

Computer Graphics



Chapter 1: Introduction to Computer Graphics

Class Activity

– My name is ...
– This summer I worked at ... / I went to ... / I had fun doing ...
– My favorite example of computer graphics is ...

- Computer game?
- Animated movie?
- Display?
- Other application?

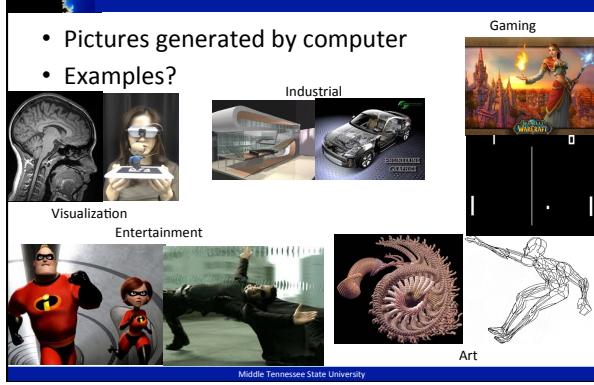
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What are Computer Graphics (CG)?

- Pictures generated by computer
- Examples?

Visualization Industrial Gaming



Entertainment Art

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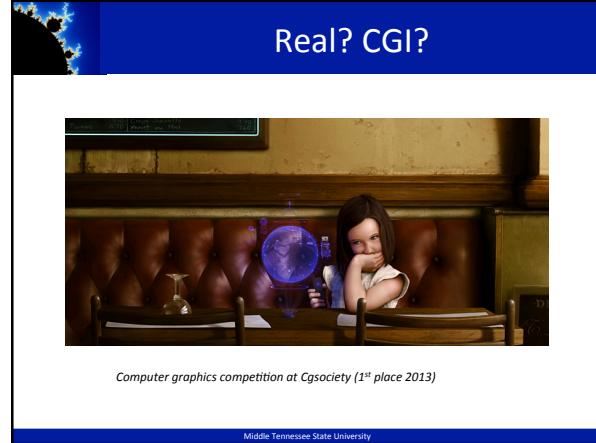
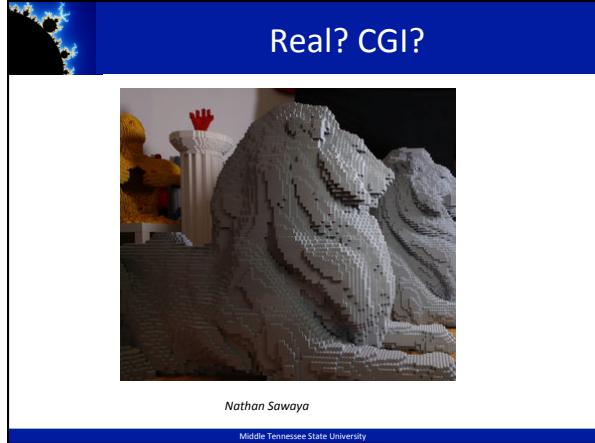


Real? CGI?



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Graphics Research

- [SIGGRAPH](#)
 - 2015 Technical Paper Preview Trailer
<https://www.youtube.com/watch?v=XrYkEhs2FdA>
 - 2014 Technical Paper Preview Trailer
<https://www.youtube.com/watch?v=u3Z1hDwGEmM>
- [Computer Graphics Society](#)
 - 2014 student design competition winners:
http://www.cgsociety.org/index.php/CGSFeatures/CGSFeatureSpecial/2014_cgstudent_awards_winners
 - 2015 Contest

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Modeling vs. Rendering

- Modeling
 - Create models
 - Apply materials to models
 - Place models around scene
 - Place lights in scene
 - Place the camera
- Rendering
 - Take “picture” with camera



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Example

- Where did this image come from?
- What hardware/software did we use to produce it?

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Preliminary Answer

- **Application:** The object is an artist’s rendition of the sun for an animation to be shown in a domed environment (planetarium)
- **Software:** Maya for modeling and rendering but Maya is built on top of OpenGL
- **Hardware:** PC with graphics card for modeling and rendering

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History of Computer Graphics

- <http://www.youtube.com/watch?v=LzZwiLUVaKg>
(History of Computer Animation - P1)
 - In what years does Computer Graphics originate?
 - What is the name of the Computer developed at MIT that helps US Navy to calculate trajectory of the rockets?
 - What is the name of the first interactive program developed at MIT?
 - In which year was 3D graphics started?
 - What is the first object the computer scientists used to test various techniques for CGI?

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Computer Graphics: 1950-1960

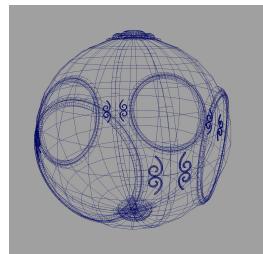
- Computer graphics goes back to the earliest days of computing
 - Strip charts
 - Pen plotters
 - Simple displays using A/D converters to go from computer to calligraphic CRT
- Cost of refresh for CRT too high
 - Computers slow, expensive, unreliable

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Computer Graphics: 1960-1970

- *Wireframe* graphics
 - Draw only lines
- Sketchpad
- Display Processors
- Storage tube

wireframe representation
of sun object



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Sketchpad

- Ivan Sutherland's PhD thesis at MIT
 - Recognized the potential of man-machine interaction
 - Loop
 - Display something
 - User moves light pen
 - Computer generates new display
- Sutherland also created many of the now common algorithms for computer graphics

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Display Processor

- Rather than have the host computer try to refresh display, use a special purpose computer called a *display processor* (DPU)

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graph LR
    Host[Host] --> DP[Display processor]
    DP --> CRT[CRT]
    CRT --> DL[Display list]
    DL --> DP
  
```

- Graphics stored in display list (display file) on display processor
- Host *compiles* display list and sends to DPU

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Computer Graphics: 1970-1980

- Raster Graphics
- Beginning of graphics standards
 - IFIPS
 - GKS: European effort
 - Becomes ISO 2D standard
 - Core: North American effort
 - 3D but fails to become ISO standard
- Workstations and PCs

<small>IFIPS International Federation of Information Processing Societies GKS Graphical Kernel System ISO International Standards Organization</small>	<small>Middle Tennessee State University</small>
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Raster Graphics

- Image produced as an array (the *raster*) of picture elements (*pixels*) in the *frame buffer*

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Raster Graphics

- Allows us to go from lines and wire frame images to filled polygons

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PCs and Workstations

- Although we no longer make the distinction between workstations and PCs, historically they evolved from different roots
 - Early workstations characterized by
 - Networked connection: client-server model
 - High-level of interactivity
 - Early PCs included frame buffer as part of user memory
 - Easy to change contents and create images

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Computer Graphics: 1980-1990

Realism comes to computer graphics



smooth shading environment mapping bump mapping

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Computer Graphics: 1980-1990

- Special purpose hardware
 - Silicon Graphics geometry engine
 - VLSI implementation of graphics pipeline
- Industry-based standards
 - PHIGS (Programmer's Hierarchical Interactive Graphics System)
 - Pixar's RenderMan:
<https://renderman.pixar.com/view/movies-and-awards>
- Networked graphics: X Window System
- Human-Computer Interface (HCI)

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Computer Graphics: 1990-2000

- OpenGL API
- Completely computer-generated feature-length movies (*Toy Story*) are successful
- New hardware capabilities
 - Texture mapping
 - Blending
 - Accumulation: antialiasing
 - Stencil buffers:
 - Limit the area of rendering
 - Work with depth buffer to create special effects per pixel basis

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Computer Graphics: 1990-2000

- Anti-aliasing Example



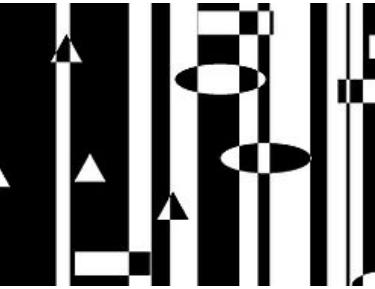
The image shows two side-by-side screenshots from a video game. On the left is the X360 version, and on the right is the PS3 version. Both screenshots show a character's face and another character in the background. A red box highlights a specific area of the character's face, with the text "300% ZOOM" below it. The PS3 version shows significantly smoother edges and less aliasing compared to the X360 version.

X360 PS3

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Computer Graphics: 1990-2000

- Stencil buffer example

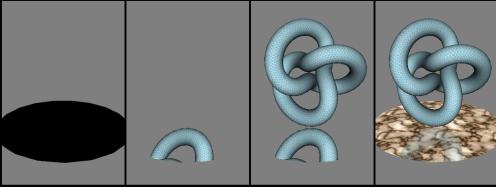


A series of five vertical panels illustrating the stencil buffer process. From left to right: 1. A black rectangle with a white triangle pointing up. 2. A black rectangle with a white triangle pointing down. 3. A black rectangle with a white oval. 4. A black rectangle with a white circle. 5. A black rectangle with a white cross. These represent different stencil patterns used for clipping or masking in rendering.

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Computer Graphics: 1990-2000

- Stencil buffer for reflection generation example



A sequence of four images showing the generation of a reflection using a stencil buffer. 1. A dark gray rectangle with a black oval. 2. A light gray rectangle with a small blue curved shape. 3. A light gray rectangle with a complex blue reflection of the curved shape. 4. A light gray rectangle with a detailed blue reflection of a complex blue object, likely a knot or a similar shape, on a textured surface.

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Computer Graphics: 2000-2010

- Photorealism
- Graphics cards for PCs dominate market
 - Nvidia, ATI
- Game boxes and game players determine direction of market
- Computer graphics routine in movie industry: Maya, Lightwave
- Programmable pipelines
- New display technologies

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Computer Graphics 2011-

- Graphics is now ubiquitous
 - Cell phones
 - Embedded
- OpenGL ES and WebGL
- Alternate and Enhanced Reality
- 3D Movies and TV
- Newer display technology

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Realities of Computer Graphics

- Generally very computationally expensive
 - More realistic=more time/computation
 - Hardware/software is very specialized and complex
- This is NOT a game programming or graphic design course
 - This course will help you if these are your interests
- Lots of math!
 - You shouldn't be afraid of...
 - Matrices
 - Vectors
 - Geometry
- Good APIs exist to make our lives easier
 - more on this later...

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