CSE4203: Computer Graphics

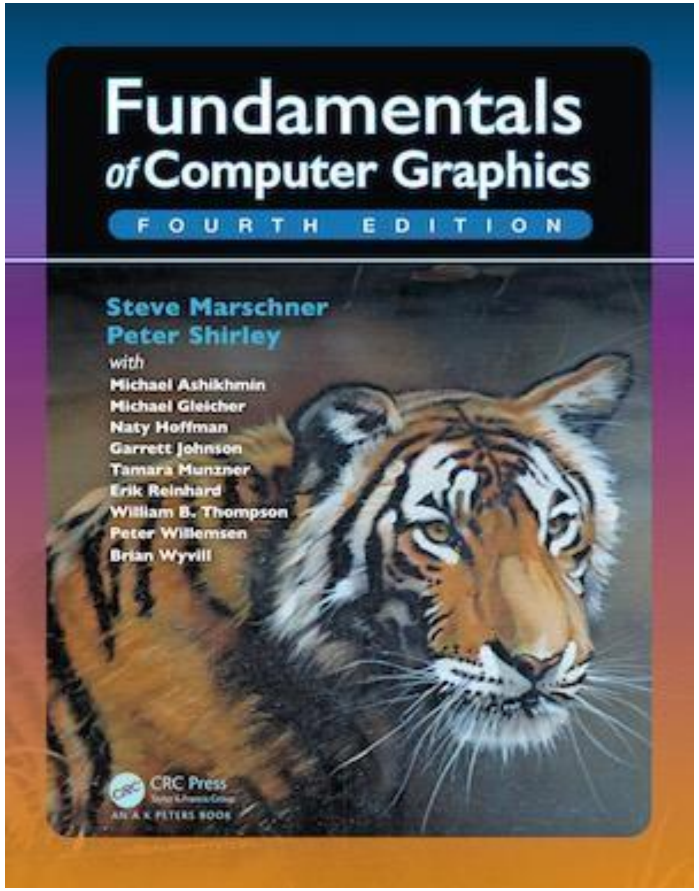
Chapter – 1

Introduction

Outline

- What is CG
- CG Areas
- Major Applications
- Graphics API

Credit



CS4620: Introduction to Computer Graphics

Cornell University

Instructor: Steve Marschner

http://www.cs.cornell.edu/courses/cs4620/2019fa/

What is CG? (1/1)

- The term computer graphics describes any use of computers to create and manipulate images.
  - Graphics can be 2D or 3D
  - Images can be completely synthetic or can be produced by manipulating photographs.

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

CG Areas (1/4)

- **Modeling:**
  - deals with the mathematical specification:
    - shape and appearance properties in a way that can be stored on the computer.

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

CG Areas: Metaphor

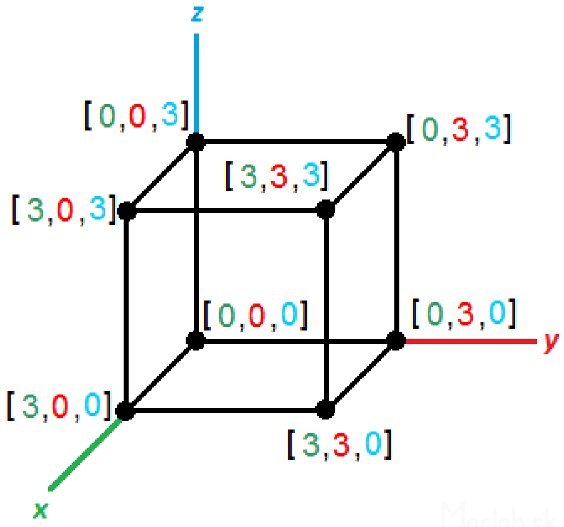
Source: https://youtu.be/6Sv4oXSTAms

CG Areas (2/4)

- **Modeling:** Example –
  - an object can be described as 3D coordinates:

    [0, 0, 3], [0, 3, 3], [0, 3, 0], [0, 0, 0],

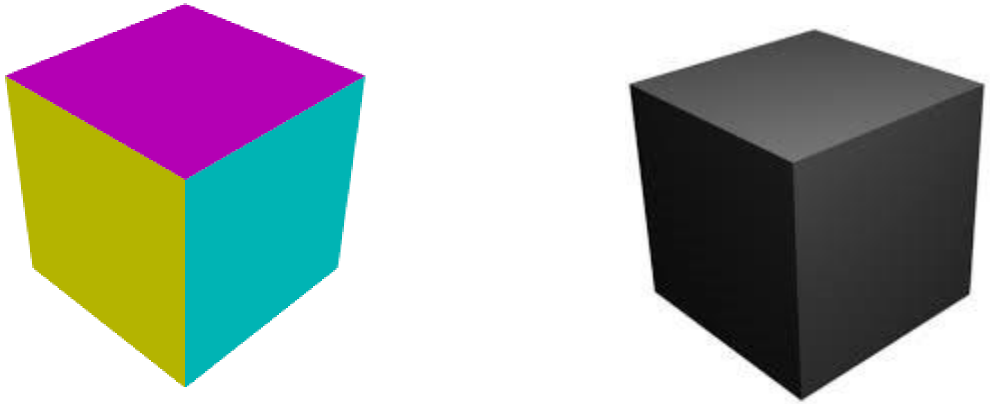
    [3, 0, 3], [3, 3, 3], [3, 3, 0], [3, 0, 0]
  - connect the points



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

CG Areas (3/4)

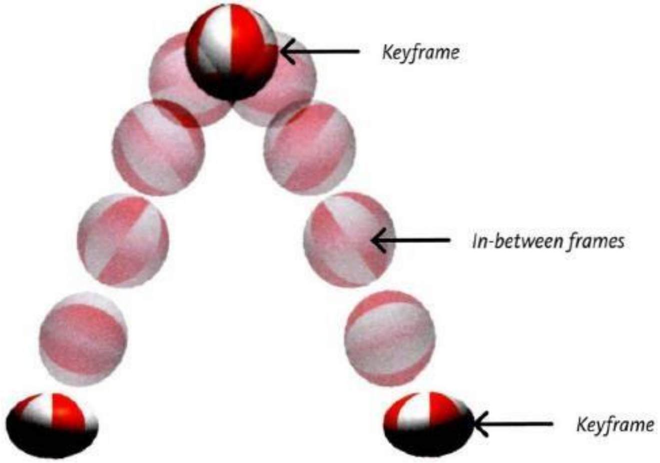
- **Rendering:**
  - a term inherited from art
  - deals with the creation of shaded images from 3D computer models.



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

CG Areas (4/4)

- **Animation:**
  - – creates an **illusion of motion** through sequences of images.
  - – uses modeling and rendering but adds ***movement*** over time



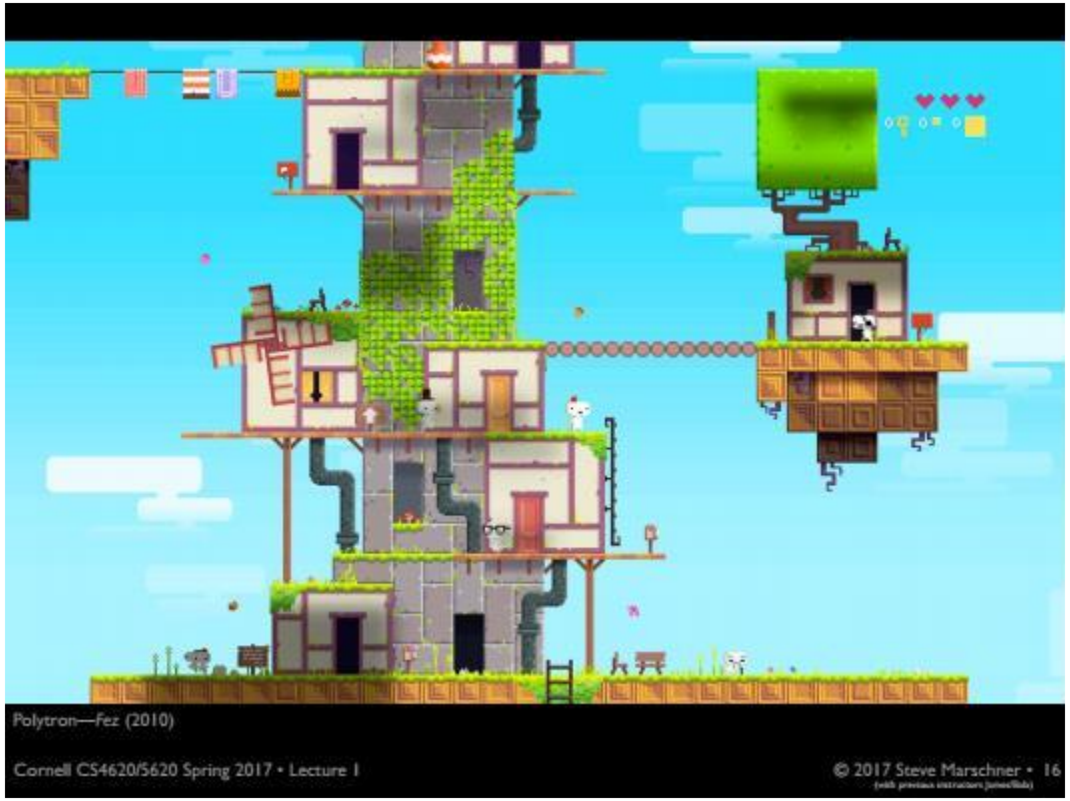
Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Major Applications (1/12)

- Video games
- Cartoons
- Visual effects
- Animated films
- CAD/CAM
- Simulation
- Medical imaging
- Information visualization

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Major Applications (2/12)



Polytron—Fez (2010)

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Games (2D)

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Major Applications (3/12)

Crytek—Crysis 3 (2013)

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Games (3D)

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Major Applications (4/12)

Movies (VFX)

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Major Applications (5/12)

Disney PIXAR
BRAVE
IN THEATERS JUNE 22
LORD MACGUFFIN
DISNEY.COM/BRAVE
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Movies (Animated)

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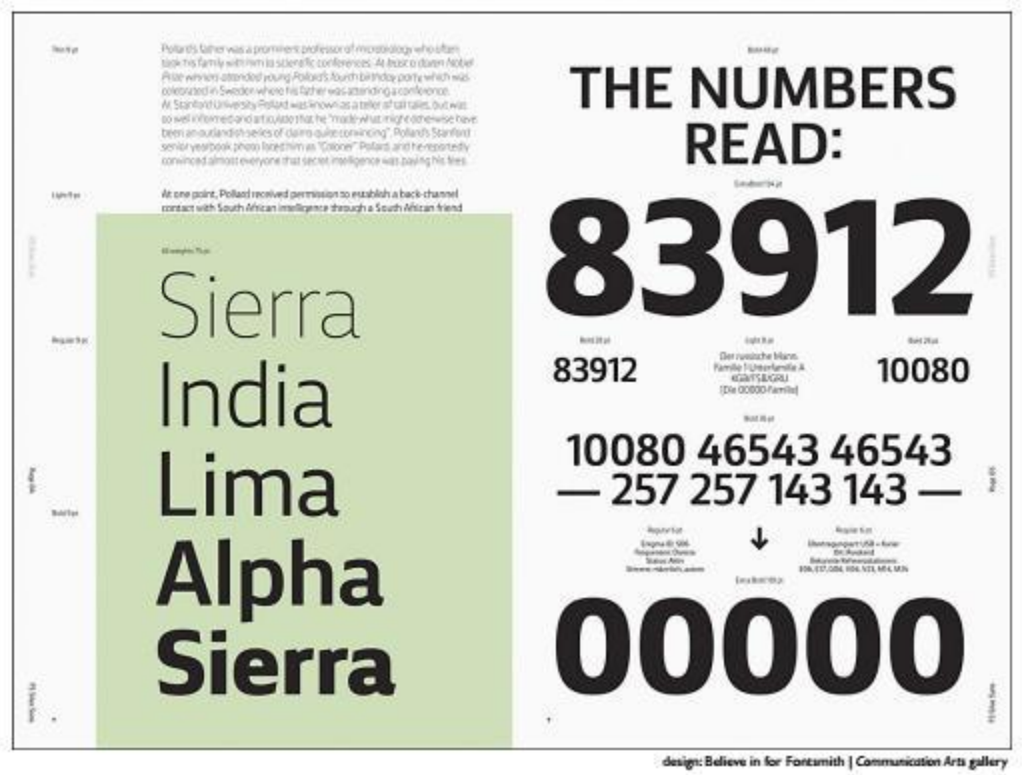
Major Applications (6/12)



Pollard's father was a prominent professor of microbiology who often took his family with him to scientific conferences. At least a dozen Nobel Prize winners attended young Pollard's fourth birthday party which was celebrated in Sweden where his father was attending a conference. At Stanford University Pollard was known as a teller of tall tales, but was so well informed and articulate that he "made what might otherwise have been an outlandish series of claims quite convincing". Pollard's Stanford senior yearbook photo listed him as "Colonel" Pollard, and he reportedly convinced almost everyone that secret intelligence was paying his fees.

At one point, Pollard received permission to establish a back-channel contact with South African intelligence through a South African friend

Sierra
India
Lima
Alpha
Sierra

THE NUMBERS READ:

83912

83912

10080

10080 46543 46543
— 257 257 143 143 —

↓

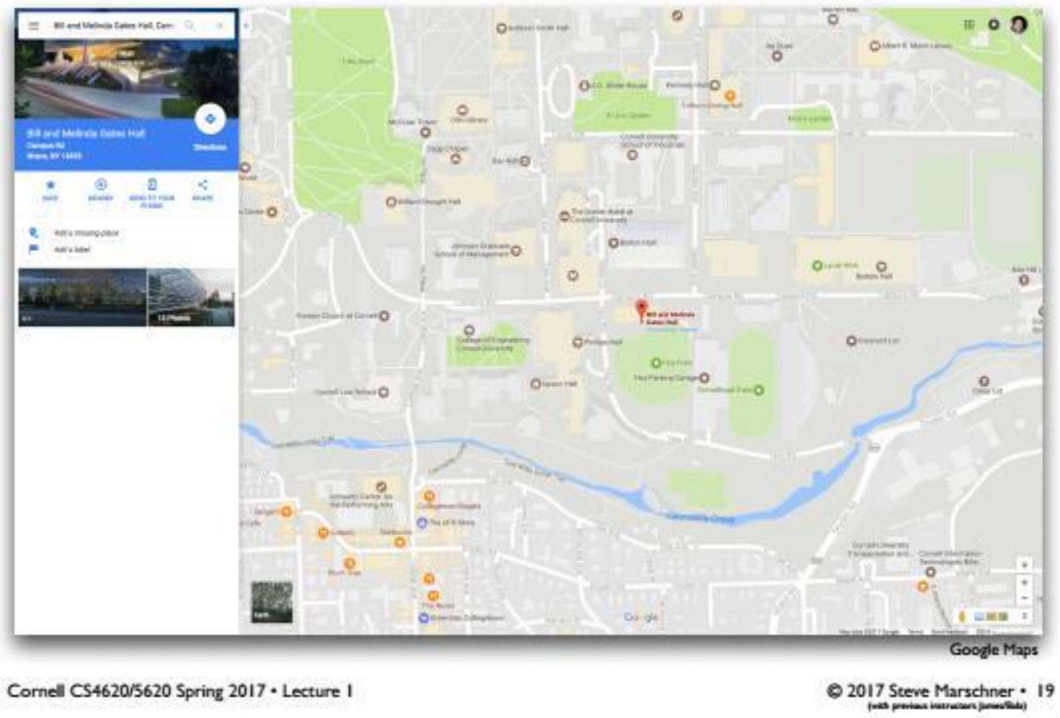
00000

design: Believe in for Fontsmith | Communication Arts gallery

Fonts

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Major Applications (7/12)



Google Maps

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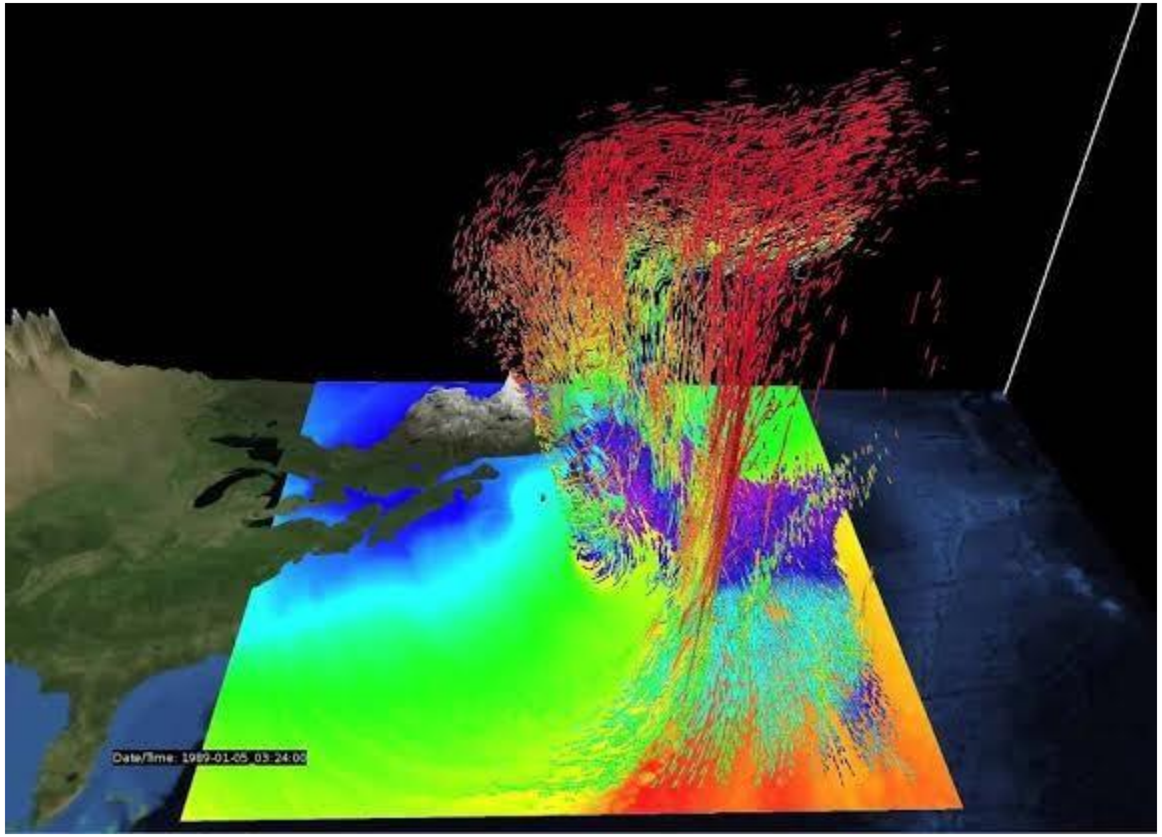
Google Maps

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Major Applications (8/12)

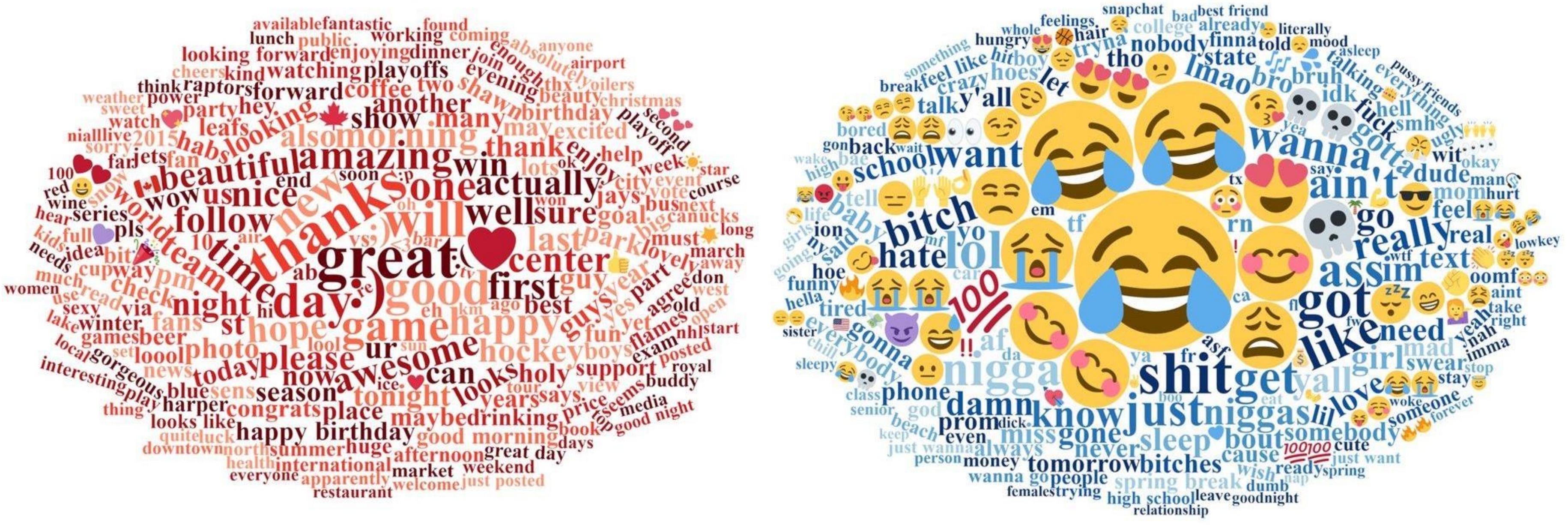


Scientific Visualization (SciVis)

Source: https://youtu.be/eJy5dHMY-S4

Major Applications (9/12)

Distinctive themes in 40M+ tweets



Snefjella, Schmidtke, & Kuperman 2018: goo.gl/bqKtqb

Information Visualization (InfoVis)

Major Applications (10/12)

U. of Utah—Alpha 1

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CAD (3D modeling)

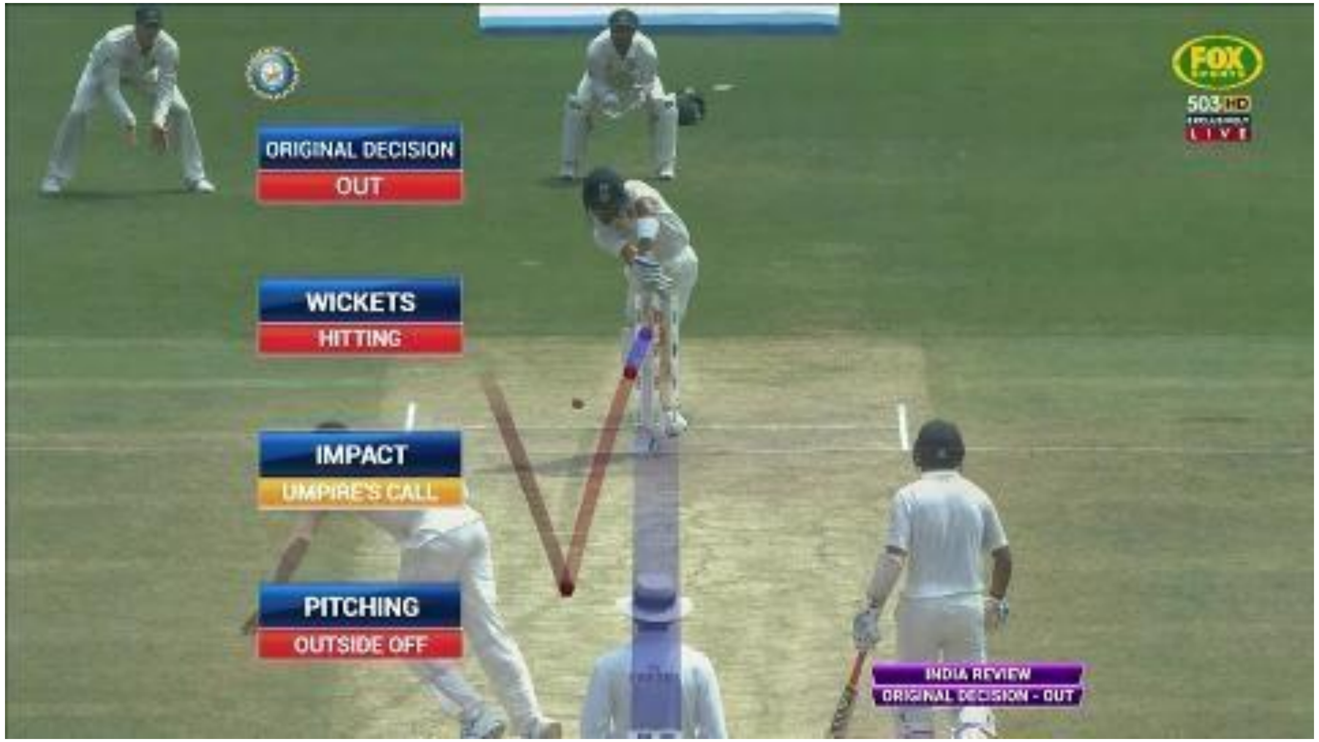
Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Major Applications (11/12)

Simulation

Source: https://www.aircharterservice.com/about-us/news-features/blog/are-vr-flight-simulators-the-future-of-pilot-training

Major Applications (12/12)



Simulation

Source: https://www.financialexpress.com/sports/what-is-drs-all-the-the-rules-number-of-chances-and-components-explained/578996/

Graphics API (1/2)

- A ***graphics API*** is a set of functions that perform basic operations such as –
  - drawing images and 3D surfaces into windows on 2D screen.

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Graphics API (2/2)

Every ***graphics program*** needs to be able to use two related APIs

- **Graphics API** for visual output.
  - Ex:
    - i.e. command for drawing lines, circles etc.
- **User-interface API** to get input from the user.
  - Ex:
    - Window
    - Receiving mouse and keyboard input

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

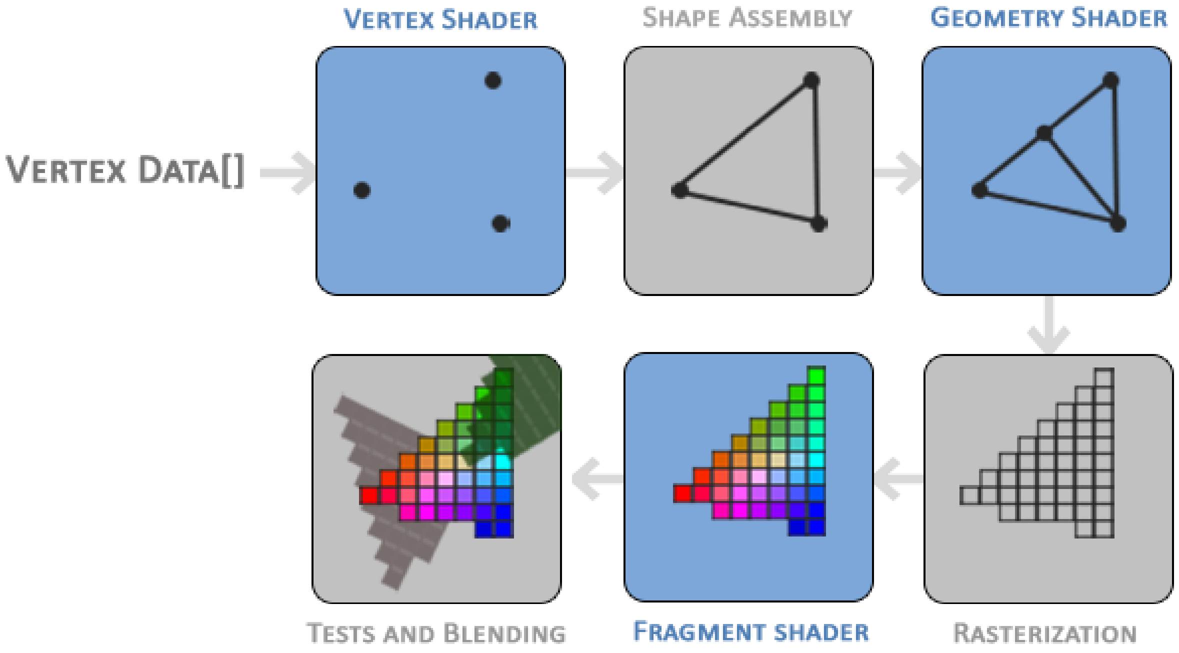
Graphics Pipeline (1/5)

- Special software/hardware subsystem that maps the **3D vertex** locations to **2D screen**.
- From modeling to rendering.
  - Shade the triangles –
    - Realistic
    - Proper back-to-front order.

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Graphics Pipeline (2/5)

- Pipeline (example):



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Graphics Pipeline (3/5)

- Why triangles?
  - It is the **simplest** universal surface element
  - it is the **convex hull of three points**.
    - A line or a point are even simpler, but do not create surfaces.
    - it isn't possible to use only a finite number of them without having cracks.

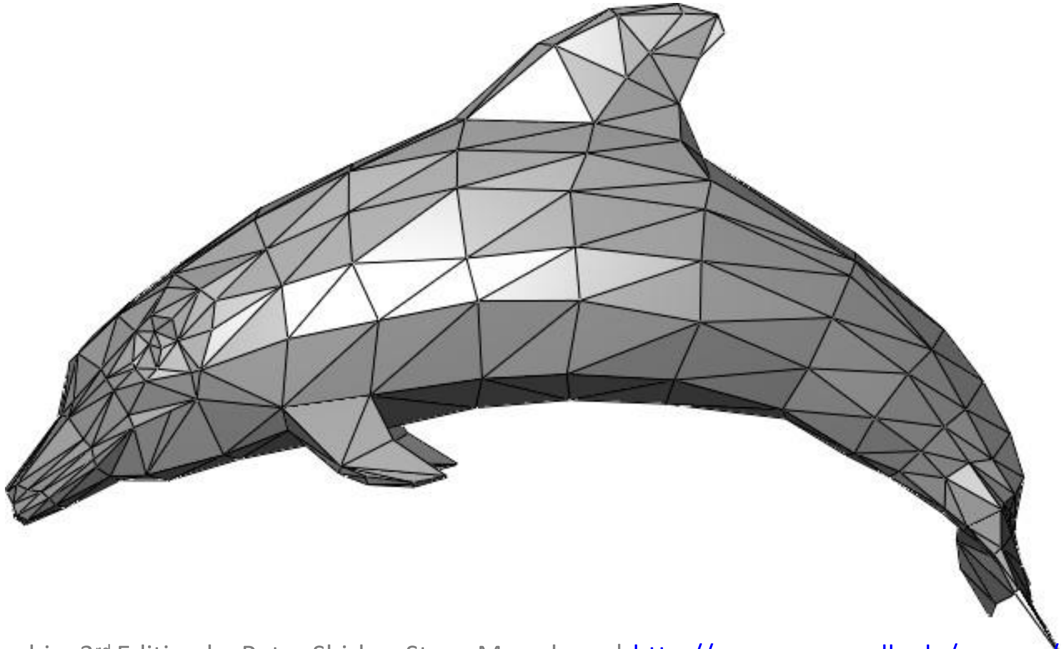
Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/

Graphics Pipeline (4/5)

- Mesh:

  A polygon mesh is a collection of vertices, edges and faces that defines the shape of a polyhedral object.

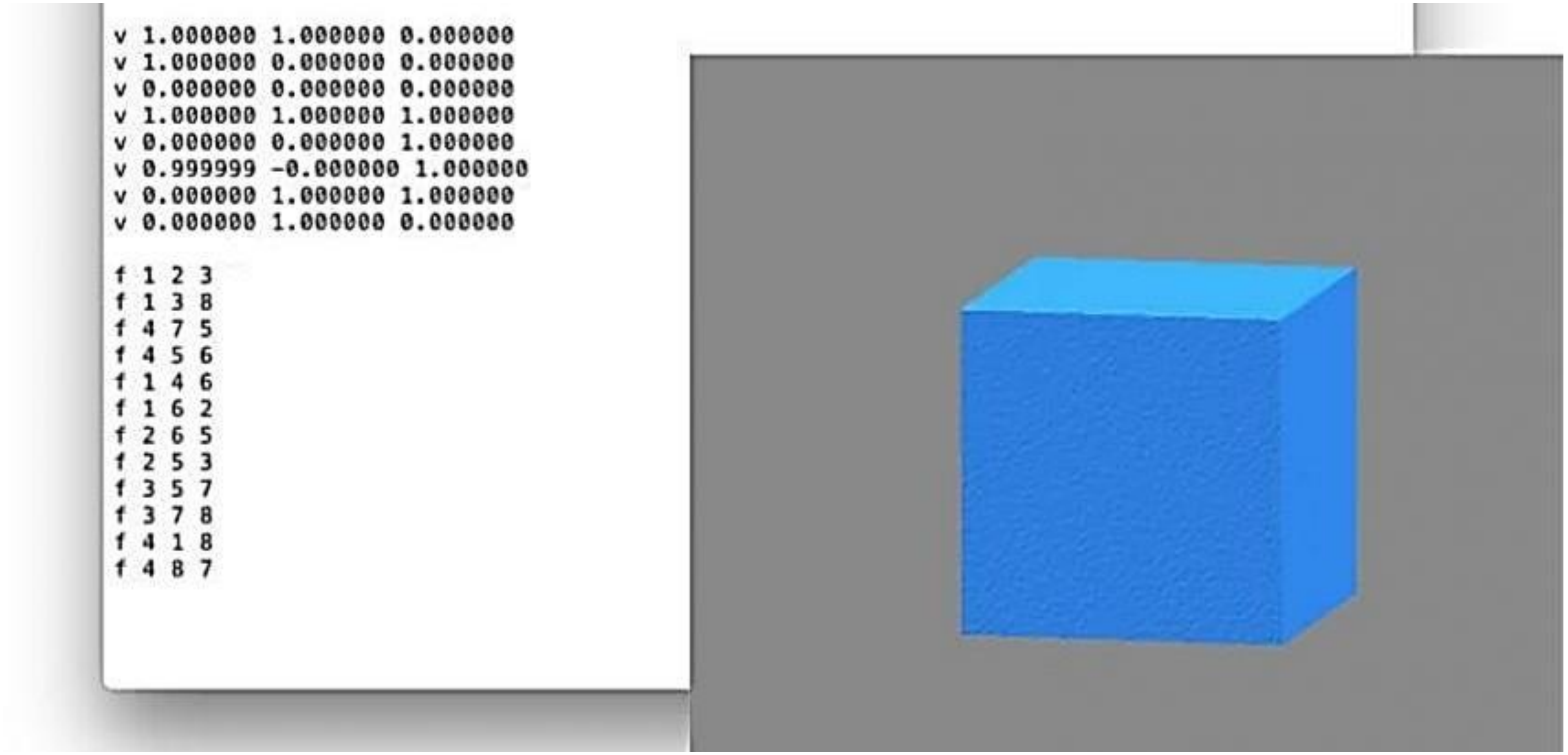
  – Ex. *Quad* mesh, Triangle mesh.



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/ | https://en.wikipedia.org/wiki/Triangle_mesh

Graphics Pipeline (5/5)

.obj file



```
v 1.000000 1.000000 0.000000
v 1.000000 0.000000 0.000000
v 0.000000 0.000000 0.000000
v 1.000000 1.000000 1.000000
v 0.000000 0.000000 1.000000
v 0.999999 -0.000000 1.000000
v 0.000000 1.000000 1.000000
v 0.000000 1.000000 0.000000

f 1 2 3
f 1 3 8
f 4 7 5
f 4 5 6
f 1 4 6
f 1 6 2
f 2 6 5
f 2 5 3
f 3 5 7
f 3 7 8
f 4 1 8
f 4 8 7
```

Source: https://www.sculpteo.com/en/glossary/obj-file-3d-printing-file-format/

LoD (1/2)

- Rendering speed ↔ number of triangles being drawn
  - More triangles: more storage.

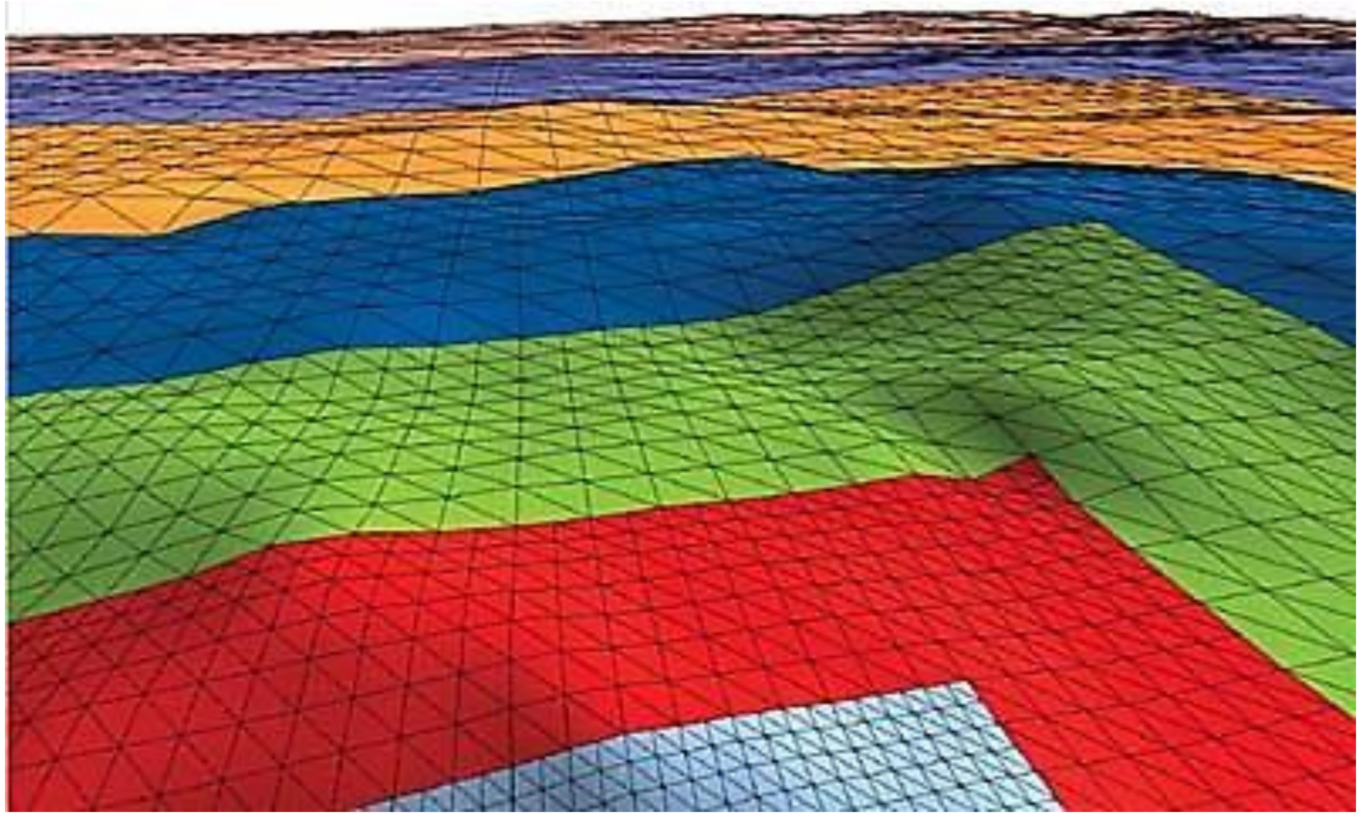
[0, 0, 3], [0, 3, 3], [0, 3, 0], [0, 0, 0],
[3, 0, 3], [3, 3, 3], [3, 3, 0], [3, 0, 0]

- It is worthwhile to minimize the number of triangles used to represent a model.
  - Ex: if the model is viewed in the distance, fewer triangles needed *(level of detail or LoD).*

Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/ |
https://en.wikipedia.org/wiki/Triangle_mesh

LoD (2/2)

- Example of *LoD*:



Credit: Fundamentals of Computer Graphics 3rd Edition by Peter Shirley, Steve Marschner | http://www.cs.cornell.edu/courses/cs4620/2019fa/
Source: https://developer.nvidia.com/gpugems/gpugems2/part-i-geometric-complexity/chapter-2-terrain-rendering-using-gpu-based-geometry

Additional Reading

- 1.7: Designing and Coding Graphics Programs

Thank You