Computer Graphics and imaging

LECTURE 1

What is computer graphics?

What is Computer Graphics?

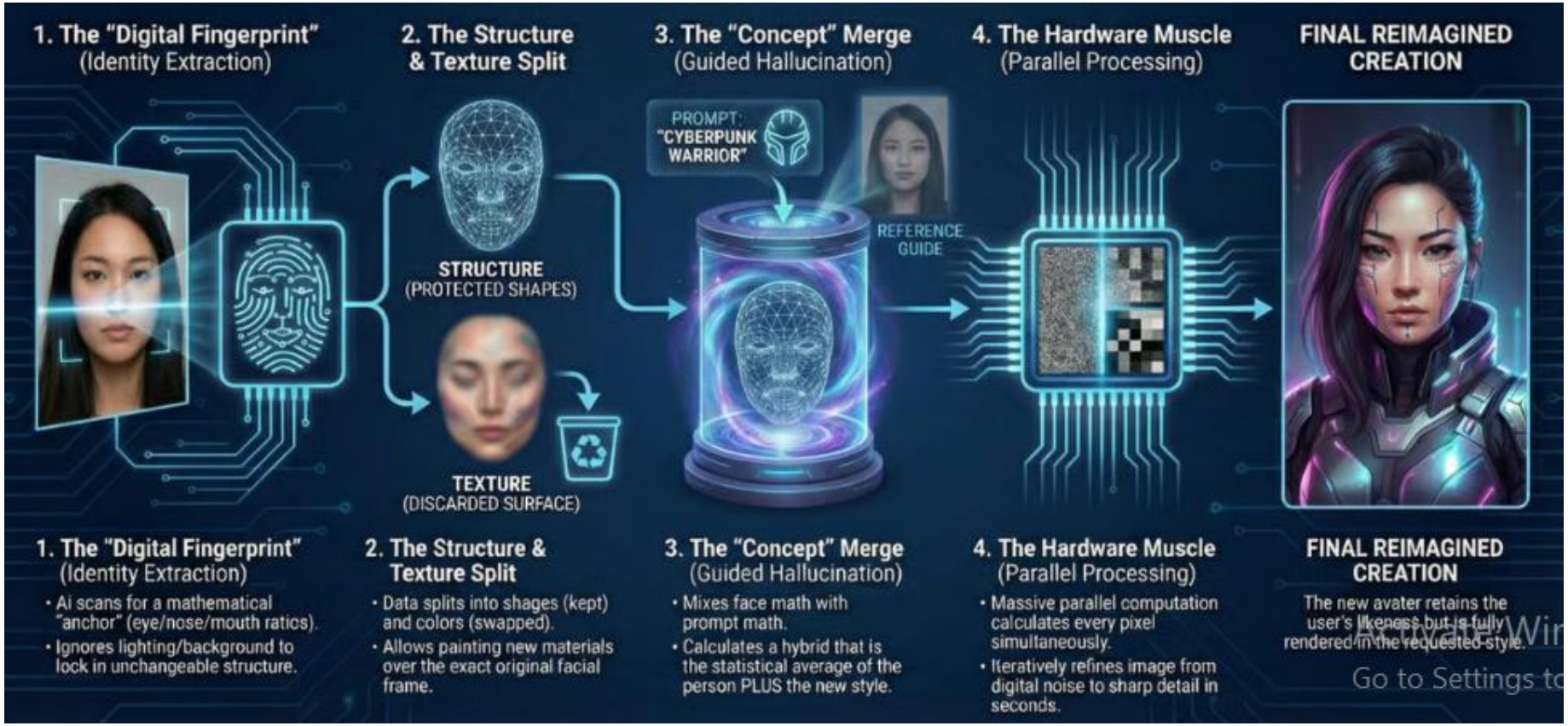
Computer Graphics is a subfield of computer science concerned with the **creation**, **representation**, **display**, **manipulation**, **and storage of visual content** **using computers**.

Key activities

Creation – generating images, objects, and scenes.
Representation – representing visual objects in a digital form.
Display – showing graphics on screens or other devices.
Manipulation – modifying, transforming, or editing graphics.
Storage – saving graphical information digitally.

AI and computer graphics

AI Image Generations




2D
3D AI
2D
3D AI

Image Representation

classification of major subfields in computer graphics might be:



classification of major subfields in computer graphics

- *Imaging:* studies image acquisition or image editing
- *Rendering:* studies algorithms to reproduce light transport
- *Geometry (modeling):* studies with ways to represent and process surfaces
- *Animation:* studies with ways to represent and manipulate motion

1-What is an image?

- **Two dimensional function**
- **Value at any point is an intensity or color** but **not digital!**



Manipulation





What is a digital image?

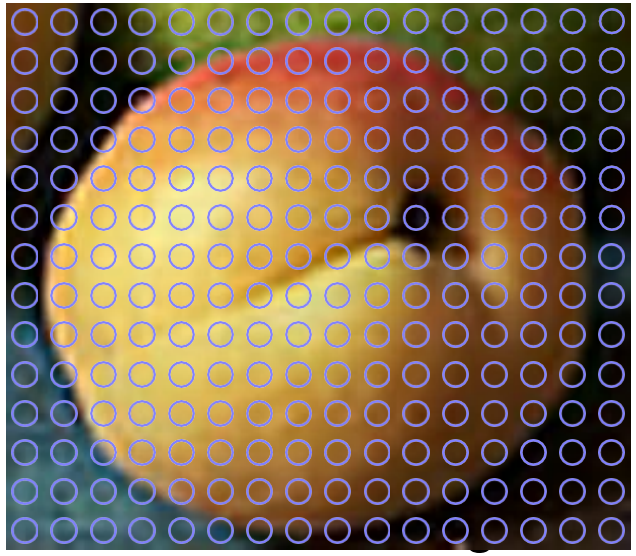
- if it's digital, it's just a collection of numbers

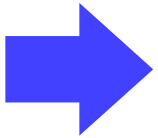
- a sampled and quantised version of a real image
- a rectangular array of intensity or colour values

1-Image capture

- **a variety of devices can be used**
  - **Scanners** Displayed on a CRT
    - **line CCD in a flatbed scanner**
    - **spot detector in a drum scanner**
  - **cameras**
    - **area CCD**

Example





103 59 12 80 56 12 34 30 1 78 79 21 145 156 52 136 143 65 115 129 41 128 143 50 85
106 11 74 96 14 85 97 23 66 74 23 73 82 29 67 76 21 40 48 7 33 39 9 94 54
19
42 27 6 19 10 3 59 60 28 102 107 41 208 88 63 204 75 54 197 82 63 179 63 46 158
62
46 146 49 40 52 65 21 60 68 11 40 51 17 35 37 0 28 29 0 83 50 15 2 0 1 13 14
8 243 173 161 231 140 69 239 142 89 230 143 90 210 126 79 184 88 48 152 69 35 123 51
27 104 41 23 55 45 9 36 27 0 28 28 2 29 28 7 40 28 16 13 13 1 224 167 112 240
174 80 227 174 78 227 176 87 233 177 94 213 149 78 196 123 57 141 72 31 108 53 22 121
62 22 126 50 24 101 49 35 16 21 1 12 5 0 14 16 11 3 0 0 237 176 83 244 206 123
241 236 144 238 222 147 221 190 108 215 170 77 190 135 52 136 93 38 76 35 7 113 56 26
156 83 38 107 52 21 31 14 7 9 6 0 20 14 12 255 214 112 242 215 108 246 227 133 239
232 152 229 209 123 232 193 98 208 162 64 179 133 47 142 90 32 29 19 27 89 53 21 171
116 49 114 64 29 75 49 24 10 9 5 11 16 9 237 190 82 249 221 122 241 225 129 240 219
126 240 199 93 218 173 69 188 135 33 219 186 79 189 184 93 136 104 65 112 69 37 191 153
80 122 74 28 80 51 19 19 37 47 16 37 32 223 177 83 235 208 105 243 218 125 238 206
103 221 188 83 228 204 98 224 220 123 210 194 109 192 159 62 150 98 40 116 73 28 146
104
46 109 59 24 75 48 18 27 33 33 47 100 118 216 177 98 223 189 91 239 209 111 236 213
117 217 200 108 218 200 100 218 206 104 207 175 76 177 131 54 142 88 41 108 65 22 103
59 22 93 53 18 76 50 17 9 10 2 54 76 74 108 111 102 218 194 108 228 203 102 228 200
100 212 180 79 220 182 85 198 158 62 180 138 54 155 106 37 132 82 33 95 51 14 87 48
15 81 46 14 16 15 0 11 6 0 64 90 91 54 80 93 220 186 97 212 190 105 214 177 86
208
165 71 196 150 64 175 127 42 170 117 49 139 89 30 102 53 12 84 43 13 79 46 15 72 42
14 10 13 4 12 8 0 69 104 110 58 96 109 130 128 115 196 154 82 196 148 66 183 138 70
174 125 56 169 120 54 146 97 41 118 67 24 90 52 16 75 46 16 58 42 19 13 7 9 10 5
0 18 11 3 66 111 116 70 100 102 78 103 99 57 71 82 162 111 66 141 96 37 152 102 51
130 80 31 110 63 21 83 44 11 69 42 12 28 8 0 7 5 10 18 4 0 17 10 2 30 20 10
58 88 96 53 88 94 59 91 102 69 99 110 54 80 79 23 69 85 31 34 25 53 41 25 21 2
0 8 0 0 17 10 4 11 0 0 34 21 13 47 35 23 38 26 14 47 35 23

A digital image

A- Sampling

- a digital image is a rectangular array of intensity values
- each value is called a *pixel*
  - "picture element"
- sampling resolution is normally measured in pixels per inch (ppi)
- computer monitors have a resolution around 100 ppi
  - laser printers have resolutions between 300 and 1200 ppi

Sampling resolution

256×256



128×128

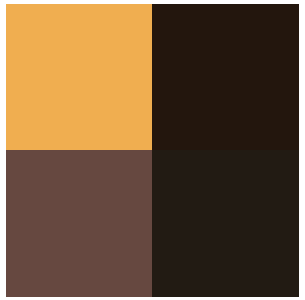


64×64

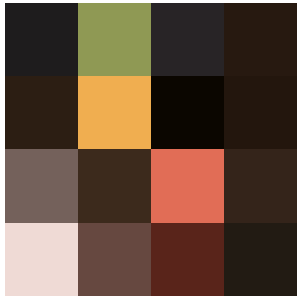


32×32





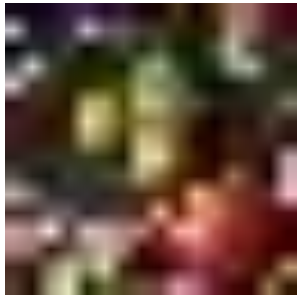
2×2



4×4



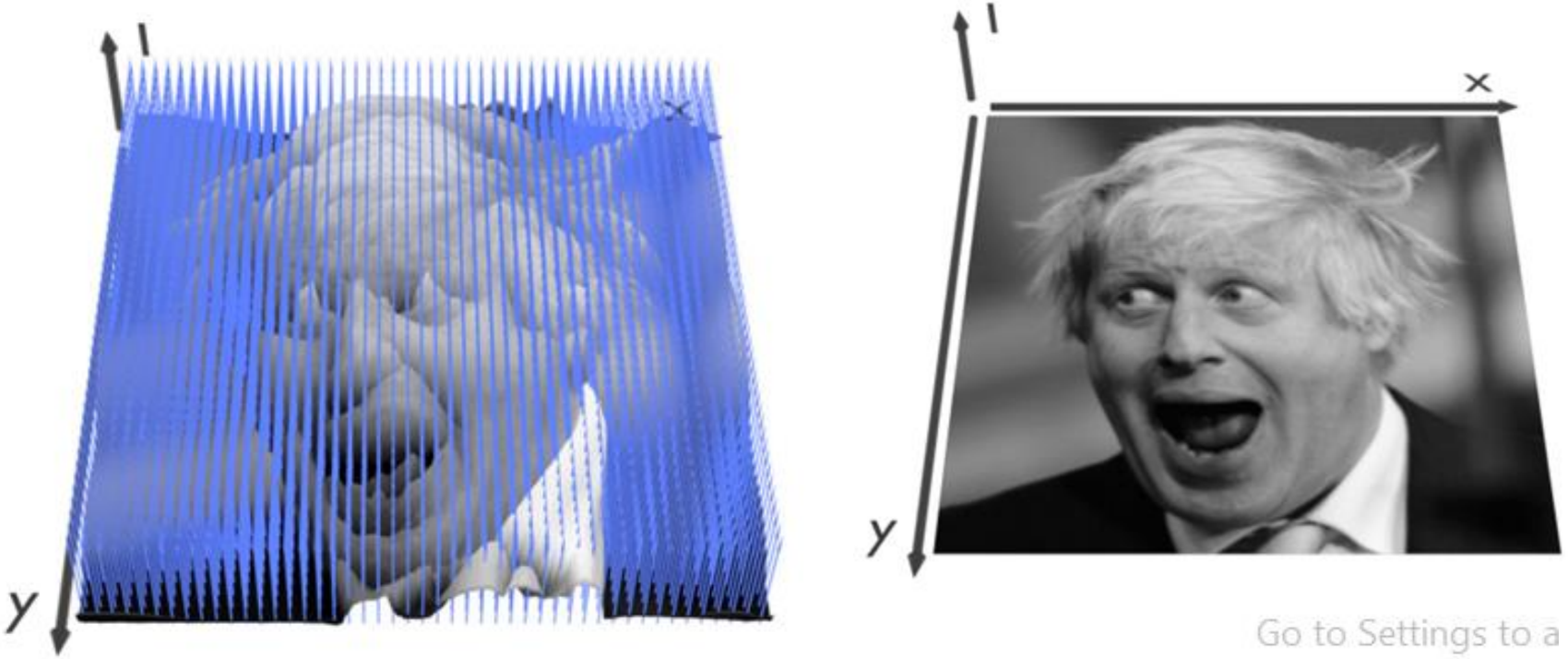
8×8



16×16

Sampling an image

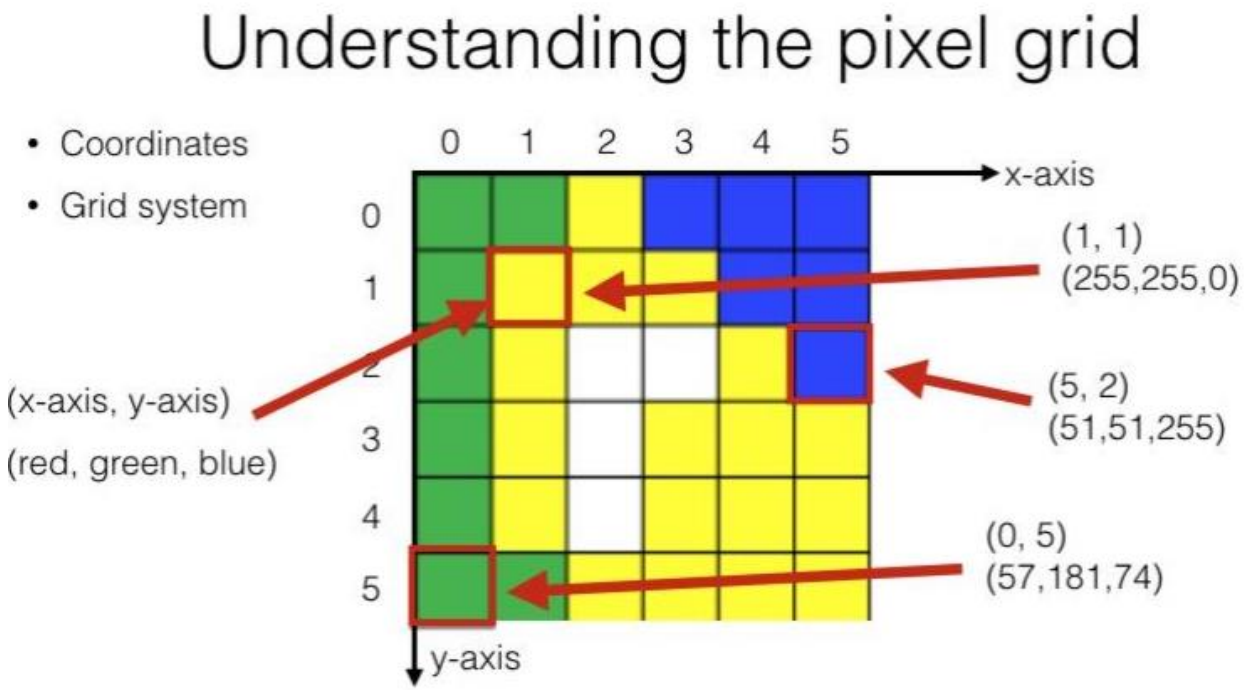
- The image can be sampled on a rectangular sampling grid to yield a set of samples. These samples are pixels.

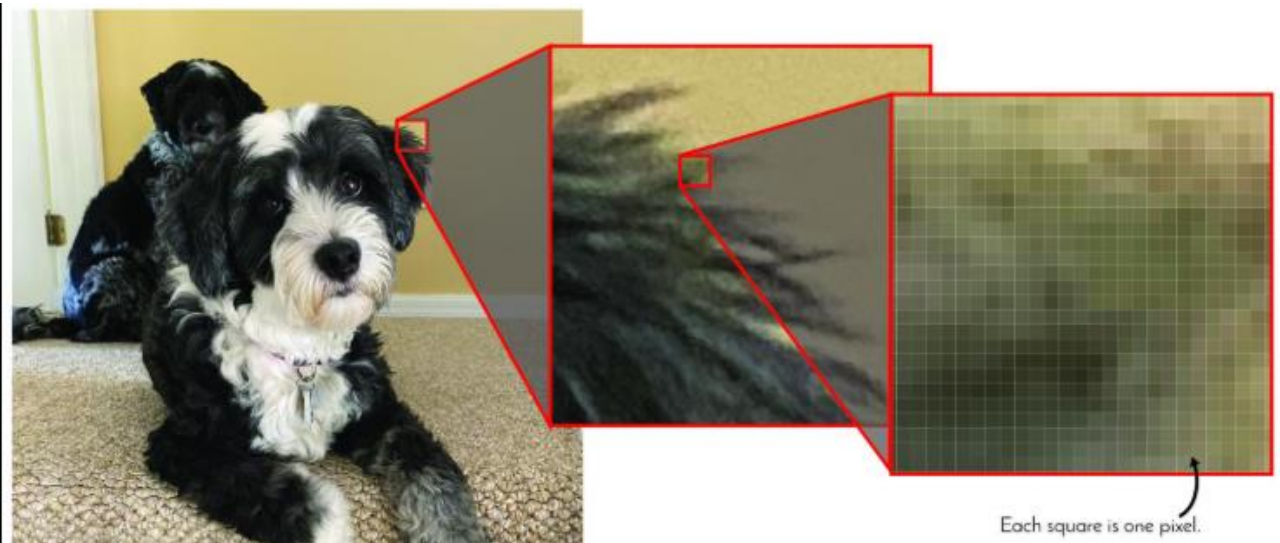


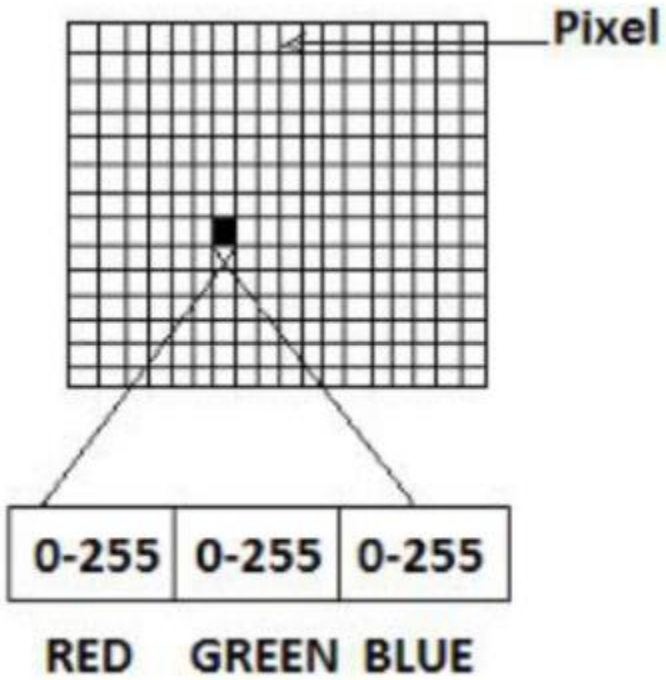
Go to Settings to a

What is a pixel?

- **A pixel is the smallest piece of information in an image.**
- **Pixels are arranged in a regular 2D grid, and are often represented using squares.**







How to create colors with RGB?

Combine parts of the three primary colors **red**, **green** and **blue**.

Each of the primary colors can have a value in the range from 0 to 255.



R:	255	0	0	0	255
G:	0	255	0	0	255
B:	0	0	255	0	255

B- Quantisation

- **Each intensity value is a number**
- **for digital storage the intensity values must be quantised**
  - **limits the number of different intensities that can be stored**
  - **limits the brightest intensity that can be stored**
- **how many intensity levels are needed for human consumption**
  - **8 bits usually sufficient**
  - **some applications use 10 or 12 bits**

Quantisation levels

8 bits
(256 levels)



7 bits
(128 levels)



6 bits
(64 levels)

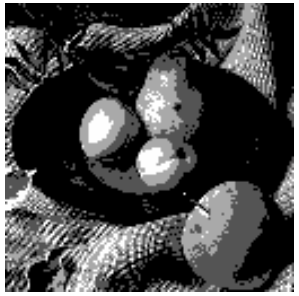


5 bits
(32 levels)





1 bit
(2 levels)



2 bits
(4 levels)



3 bits
(8 levels)



4 bits
(16 levels)

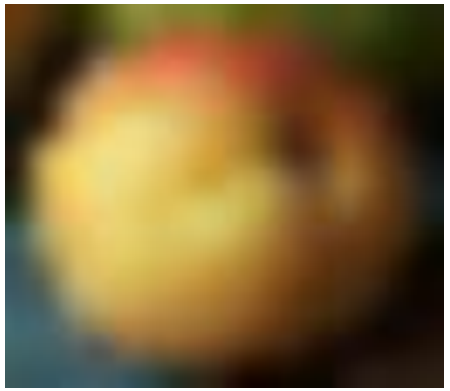
2-Image display

- **a digital image is an array of integers, how do you display it?**
- **reconstruct a real image on some sort of display device**
  - **CRT - computer monitor, TV set**
  - **LCD - portable computer**
  - **printer - dot matrix, laser printer, dye sublimation**

Example

103 59 12 80 56 12 34 30 1 78 79 21 145 156 52 136 143 65 115 129 41 128 143 50 85
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0 8 0 0 17 10 4 11 0 0 34 21 13 47 35 23 38 26 14 47 35 23

The image data

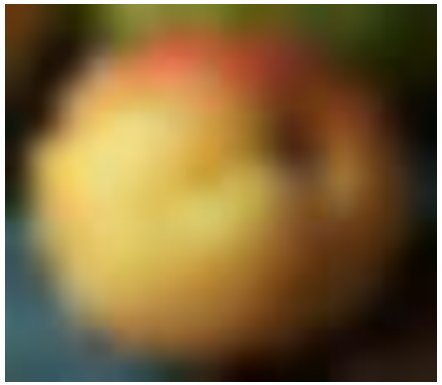


Displayed on a CRT

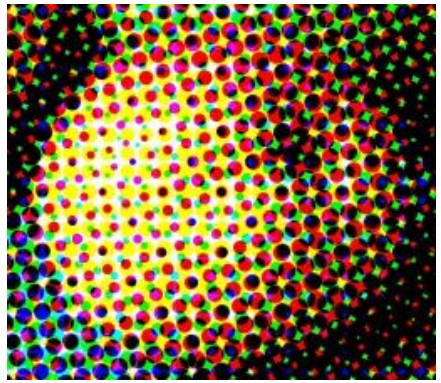
Different ways of displaying the same digital image



Nearest-neighbour
e.g. LCD



Gaussian
e.g. CRT



Half-toning
e.g. laser printer

classification of major subfields in computer graphics

- *Imaging:* studies image acquisition or image editing
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- *Animation:* studies with ways to represent and manipulate motion

Rendering

Lighting

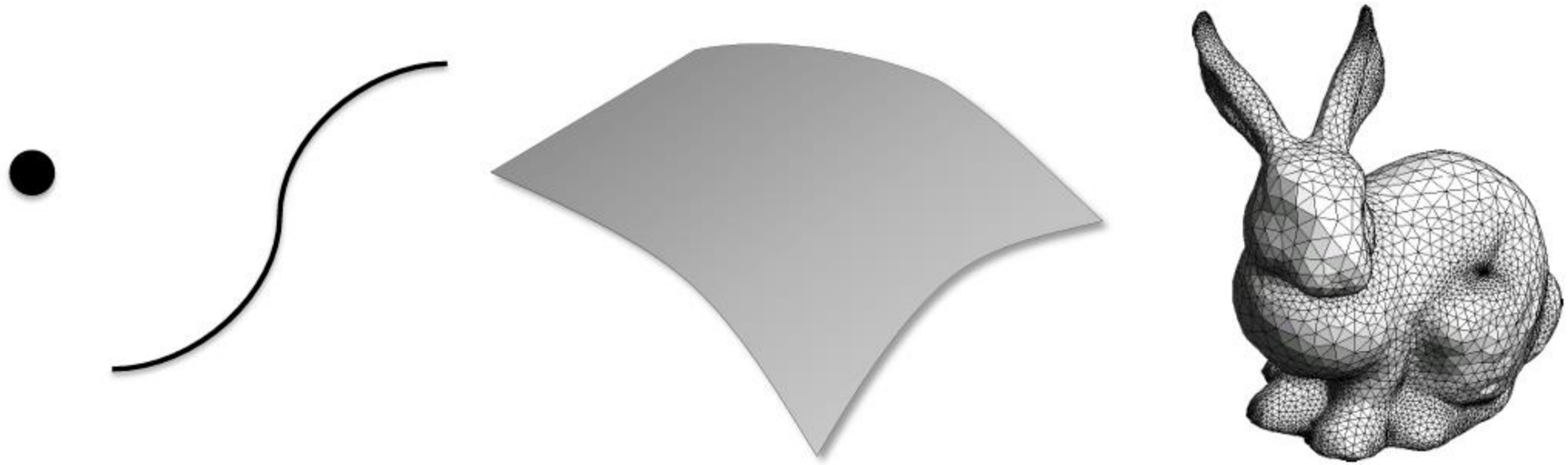


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Modeling

Geometry comes in many forms.
Examples, left to right: points, lines, continuous surfaces, surface meshes.



- Point Set Surfaces







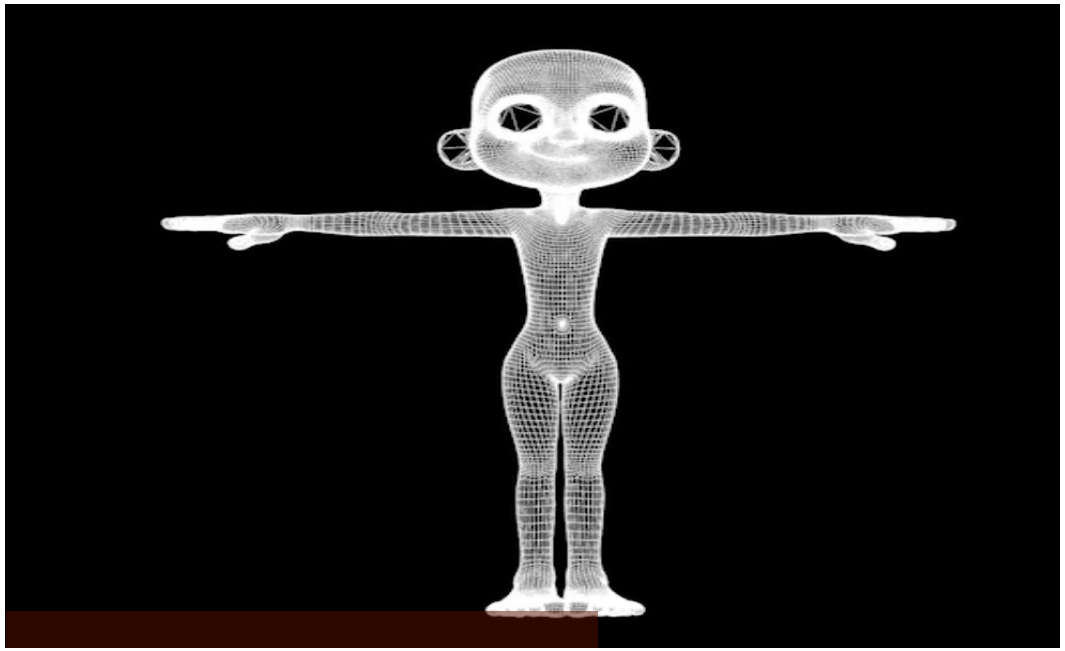


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Animation

To create an illusion of motion through sequences of images





Applications of Computer Graphics

Computer graphics is used in almost all areas of computer science.

1. **Graphical User Interface (GUI): the interface between users and the application program. It has many components [menus, icons, buttons, etc.].**
2. **Office Automation: Standard packages of Ms Word, Excel, PowerPoint use GUI.**
3. **Entertainment: Computer Graphic systems are used to design movies, video games, animation movies, cartoons etc.**
4. **Education: GUI helps us in preparing presentations, video lectures, etc.**
5. **Computer Aided Design (CAD): One of the most important application of graphics is in engineering and architectural systems.**

Graphics Applications

- Entertainment
  - film production
  - film effects
  - games
- Science and engineering
  - computer-aided design
  - visualization (scientific, information)
- Virtual Prototyping
- Cultural Heritage
- Training & Simulation
- Graphic Arts, Fine Art

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(with previous instructors
James/Bala)




Disney · PIXAR
BRAVE
IN THEATERS JUNE 22
LORD MACGUFFIN
DISNEY.COM/BRAVE
© Disney/Pixar



Pixar—*The Blue Umbrella* (2013)



The Hobbit: An Unexpected Journey (New Line Cinema, 2012)—visual effects by Weta Digital


KING KONG
© 2005 Universal Studios. Used With Permission.



Crytek—*Crysis 3* (2013)



Quantic Dream—*Two Souls* (2013) screenshot: videogamer.com



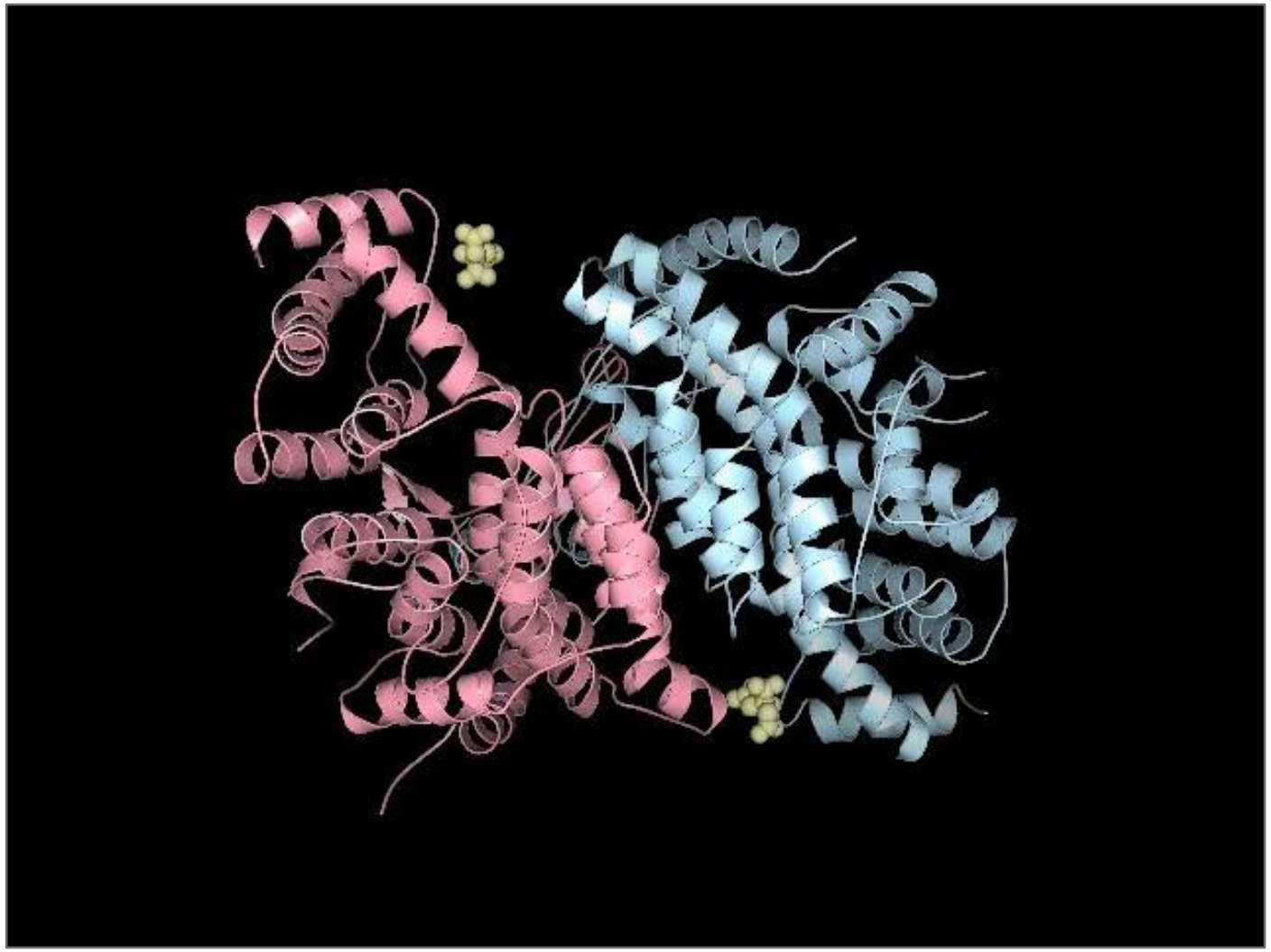
Polytron—*Fez* (2010)

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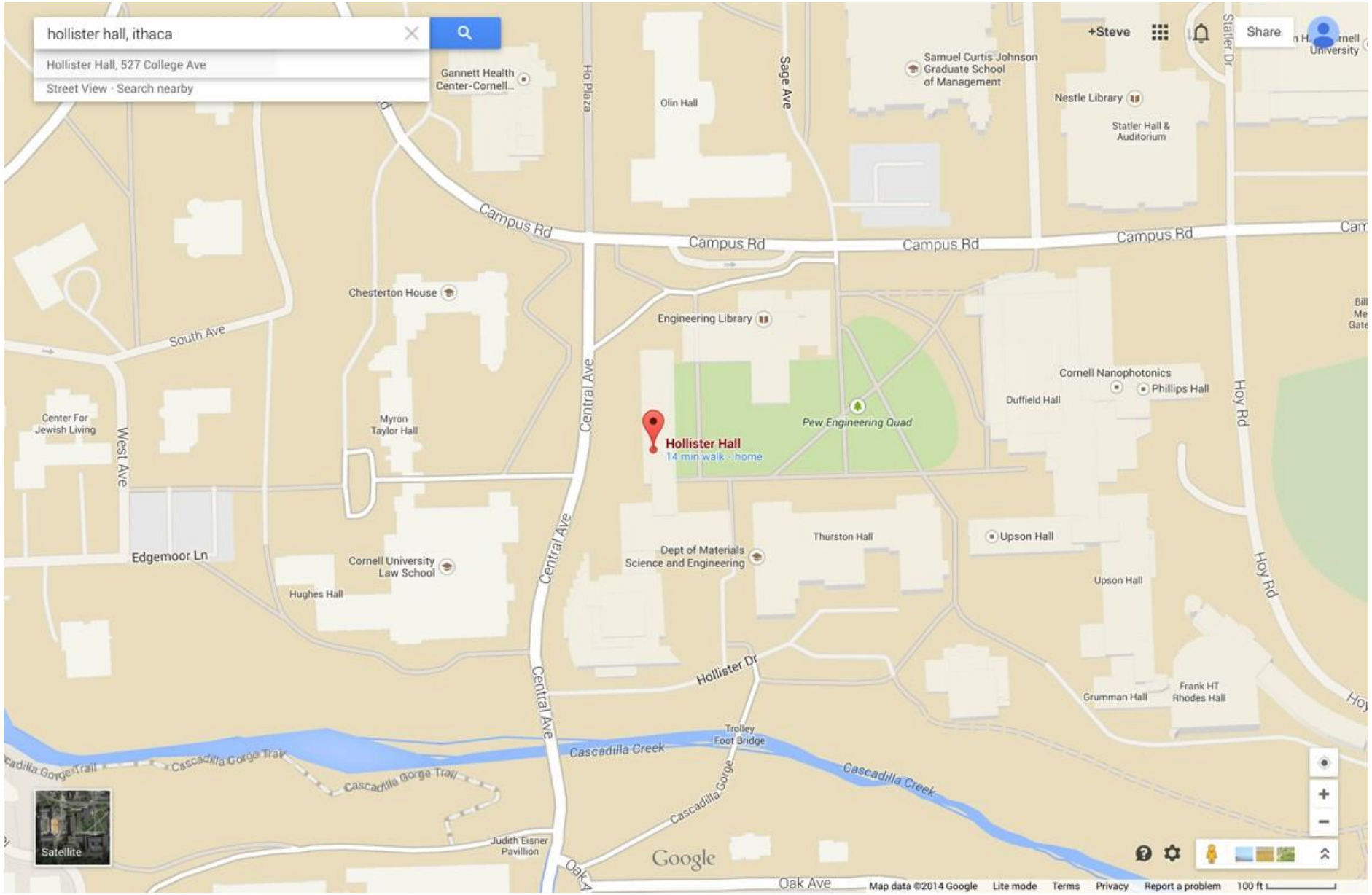


U. of Utah—Alpha 1



Simulated deformation of citrate synthase during substrate binding

Kalju Kahn, UCSB


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Hollister Hall, 527 College Ave
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Olin Hall
Sage Ave
Samuel Curtis Johnson Graduate School of Management
Nestle Library
Statler Hall & Auditorium
Statler Dr
Campus Rd
Chesterton House
Engineering Library
South Ave
Cornell Nanophotonics
Phillips Hall
Duffield Hall
Hoy Rd
Center For Jewish Living
West Ave
Myron Taylor Hall
Central Ave
Hollister Hall
14 min walk · home
Pew Engineering Quad
Edgemoor Ln
Cornell University Law School
Hughes Hall
Dept of Materials Science and Engineering
Thurston Hall
Upson Hall
Hollister Dr
Grumman Hall
Frank HT Rhodes Hall
Trolley Foot Bridge
Cascadilla Creek
Cascadilla Gorge Trail
Cascadilla Gorge
Judith Eisner Pavillion
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Wednesday, August 27, 2014

Graphics Applications

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Autodesk 360 Cloud Render

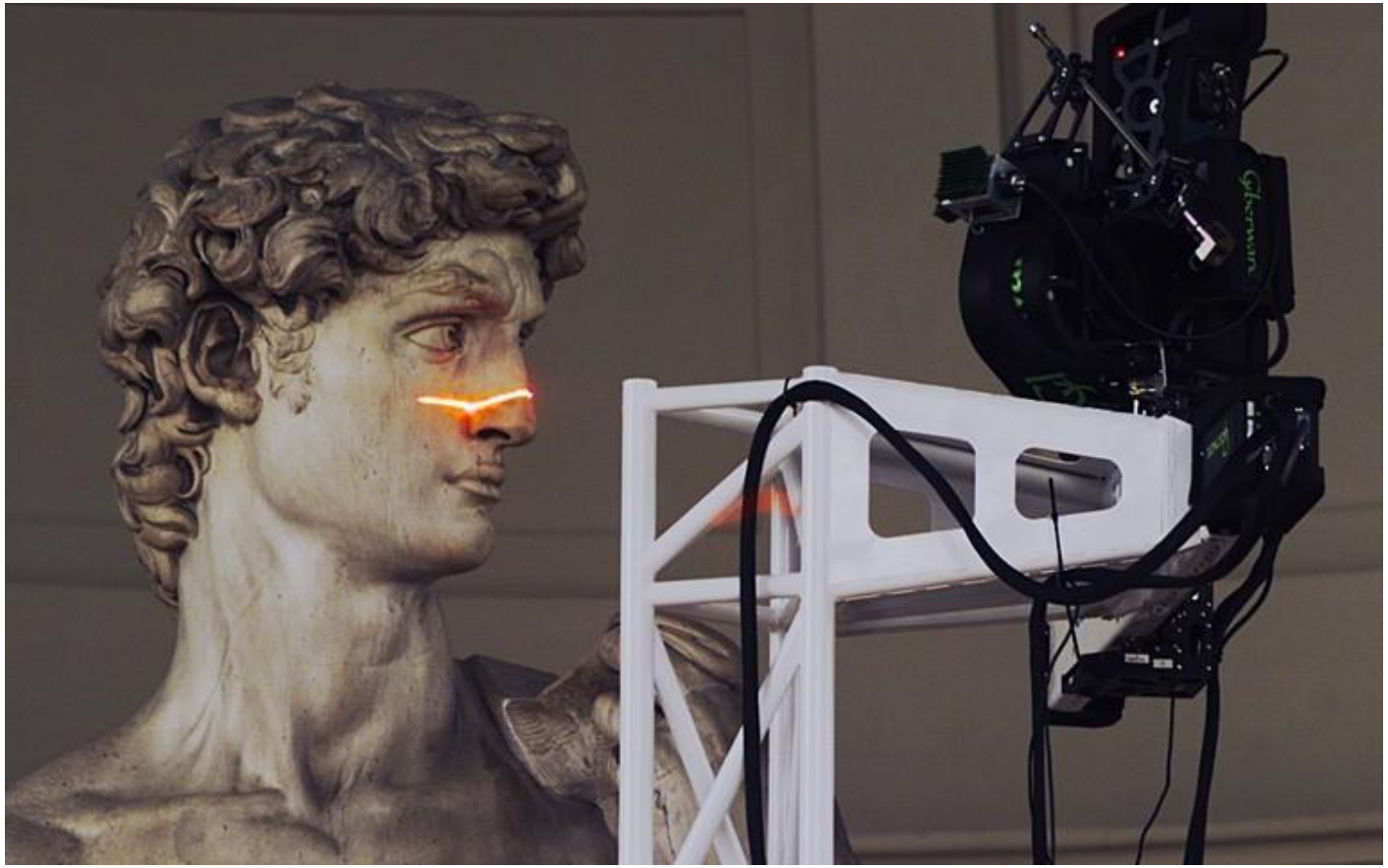




IKEA—rendered catalog image (2012)



[Walter et al. 2005] model: University of Bristol



Wednesday August 27 14

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NASA/Ames—ACFS



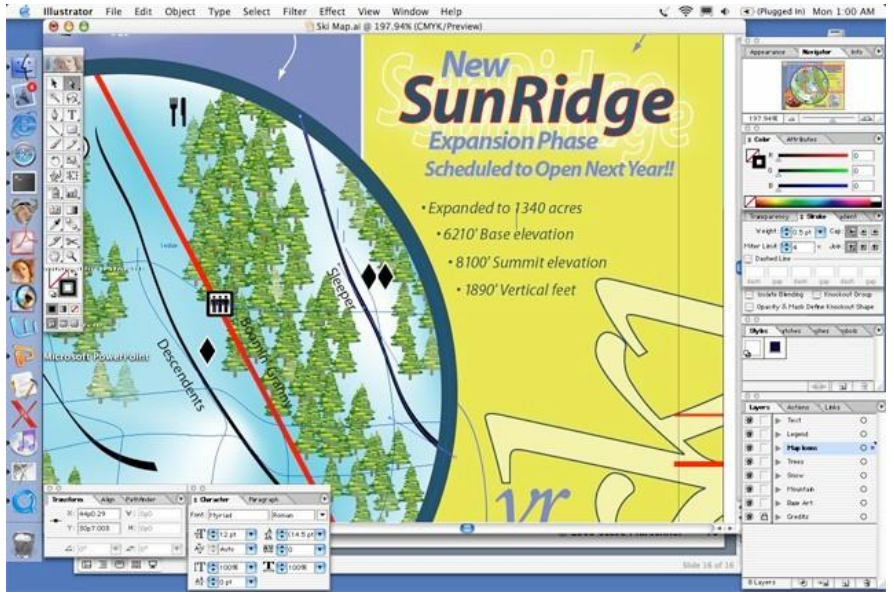
Army Research Lab—IES

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Adobe Photoshop [Photo: P.Greenspun]



Adobe Illustrator

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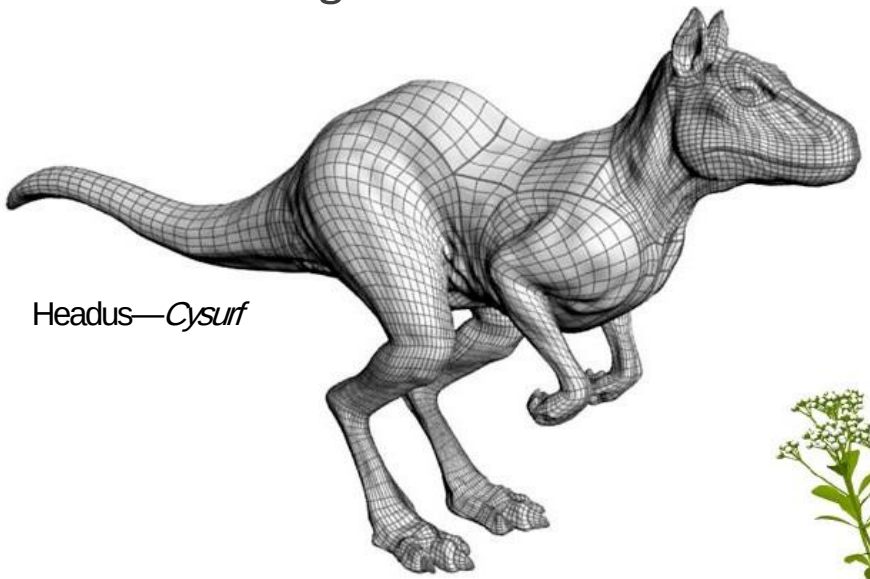


Computer aided sculptures Ergun Akleman

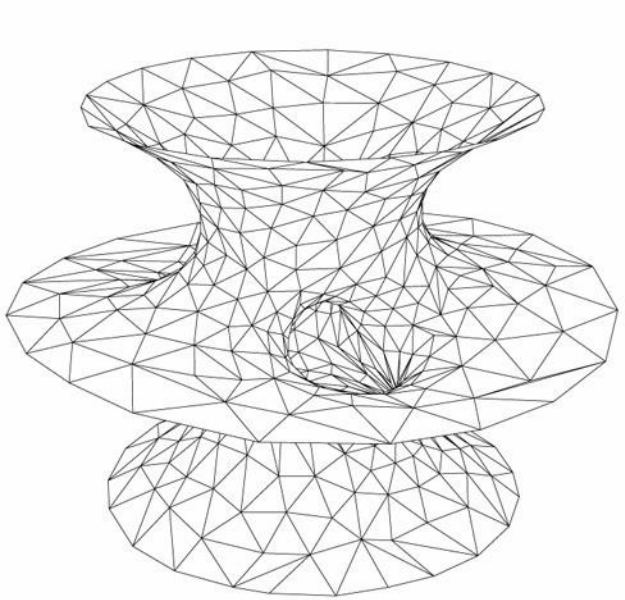
What is graphics about?

3D Modeling

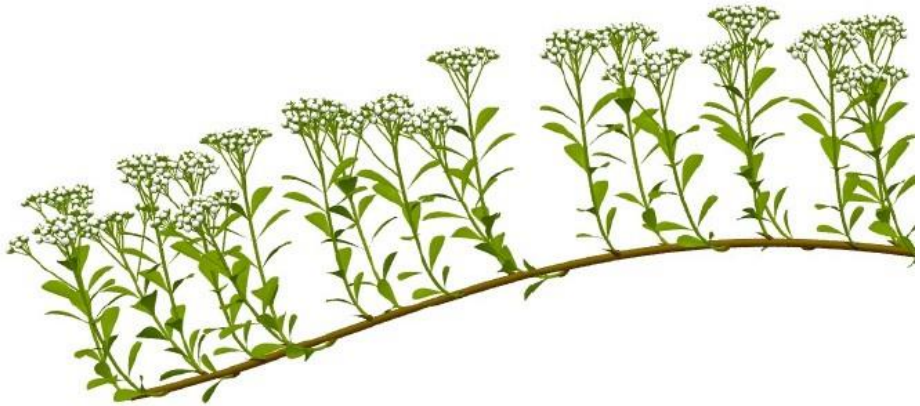
- representing 3D shapes
- polygons, curved surfaces, …
- procedural modeling



Headus—*Cysurf*



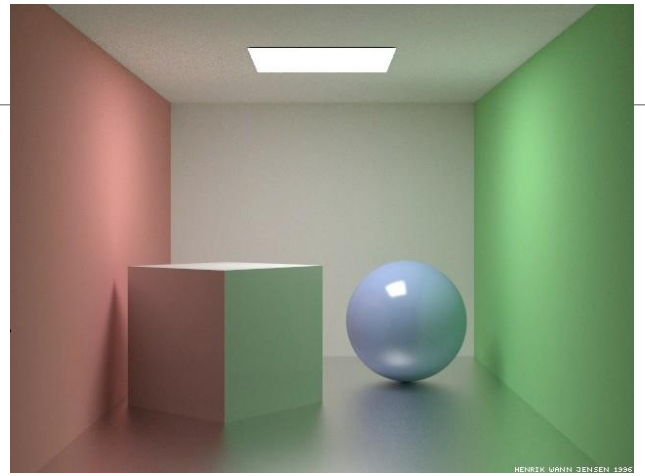
[Hoppe et al. 1993]



[Prusinkeiwicz et al. 2001]

3D Rendering

- 2D views of 3D geometry
- projection and perspective
- removing hidden surfaces
- lighting simulation



Henrik Wann Jensen



Cornell PCG

Autodesk 360 Cloud Render

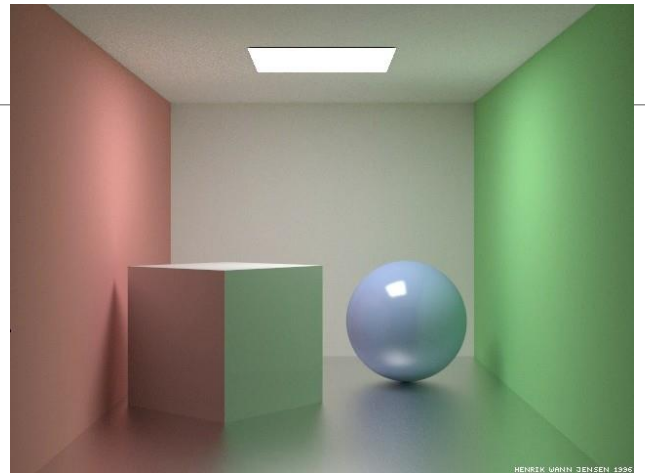


Autodesk 360 Cloud Render



3D Rendering

- 2D views of 3D geometry
- projection and perspective
- removing hidden surfaces
- lighting simulation



Henrik Wann Jensen



Cornell PCG

Animation

- keyframe animation
- physical simulation

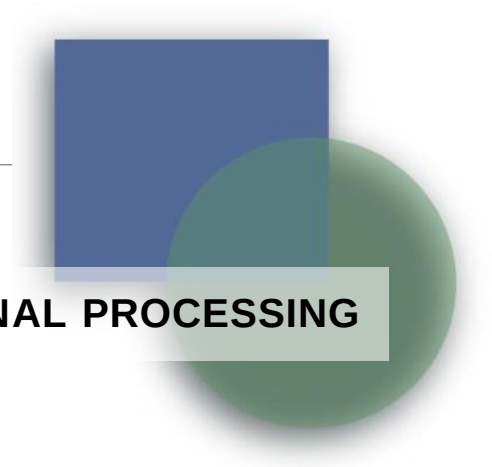


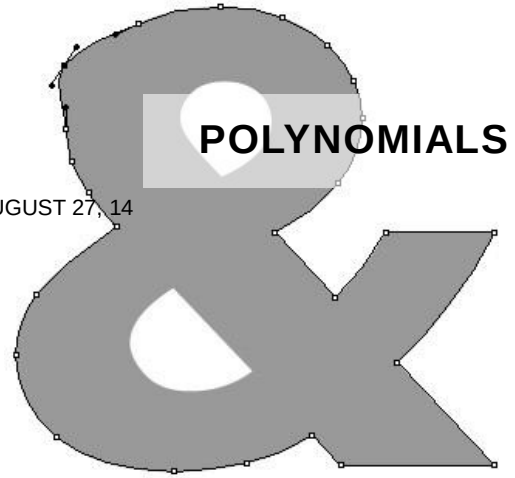
Avengers (2012)



Images

- 2D imaging
  - compositing and layering
  - digital filtering
  - color transformations
- 2D drawing
  - illustration, drafting
  - text, GUIs



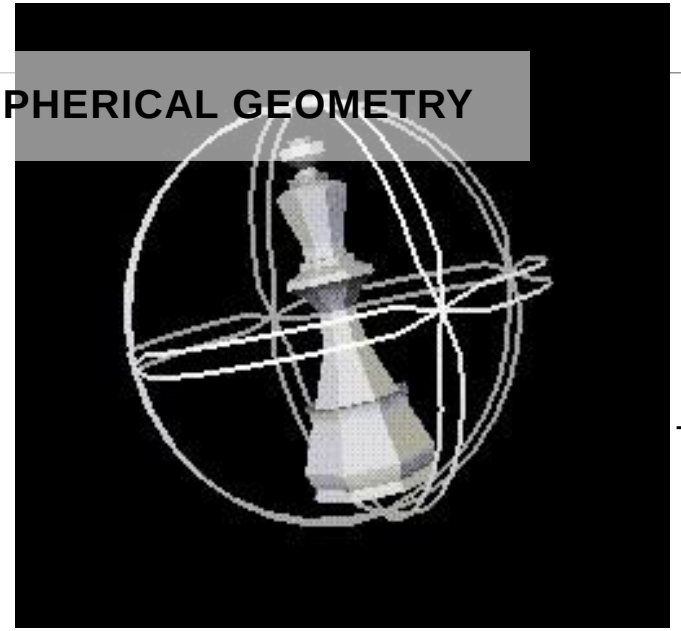


User Interaction

- 2D graphical user interfaces
- 3D modeling interfaces
- virtual reality



TU Berlin



SGI—OpenInventor

Computer graphics:

Mathematics made visible.

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(with previous instructors James/Bala)

Translucent materials



Diffuse “milk”

Translucent materials



Diffuse “milk”



Skim milk

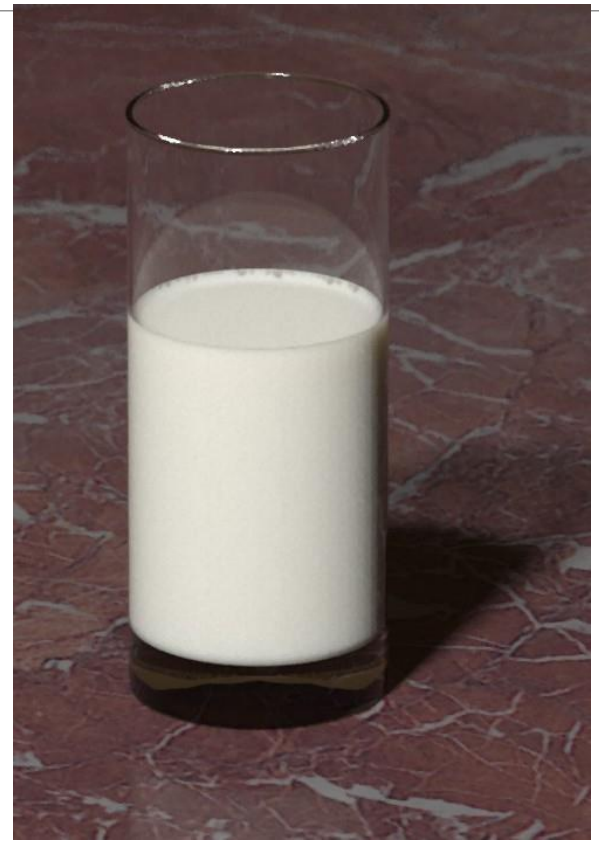
Translucent materials



Diffuse “milk”



Skim milk



Whole milk

Digital characters



[New Line Productions]

Gollum from *The Lord of the Rings*: hair and skin are two major rendering challenges in film effects

Rendering hair

a = 1.0



Rendering hair

a = 1.2



Rendering hair

a = 1.5



High-quality woven cloth appearance

