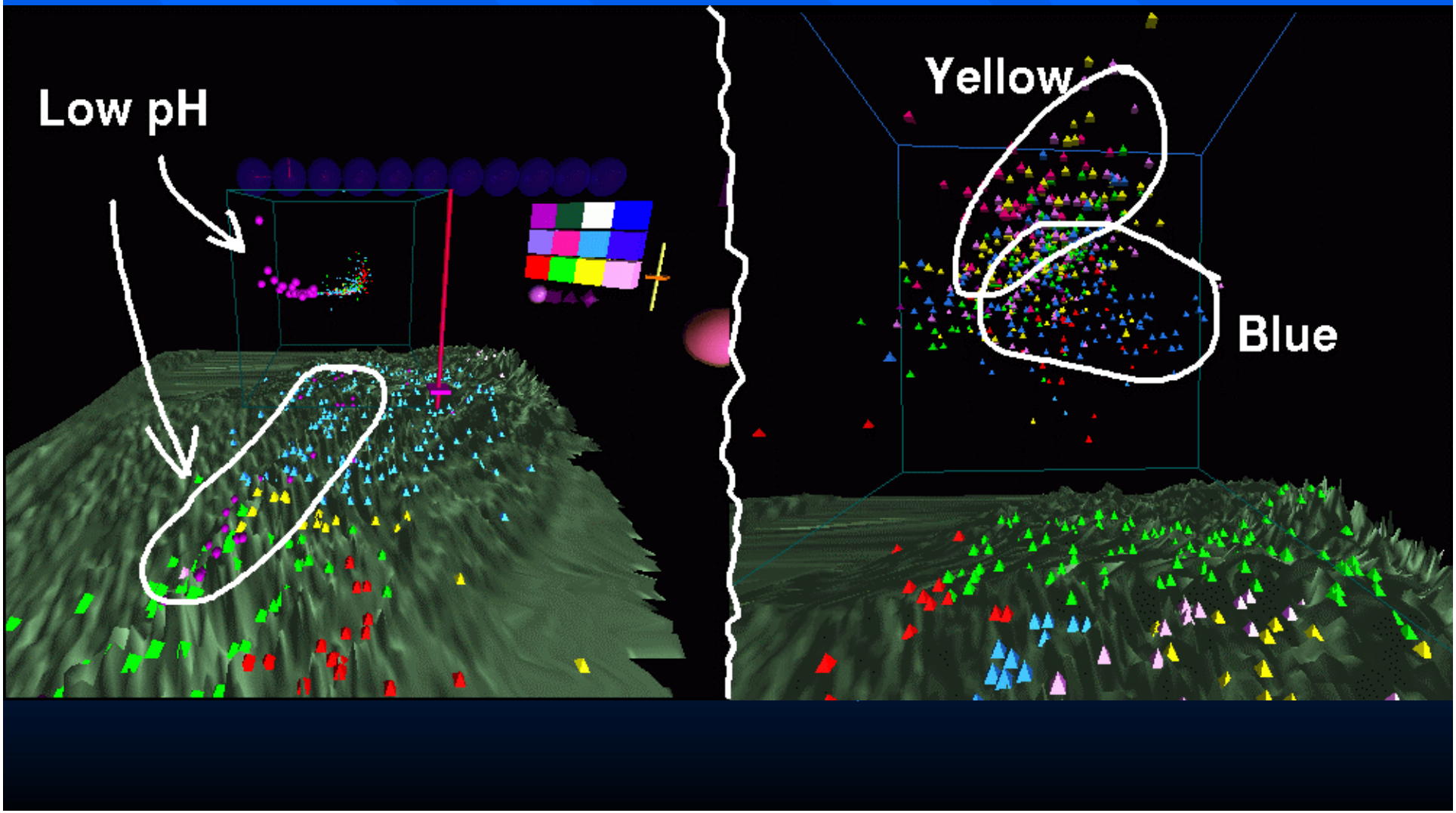
Applications of IPT Environments

- Environmental data (with spatial content)
- Medical, genetic, and biological data
- Manufacturing quality control data

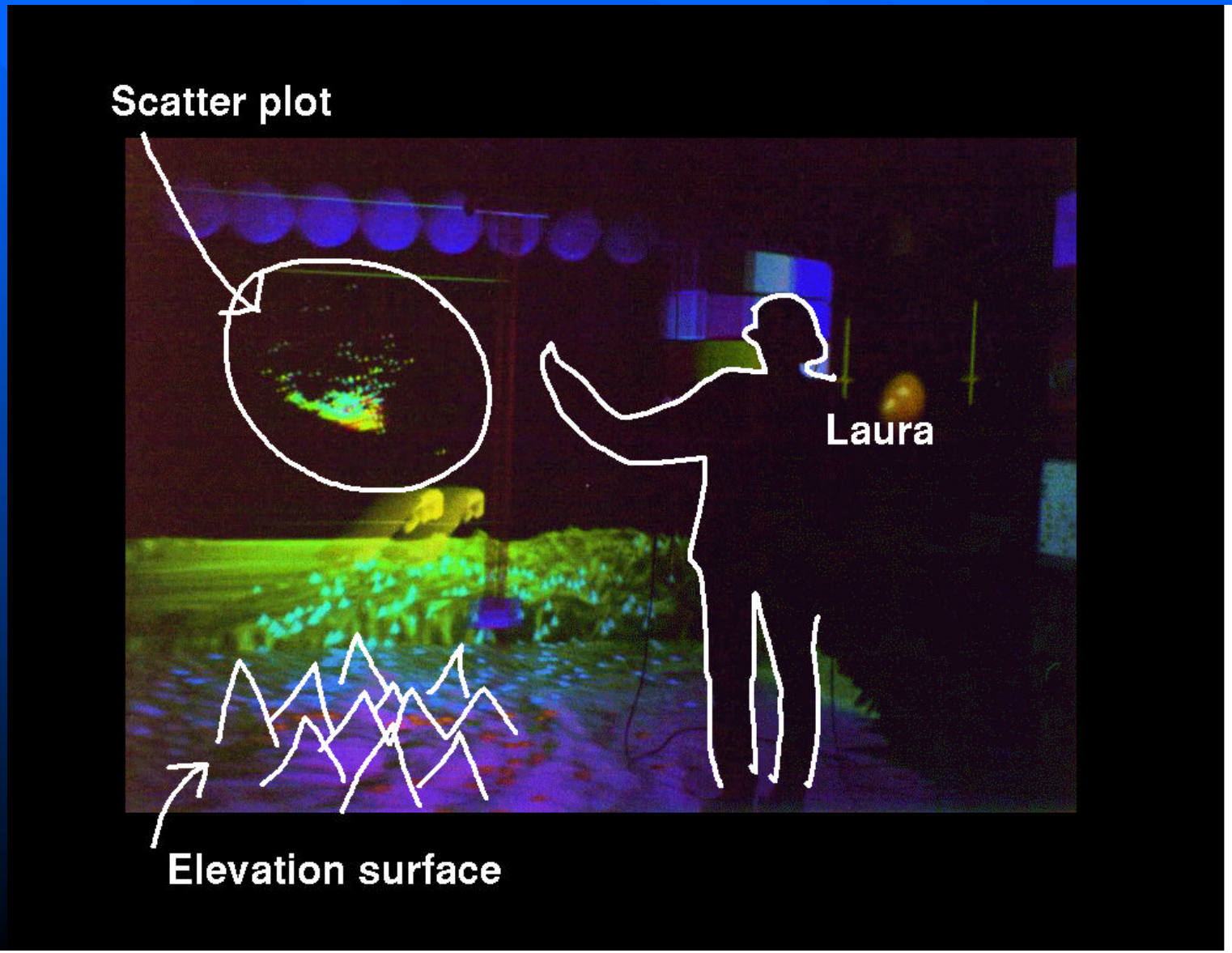
Statistics in the C2 - 1



Statistics in the C2 - 2



Statistics in the C2 - 3



C2 Strengths

- Effective immersive environment
  - Lightweight non-intrusive glasses
  - Can see own hands and other participants
- Effective for group VR
  - Good tool for group collaboration

C2 Weaknesses - 1

- CRT Projectors
  - Projectors not very bright
  - Shock, vibration & heat, hard to keep focus
  - Geometric distortion at wall interfaces
- Tracking
  - One user tracked, badly distorted stereo for users not at viewpoint
- User Interface
  - Usually 3-D extension of desktop metaphor

C2 Weaknesses - 2

- Expensive
  - $1,000,000 fully outfitted
  - $600,000+ SGI computers
  - $30,000 per projector

Motivation for MiniCAVE

- Installed MATLAB 5 on SGI Onyx and Pentium
  - Benchmarks on 200 megahertz Pentium Pro ($3000) and 200 megahertz SGI Onyx ($120,000) similar
- Liquid Crystal Projectors sharp, bright, and stable under shock, vibration and temperature variation
- Stereographics Crystal Eyes technology available for Windows NT

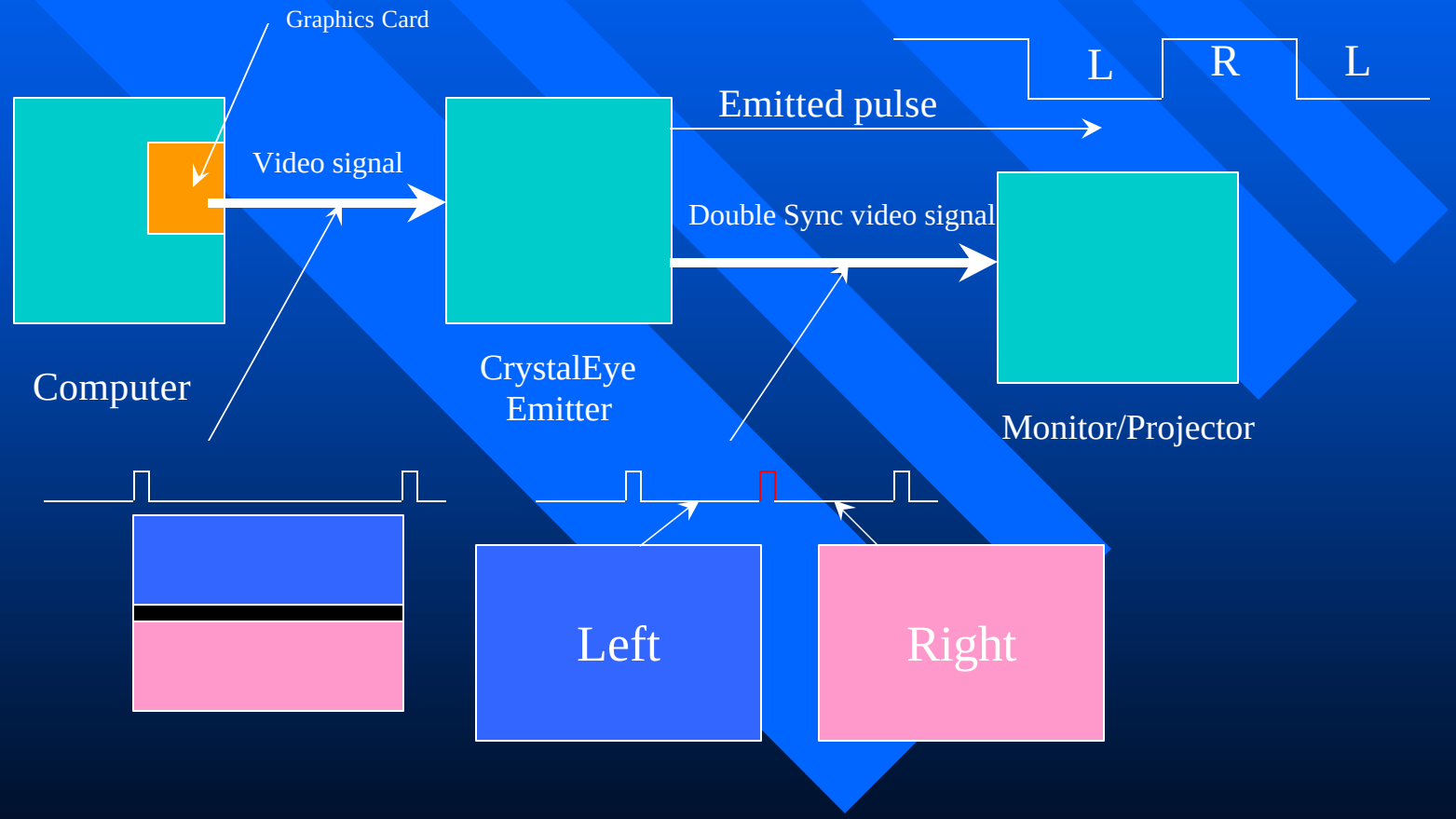
MiniCAVE Concept

- Windows NT/Intel Pentium II 400 mhz
- LCD-based projection systems
- 12 ft cubes scaled to 6 ft cubes
- Tracking optional, reduced latency
- Voice command metaphor
- $100,000 entry level

Implementation Using Monitor

- Stereo using CrystalEyes
  - Above-below stereo
  - Image resolution 1024x384 each eye
  - Vertical refresh rate 120-150 (60-75 each eye)
    - SGI monitor can handle both 120 and 150
    - CRT projector can only handle 120 refresh rate

Principles of Above-Below CrystalEyes Stereo



Speech Motivation

- User interfaces (Van Dam)
- Shortcuts in XGobi
- User controls difficult to handle in the C2 Stats application

MiniCAVE - Successes

- Port of SkyFly Stereoscopic Demo to NT successful with adequate frame rates on 333 megahertz machine
- CrystalEyes interface on NT successful
- Speech recognition using Dragon Dictate successful
  - but requires training of speech recognizer

MiniCAVE - Future Steps

- Build 4-sided MiniCAVE
- Use MiniCAVE for Visual Data Mining
- Develop further Data Mining software for MiniCAVE and C2 and for communication among these environments

Discussion

- IPT environments effective for group interactions and discussions
- Many successful demos at ISU & GMU
- Experiments show that humans perform better on visualization tasks in C2 than with monitor (Nelson et al., 1999)
- PC-based technology (for MiniCAVE) is affordable

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