The Visual Computer

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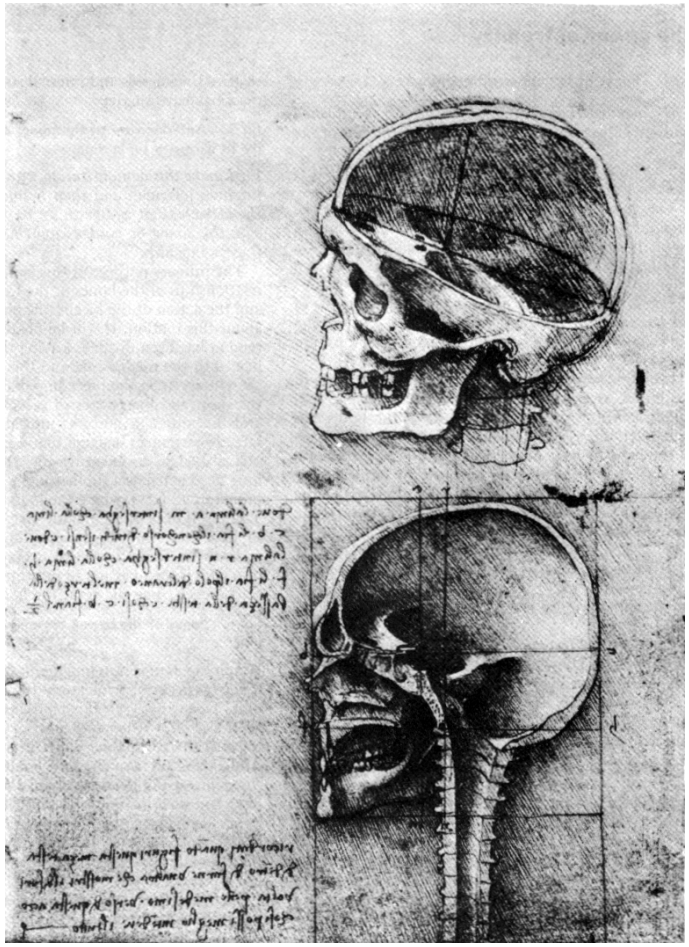
State-of-the-Field Talk

Supercomputing '97

Overview

- The 4 mantras …
  - The history of scientific illustration
  - Perception
  - Interaction
  - Visualization
- Opportunities in graphics architectures
- Innovative applications of the future

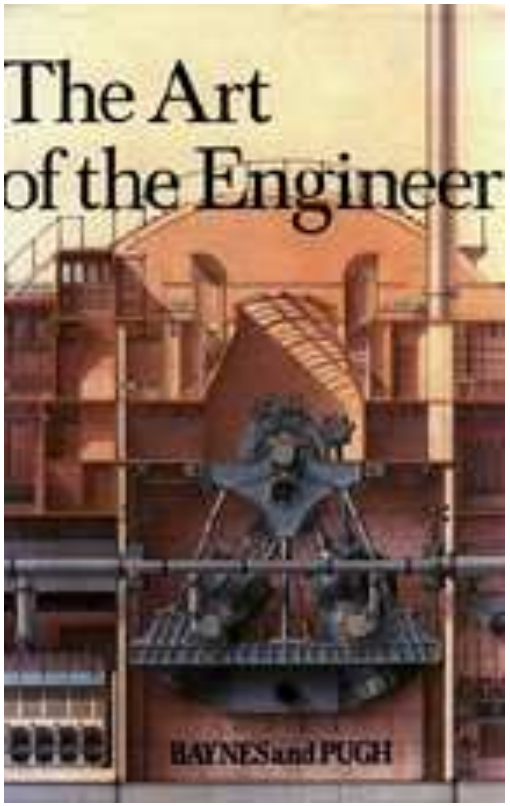
Then vs. Now



Leonardo's Notebooks

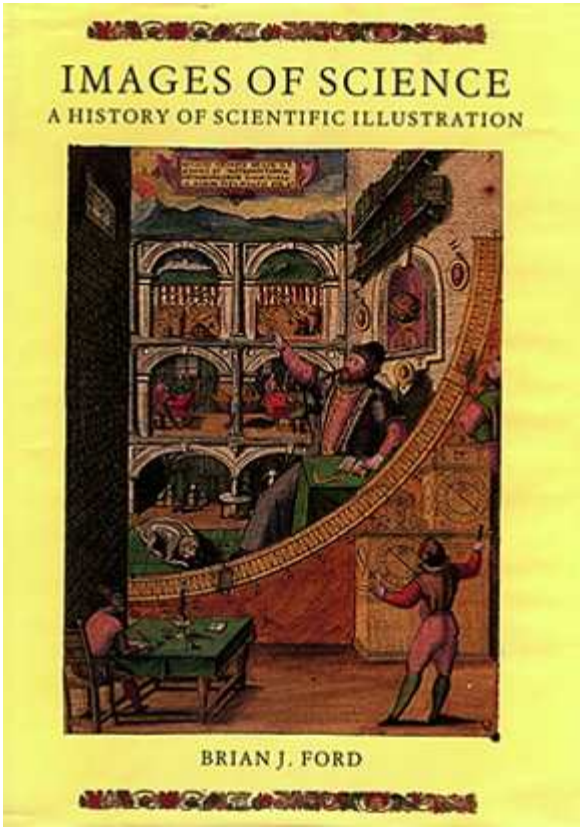
Karl Heinz Hoehne's Voxel-Man
Images of the Visible Man

History of Scientific Illustration



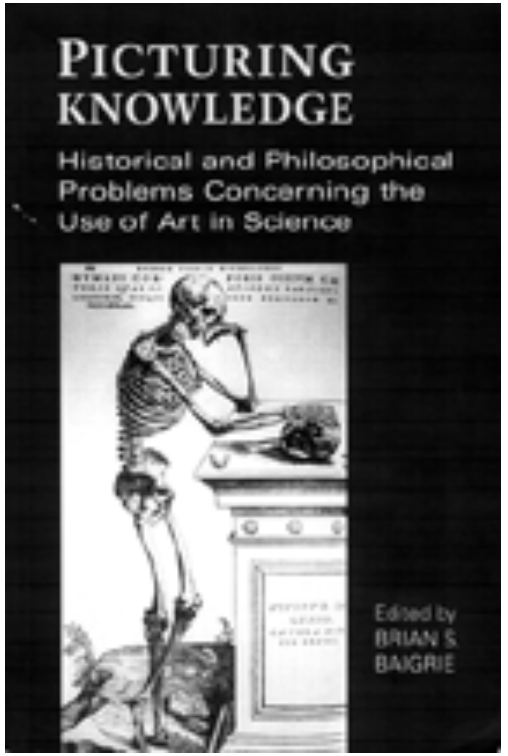
The Art of the Engineer

Baynes and Pugh, 1981



Images of Science

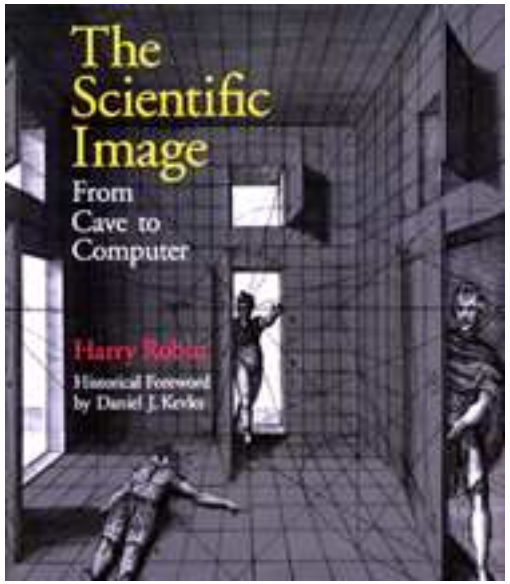
B. J. Ford, 1992



Picturing Knowledge

Ed. B. S. Baigre, 1996

The Purposes of Scientific Images

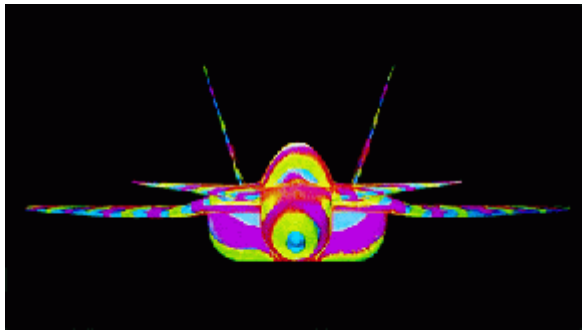


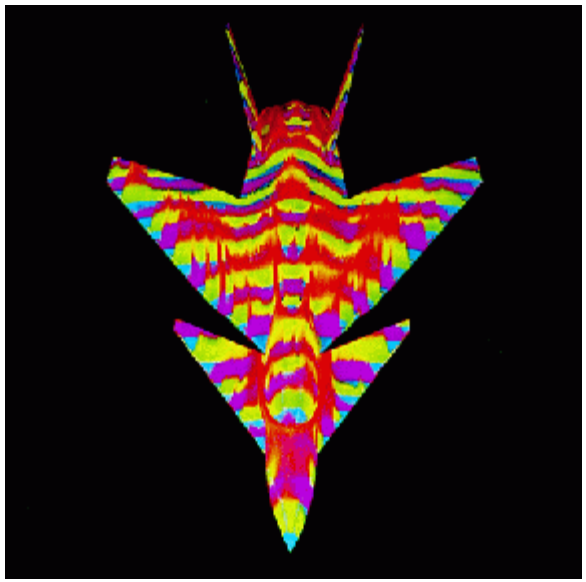
The Scientific Image

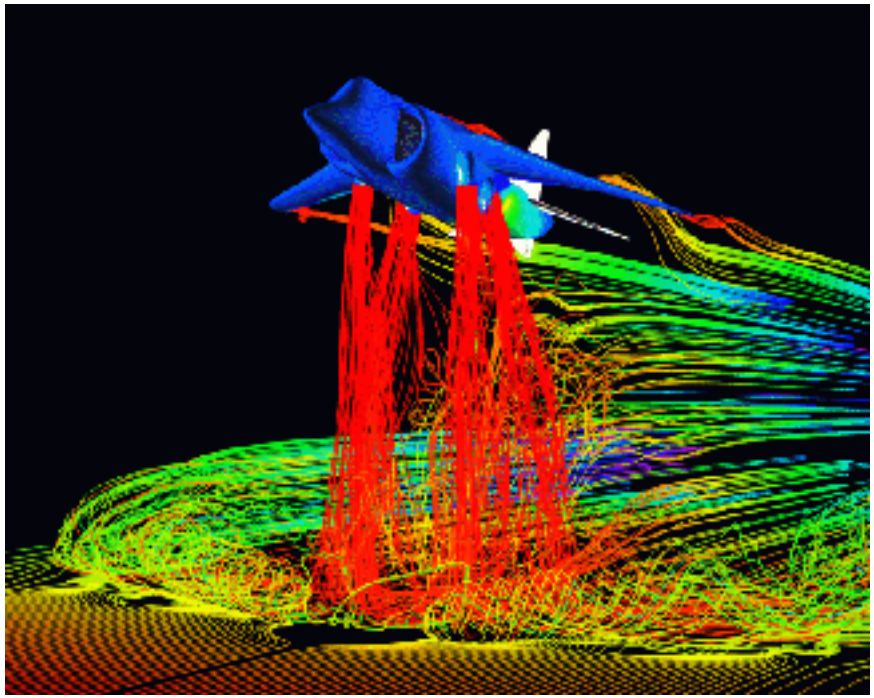
H. Robin, 1992

- **Records of Observations**
- **Self-illustrating phenomena**
- **Concepts and classifications**
- **Descriptions of equipment and methodology**

Self-Illustrating Phenomena



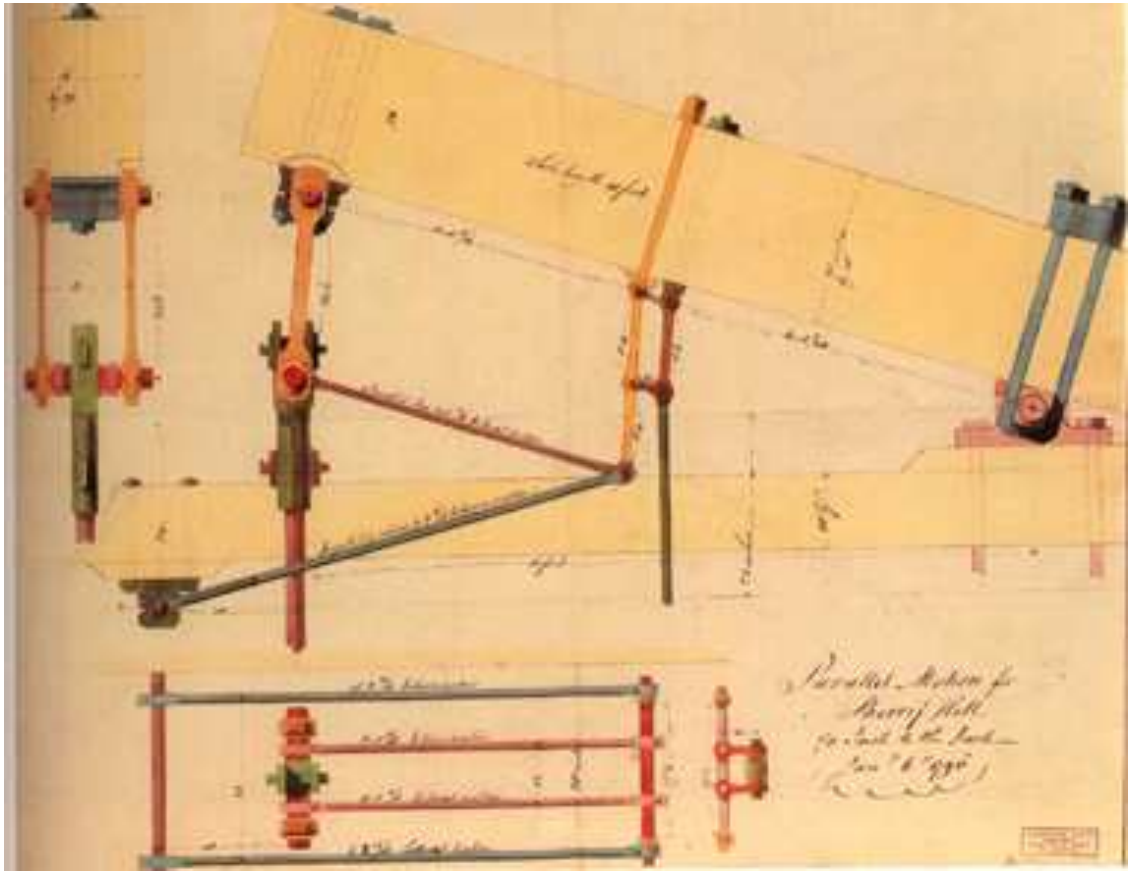




Harrier Jet flow during landing
NASA Ames FAST System

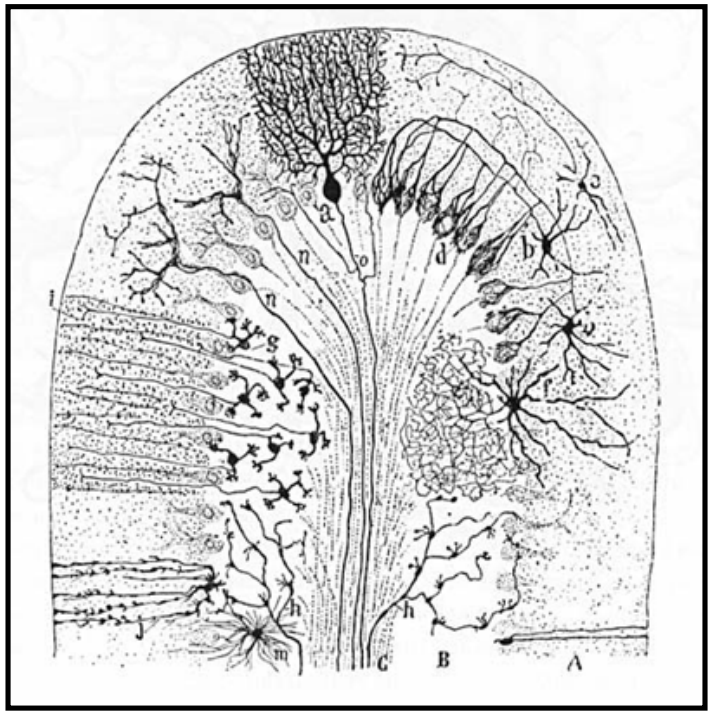
Eric Schulzinger (1988)
Air-Flow on a Supersonic Aircraft
From Robin, p. 141

Towards Abstraction ...

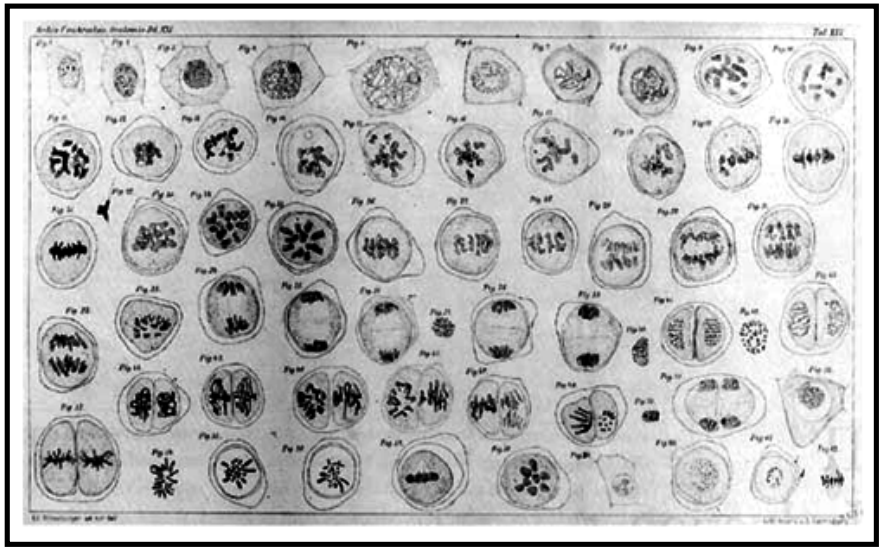


James Watt (1796)
Drawing of the engine for John Wilkinson
From Baynes and Pugh, p. 69

Observations

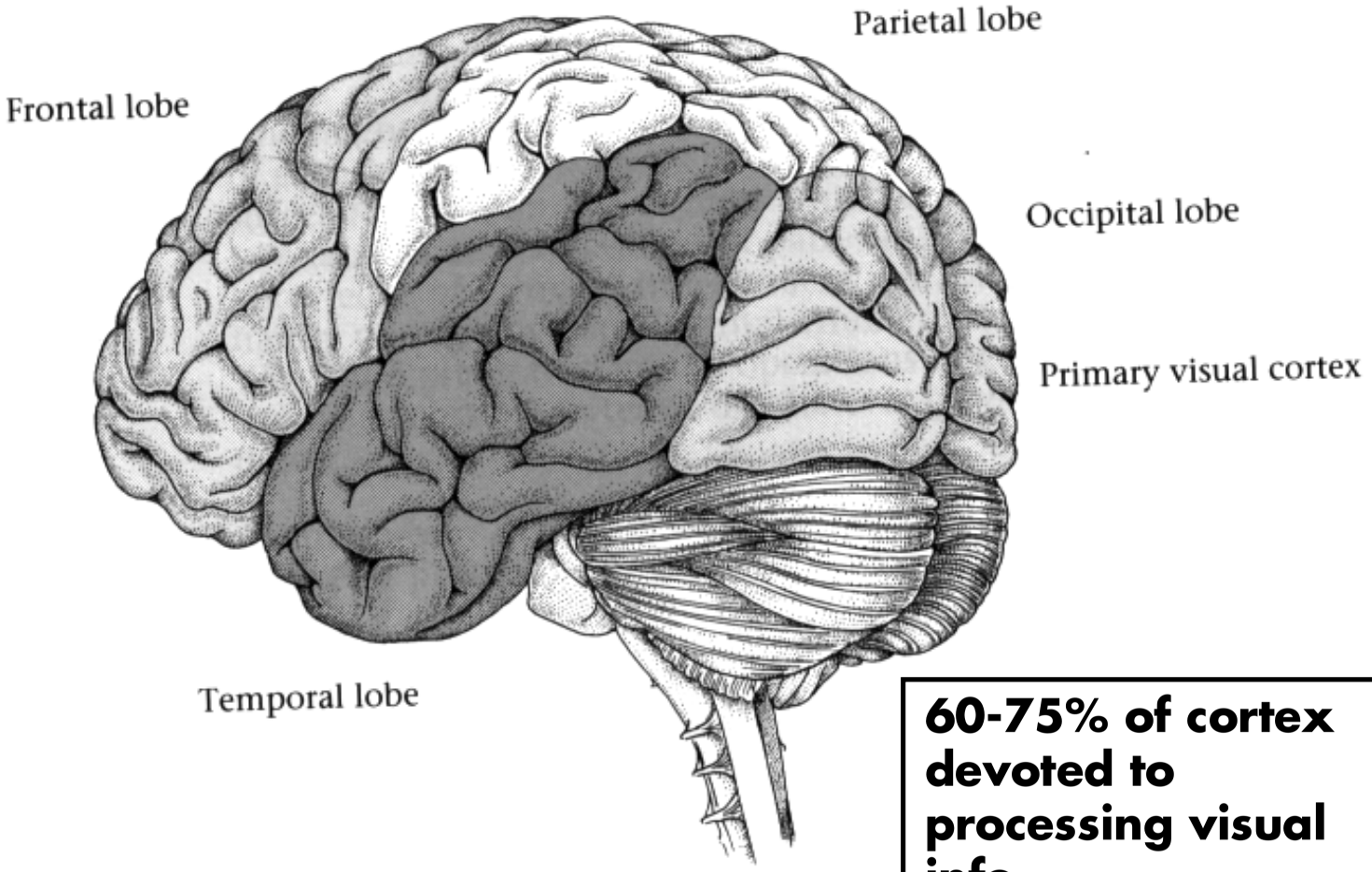


Santiago Ramon Y Cajal (1894)
Cell Types in the Cerrebellum
From Robin, p. 44



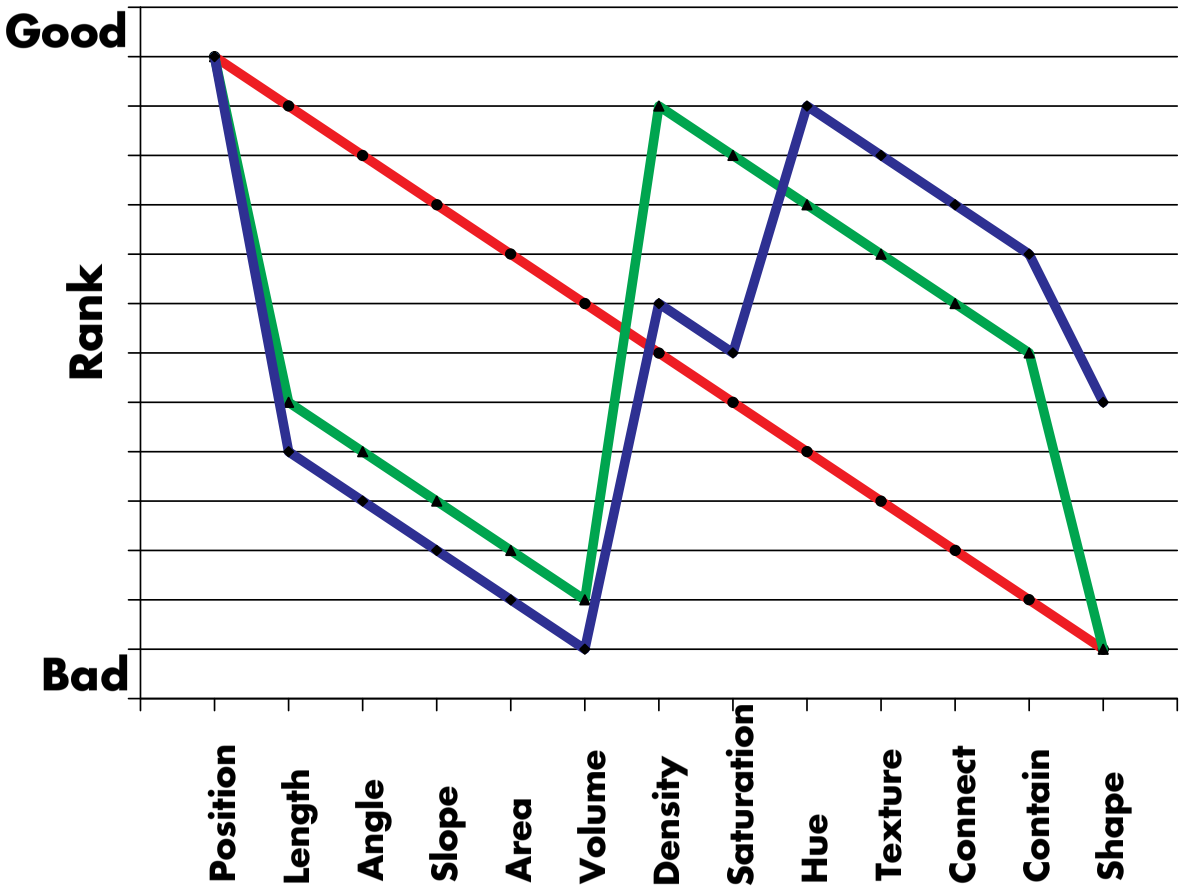
Eduard Strasburger (1882)
Division of the Cell Nucleus
From Robin, p. 49

Perceptually-Based System!



60-75% of cortex devoted to processing visual info

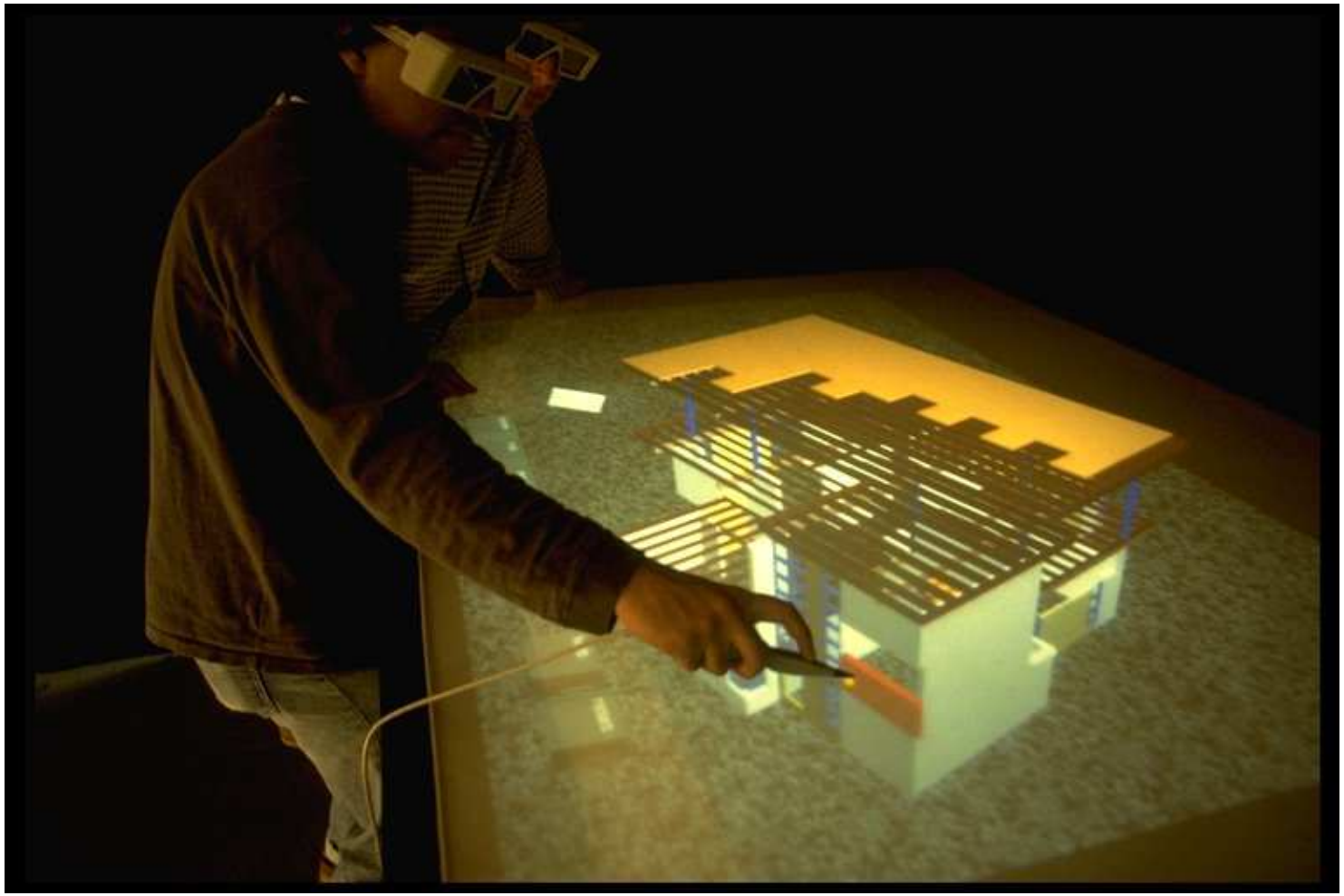
Perceptual Coding



Quantitative
Ordinal
Nominal

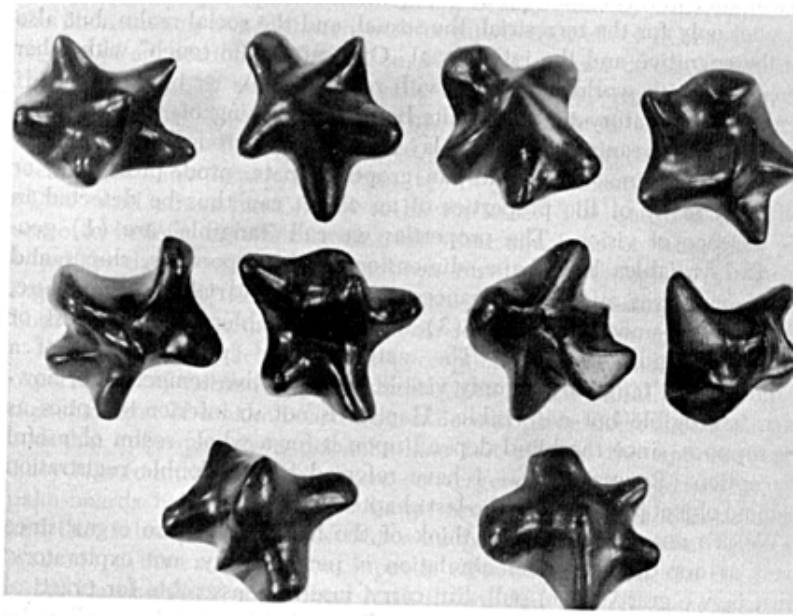
From:
Cleveland,
Mackinlay,
Card

The Responsive Workbench



Natural retinal images (immersion) vs. artificial images

The Power of Interaction



Gibson's Experiment

Goal: Match 2 shapes

Active touch: 96%

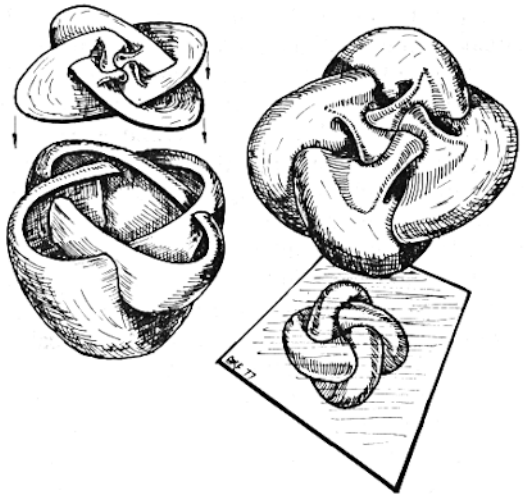
Passive (rotation) 72%

Passive (imprint) 49%

From J. J. Gibson (1966)
***The Senses Considered as a Perceptual System,* p. 124**

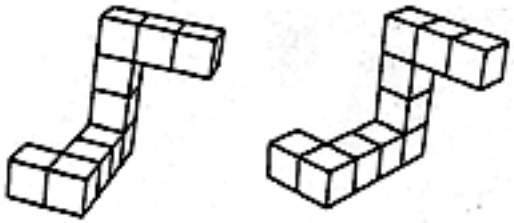
Thanks to David Kirsh for this example.

Visualization

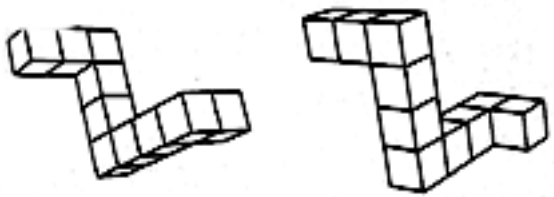


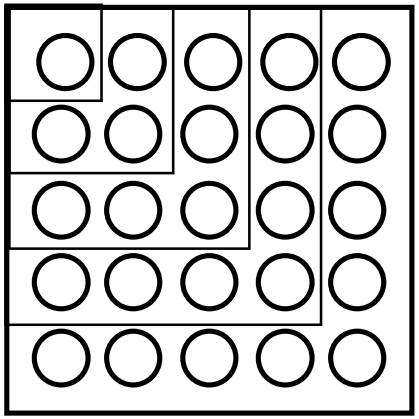
B. Morin's (who is blind)

Sphere Eversion (From G. Francis)



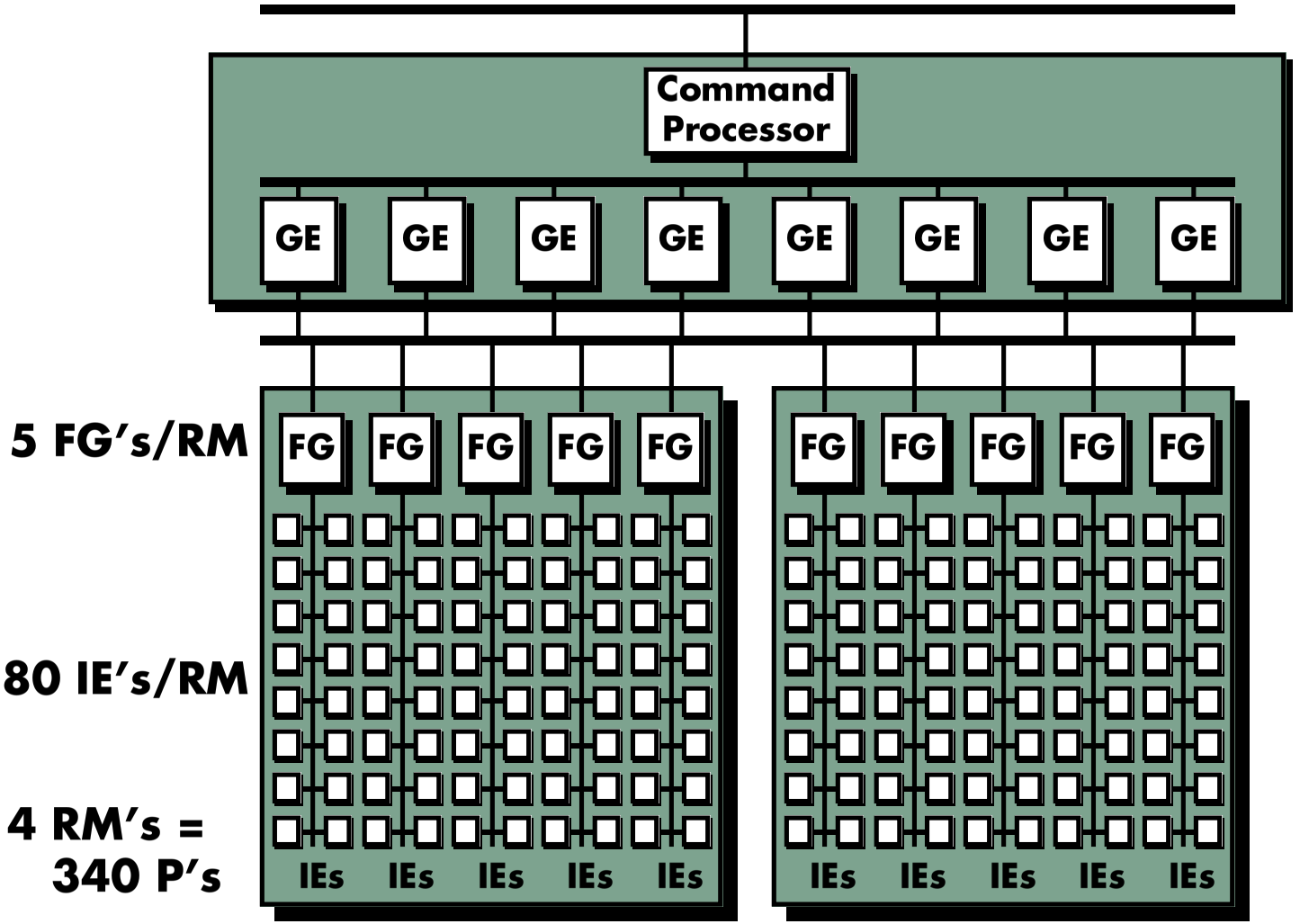
Shepherd's Mental Rotation





Visual Proof: $1+3+5+7+9=5^2$

Massively Parallel Graphics



SGI Reality Engine

Existing Generations

Kurt Akeley's Classification

1st generation (1984), e.g. SGI 2000, DN 570,...

- **Transformation and rasterization of lines**
- **Wireframe**

2nd generation (1988), e.g. SGI GT, HP VRX,...

- **Efficient polygon rasterization**
- **Z-buffered hidden surface engine**
- **Lighting, smooth-shading**

3rd generation (1992), e.g. SGI RE

- **Antialiasing**
- **Texture mapping**

Future Generations

My Predictions ...

4th generation (1996), e.g. HP PixelFlow, (SGI IR)

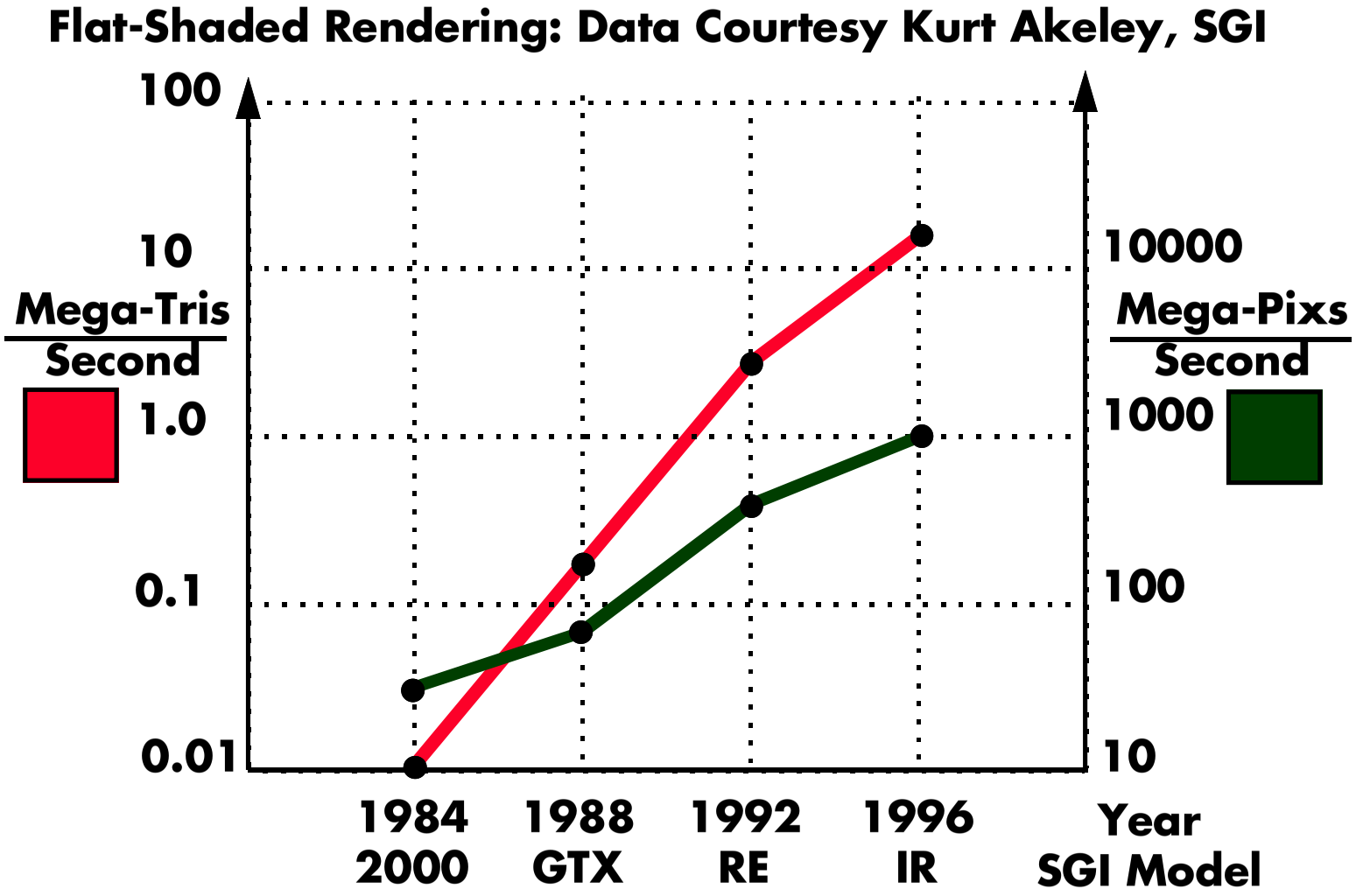
- **Flexible lighting, shading, texturing**
- **Higher-level (e.g. curved) geometric primitives**
- **Image/video processing**

5th generation (2000?)

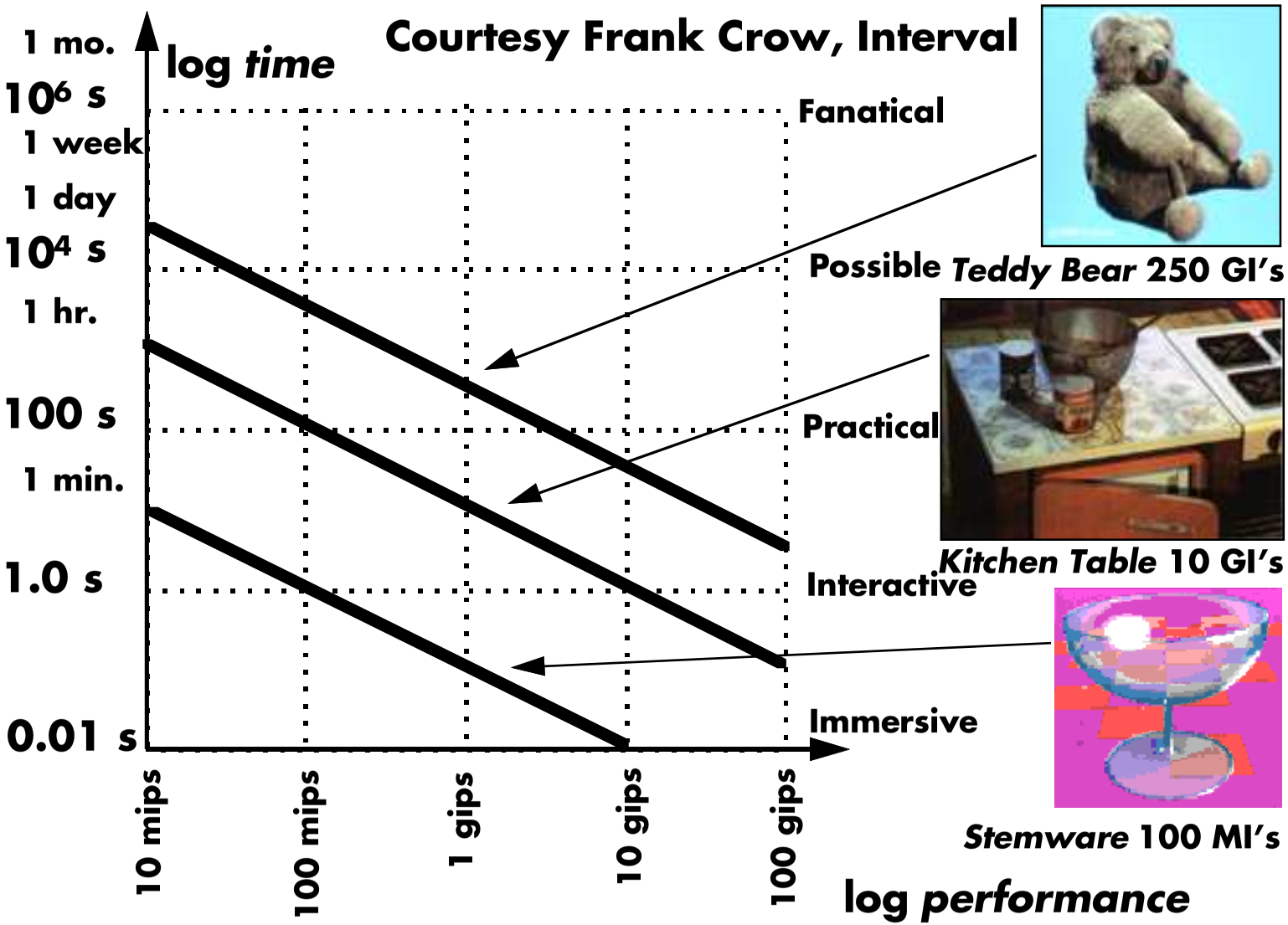
- **Ray tracing: shadows, reflections**
- **Radiosity: interreflections**
- **Image-based rendering, light fields**
- **???**

Continued increase in funcationality ...

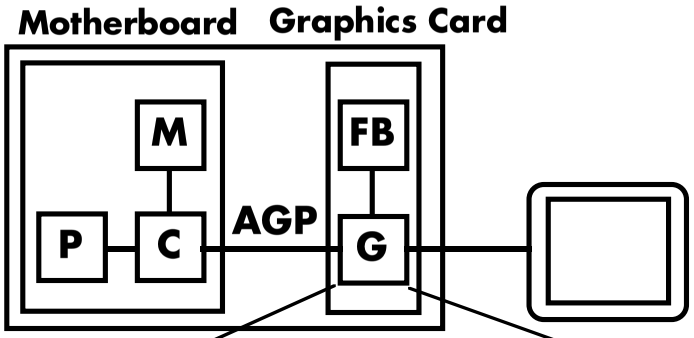
Performance Increases

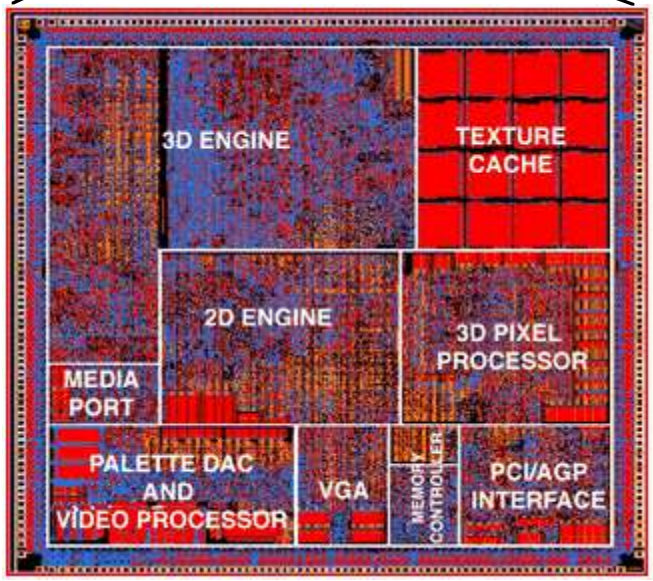


From Batch to Interactive



Current Commodity Graphics





E.g. NVIDIA RIVA128

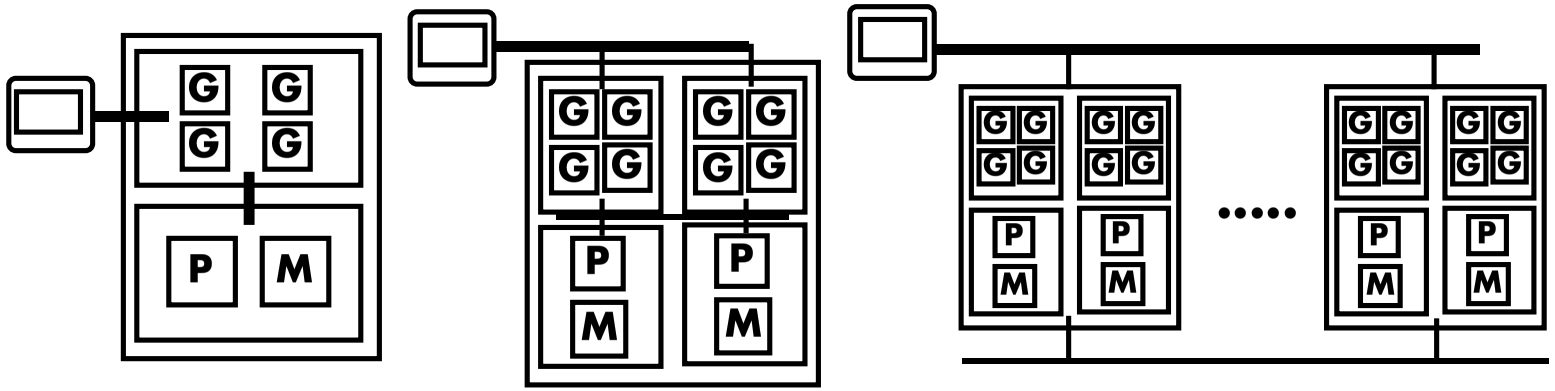
- Game machine
  - SGI/Nintendo 64
- PC Gfx accelerator
  - Technology
    - 0.35 micron 5LM
    - 3.5 million transistors
  - Performance
    - (20) Gops
    - 1(5) MTri/Sec
    - 50 (100) MPix/Sec
  - Cost: $25

Future Graphics Architectures

"Graphics and media will consume 90% of the cycles and bandwidth in the Year 2000 PC"

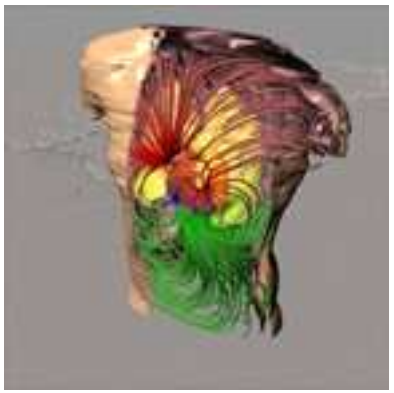
High-Performance Graphics Systems

Scalable w/ commodity parts?



Future Opportunities

Three driving types of scenarios ...



From C. Johnson (Utah)

1. Interactive Simulation (steering)

2. Scientific Instruments

From M. Whitton, H. Fuchs (UNC)

3. Telepresence and Tele-immersion

Themes

- The 4 mantras ...
  - Illustrations vs. just text
  - Perception and observation vs. just reasoning
  - Interaction vs. just batch
  - Visual and spatial thinking vs. just symbol manipulation
- Graphics architectures
  - Most computation and bandwidth intensive
  - Still tremondous opportunity for innovation
- Innovative applications of the future
  - Steering, instruments, telepresence, ...