# Introduction to Computer Graphics

1 February 2007
CMPT370
Dr. Sean Ho
Trinity Western University

TRINITY WESTERN UNIVERSITY

# Review last time

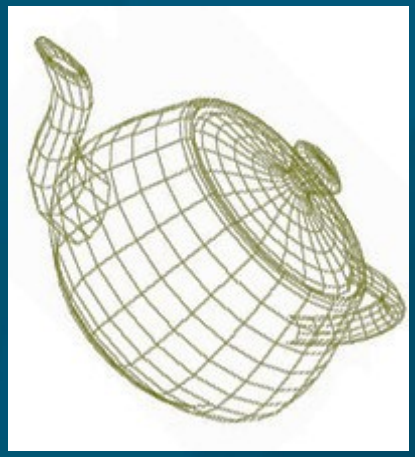
- Communication issues
  - Latency vs. bandwidth
  - Synchronous vs. asynchronous communication
  - Barriers, locking
  - Data parallelism: heat equation example

# What's on for today

- Visual computing:
  - Computer graphics and image analysis
- Objectives of visual computing
  - Capture and understand reality
  - Emulate and enhance reality
  - Parthenon video
- Image formation
  - Camera model
  - Light and colour models
  - Later: modelling objects

# Graphics vs. Image analysis

- Computer graphics is synthetic:
  - From an internal data structure (representation),
    - Triangle mesh, VRML, etc.
  - Produce (render) an image
- Image analysis is analytic:
  - From an image of the real world
    - Digicam, video, MRI/CT, satellite
  - Produce an representation of the objects of interest



Graphics

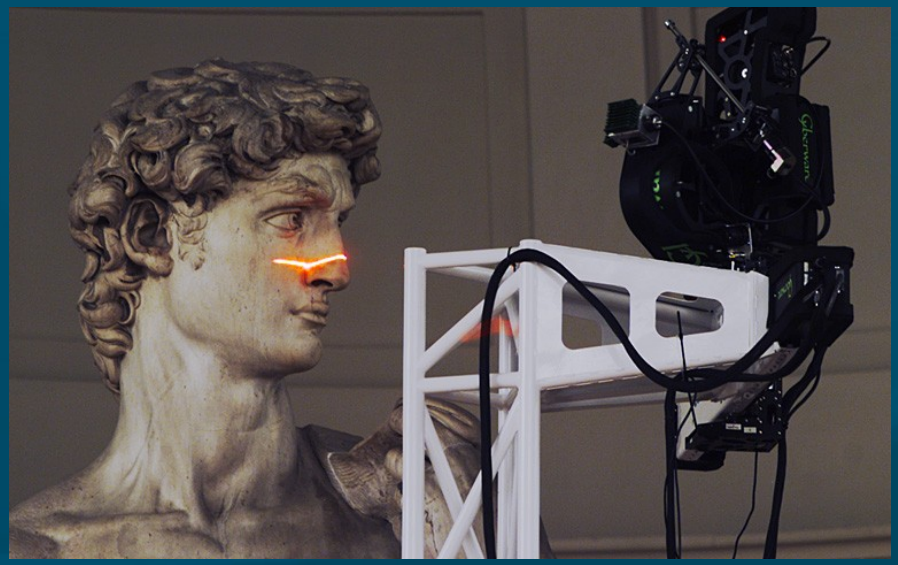
Image Analysis

# Objectives of graphics/analysis

- Image Analysis:
  - Capture reality
    - Image acquisition: camera, laser rangefinder, etc.
  - Understand reality
    - Object recognition: segmentation
- Graphics:
  - Emulate reality
    - Photorealistic rendering, physically-based modelling
  - "Enhance" reality
    - Special effects, unrealistic physics

# Objectives: Capture reality

- Acquire a representation of the world
  - Want it as faithful as possible to reality
  - Higher resolution, broader dynamic range
  - Optics/engineering/hardware

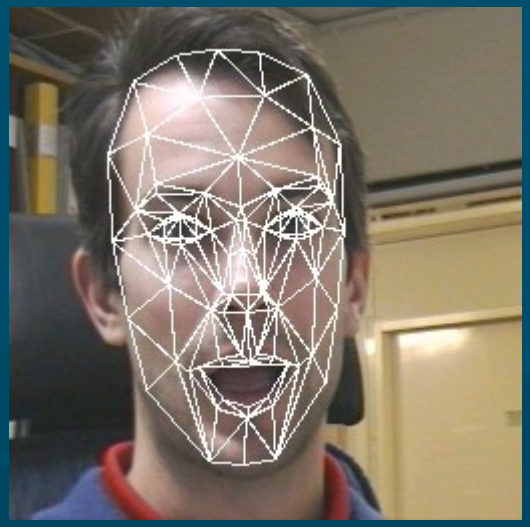


Digital Michelangelo

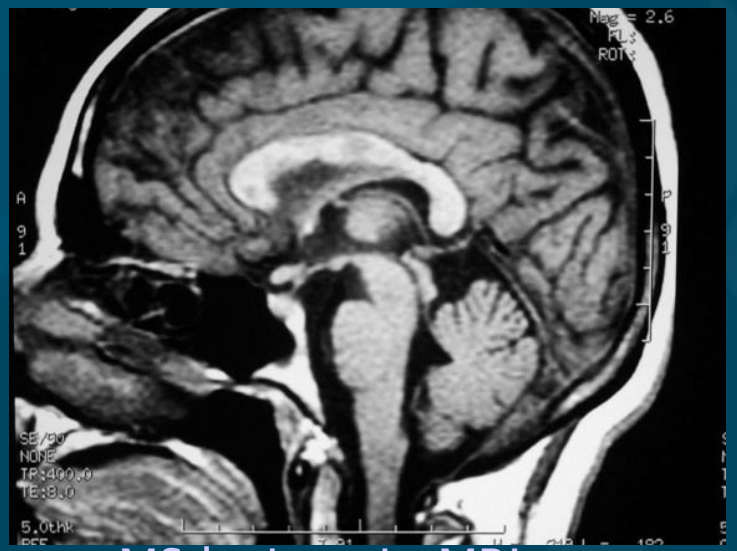

High Dynamic Range (HDR) image

# Objectives: Understand reality

- Interpretation and segmentation:
  - Finding objects of interest within an image
- Object representation:
  - Compact data structures suitable for, e.g.
    - Population analysis and discrimination



Face recognition (AAM)



MS lesions in MRI

# Objectives: Emulate reality

- Try to get as close to reality as possible
  - Modelling: geometry, texture, etc. of objects
  - Lighting/shading: behaviour of light
  - Animation: natural motion of objects

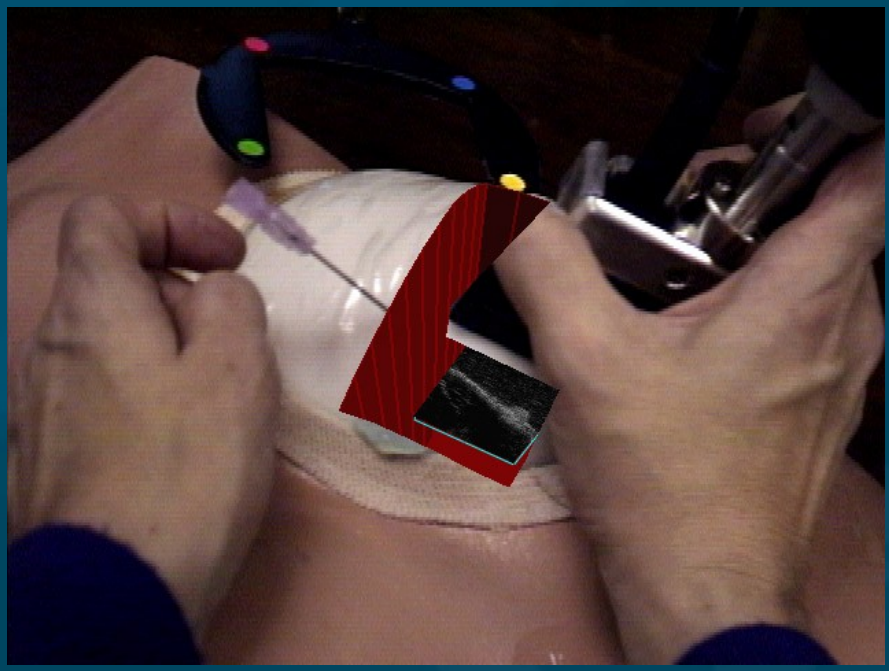
- The "uncanny valley": not-quite-realistic human characters are very disconcerting

Soanala: 3DSMax using sub-surface scattering for skin

# Objectives: "Enhance" reality

- Combine real and generated elements
- Movie special effects
- Augmented reality HUD for telesurgery, manufacturing/design, etc.

Photorealistic rendering



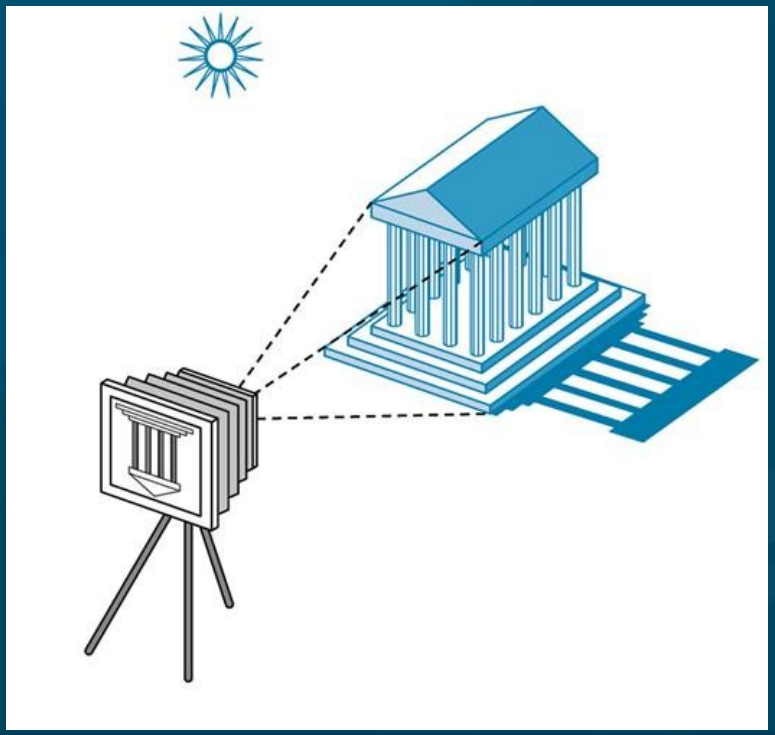
UNC AR
ultrasound breast biopsy

# Parthenon example (SIGGRAPH 04)

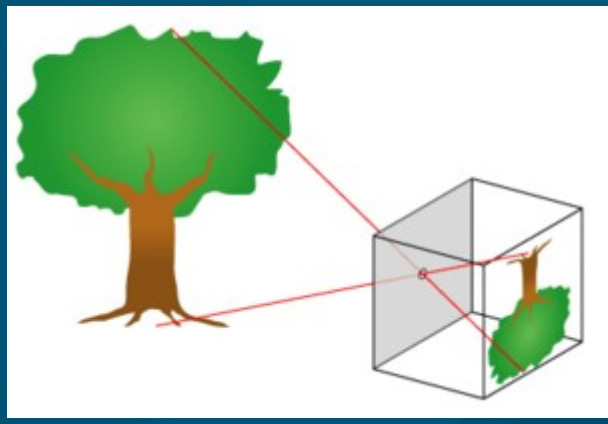
- The Debevec/USC Parthenon is just one example of combining image analysis and computer graphics
  - 53 pano laser scans
  - 90 million polygons
  - Custom scanning rig for sculptures in London's Parthenon Museum
  - Time-lapse daylight sequence uses HDR images taken in Marina Del Rey
  - Total production time: 58 days (37-CPU render farm)

# Image formation

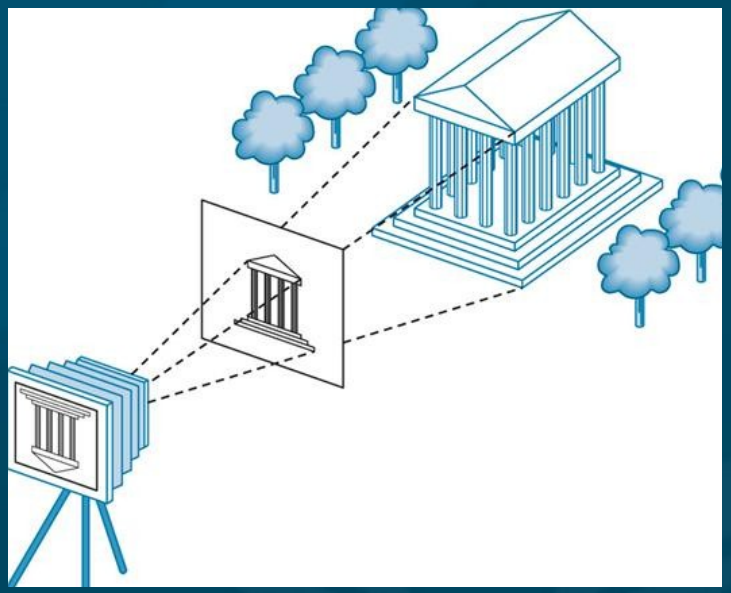
- Components to produce a static image:
  - Objects
    - Material properties: colour, shininess, bumpiness, etc.
  - Light sources
    - Colour spectrum, direction, area, etc.
  - Viewer
    - Camera model: lens, depth of field, etc.



# Camera model

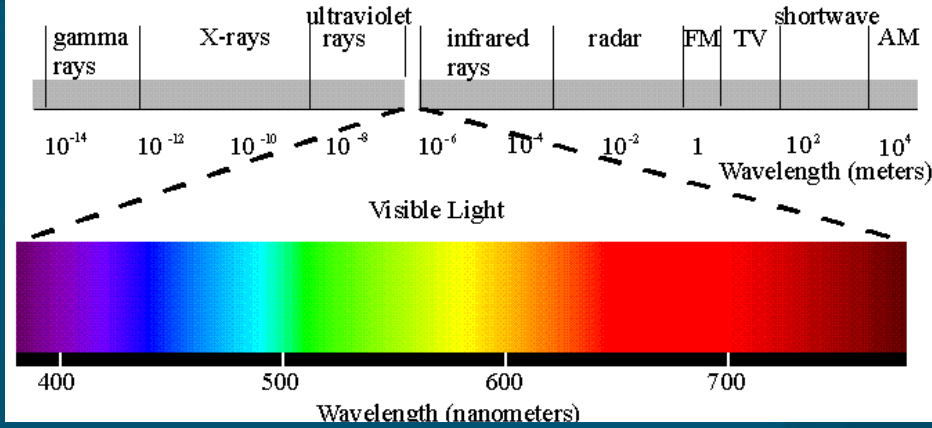


- The most basic is a pinhole camera:
  - Image produced is upside down and flipped
  - Larger hole yields smaller depth-of-field (more blurry)
- Synthetic camera model:
  - Image plane is in front of center of projection
  - Cast rays from CoP through each pixel of image plane, into the scene

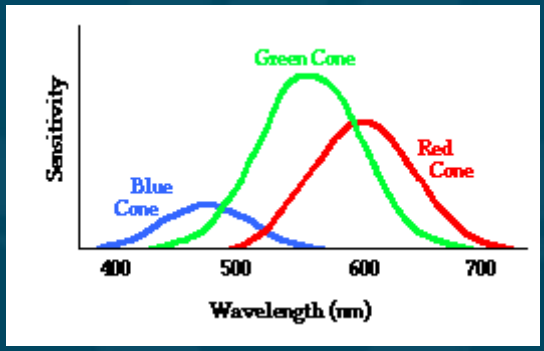


- Control depth of field? Lens distortion?

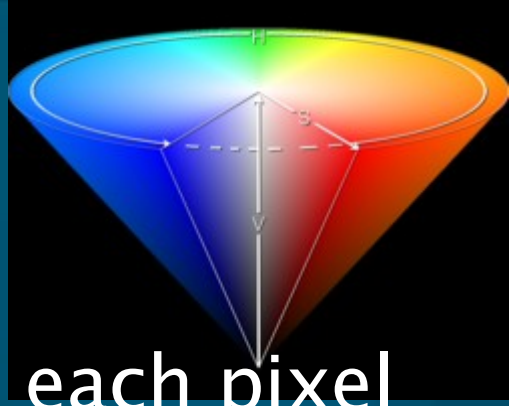
# Light




- Visible light is electromagnetic radiation about 350-750nm in wavelength (~400 to 850 THz in frequency)
- Light colour is a frequency distribution of energy
  - Lasers: monochromatic
- But our eyes only have four kinds of sensors:
  - Rods: luminance (shades of grey)
  - R,G,B cones: chrominance (colour)
  - Each sensor has its own frequency response curve



# Colour models



- "True" image: frequency distribution at each pixel
- RGB: matches our cones
  - Additive colour: CRTs use 3 electron guns
  - Must still define chromaticities of R,G,B
- CMYK: subtractive colour: C<->R, M<->G, Y<->B
  - Inks/pigments: newspaper, paint
- HSV: hue, saturation, value
- CIELAB: lightness, a/b chrominance:
  - Absolute colour space: only depends on whitepoint
  - Convert to absolute via profile: AdobeRGB, sRGB

# TODO

- Lab2 due next Tue 6Feb
  - Design + implement your own OpenMP program
  - Lab write-up