Frontiers of Computer Graphics

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Computer Graphics

- From data to images?
- Many correlated areas
Visualization

• **Light, Camera, Simulation!**
• **Construct the scene**
  • Modeling the Geometry
• **Illuminate the scene**
  • Model the light sources
• **Photograph the scene**
  • Shading computation
  • Image generation

Motivation

• **Motivation**
  • Photorealistic images
Visualization

- **Applications**
  - Special Effects
  - Virtual Worlds
    - Movie industry
    - Television industry
    - Theme parks
    - Arcade games
  - Medical images
  - Engineering (CAD/CAM)

State of the art in plant modeling
Some Math Notation

- **Spaces of Graphical Objects**
  - Space of images
  - Space of audio signals
  - Space of geometric models
  - etc.
- **Operators on Spaces of Graphical Objects**

Some Math Notation

- **Graphical Objects**
  - Surface
  - Volume
  - Image
- **Shape + Attributes**
  \[ f : U \subset \mathbb{R}^m \rightarrow \mathbb{R}^n \]
Some Math Notation

- **Visualization operator**
  - \( T: \{\text{geometric models}\} \rightarrow \{\text{Images}\} \)

- **Direct Problem**
  - Given \( T \) and \( X \), compute \( Y = TX \)

- **T computation (Rendering)**
  - Camera position
  - Scene geometry and attributes
  - Illumination information

Computer Vision

- **Human Perception**
  - Eye: Captures the scene
  - Brain: Reconstructs the scene

- **Representation and reconstruction**
  - Discretization
  - Reconstruction
Computer Vision

- Ambiguity in the Reconstruction

Computer Vision

- Cognitive reconstruction
  - Knowledge + Information
  - Intelligent reconstruction
- Artificial intelligence
- Primary vision
- High level vision
Some Math Notation

- **Computer Vision**
  - $T: \{\text{Images}\} \rightarrow \{\text{Models}\}$
- **Inverse Problems**
  - Given $Y$ and $T$, compute $X$ from $Y = TX$
  - Given $X$ and $Y$, compute $T$, from $Y = TX$
- **A simple example**
  - The virtual referee
  - Video

Two important problems

- How to represent a graphical object?
- How to reconstruct a graphical Object?
Ambiguous Reconstruction

- An example using geometric models

Computer Graphics

- Time comes into play

Motion Modeling

Dynamic Vision

Image sequence (Video)

Motion Visualization

Video Processing
Animation

- **Continuous deformation of graphical objects**
  - Warping
  - Morphing
  - Video
- **Book and site**
  - “Warping and Morphing of Graphical Objects”
  - http://www.visgraf.impa.br/morph/

Some Math Notation

- **Visualization**
  - Direct problem
  - $T: \{\text{Motion modeling}\} \rightarrow \{\text{video}\}$
- **Dynamic Vision**
  - Inverse problems
  - $T: \{\text{Video}\} \rightarrow \{\text{Motion models}\}$
Computer Vision

- **Some Inverse Problems**
  - Recover Camera information
    - Camera calibration
  - Recover Geometry
  - Recover Motion
  - Recover Illumination

Computer Graphics

- **The Human factor**
  - User interface
    - Perceptibility and semantics
      - Semiotics
      - Gestalt Psychology
      - Computer Vision
  - Interactivity
  - Immersibility
The Human Factor

• **Interactivity**
  • Input and output devices
  • Haptic devices
    • Haptic mouse
    • Force feedback devices
• **Ivan Sutherland (1963)**

Computer Graphics

• **Immersibility**

“I see a computer display as a window in Alice’s wonderland in which a programmer can depict either objects that obey well-known natural rules or purely imaginary objects that follow laws he has written into his program”

*I. Sutherland, 1970, Scientific American*
Immersibility

- **Mixed reality**

  Augmented Reality  
  Real environment  
  Virtual environment

- **Virtual reality x Real Virtuality**

Real Virtuality

Scene from *101 Dalmatians* by Walt Disney
Modeling meets Vision

- Evolution of modeling paradigms
  - From geometry to cognition

Visualization Meets Vision

- Classical visualization paradigm
  - From models to image
    - Visualization = Models + Simulation
    - Direct problem
- New visualization paradigm
  - From Image to Models
    - Visualization = Samples + Reconstruction
    - Inverse problems
Computer Graphics

- **Main problems**
  - Real time x Huge data sets
    - “So many data so little power”
  - Devise good, very good, representation and reconstruction techniques
    - graphical objects
    - operators between graphical objects

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