Computer Graphics

Lecture 01 – Introduction

Edirlei Soares de Lima

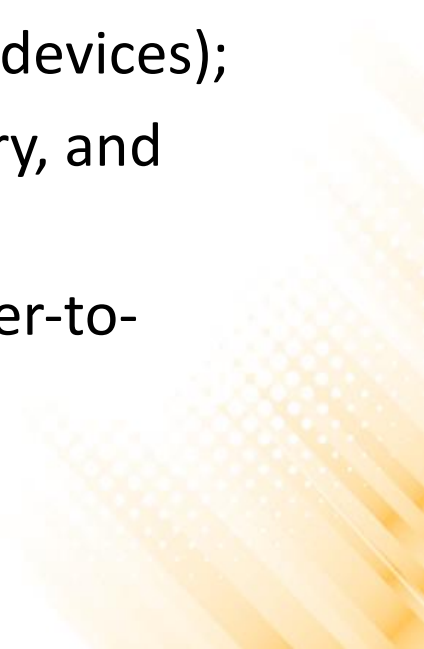<edirlei.lima@universidadeeuropeia.pt>

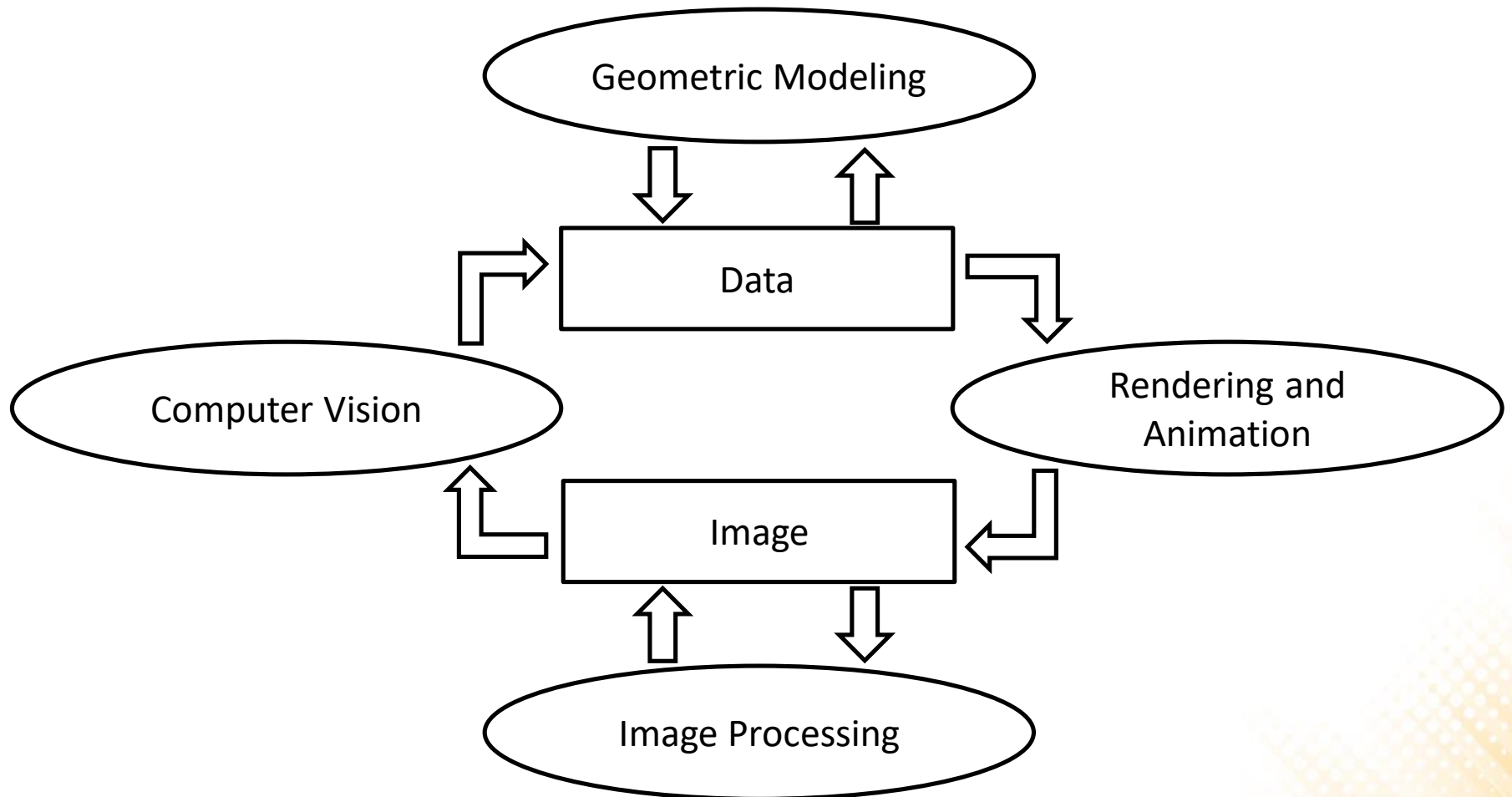# What is Computer Graphics?

- The term computer graphics describes any use of <u>computers to create and manipulate images</u> [Marschner, S., et al., 2015].

- Computer graphics is the science and art of <u>communicating visually via a computer's display</u> and its interaction devices [Hughes, J. F., et al., 2013].
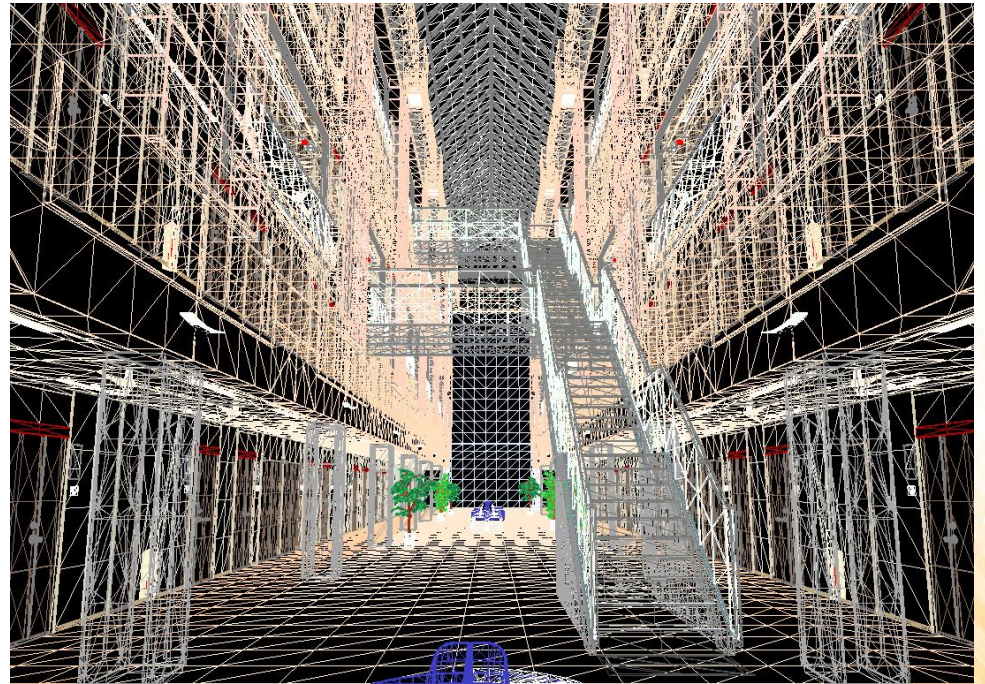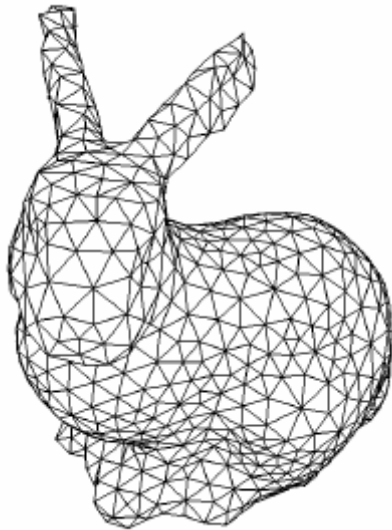
What is Computer Graphics?

- **Computer graphics is a cross-disciplinary field:**
  - Physics (e.g.: model light behavior);
  - Mathematics (e.g.: describe shapes);
  - Human Perception (e.g.: only render things that will be noticed);
  - Human-Computer Interaction (e.g.: interaction devices);
  - Engineering (e.g.: optimize allocation of memory, and processor time);
  - Graphic Design and Art (e.g.: make the computer-to-human communication more effective);
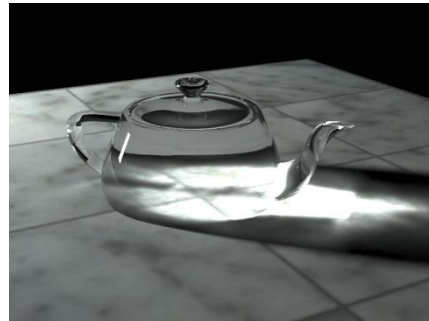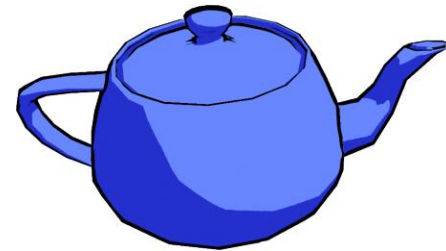
What is Computer Graphics?

Computer Graphics Areas

- **<u>Modeling:</u>** Deals with the mathematical specification of shape and appearance.
  - Definition of surface, interpolation rules, reflection models.
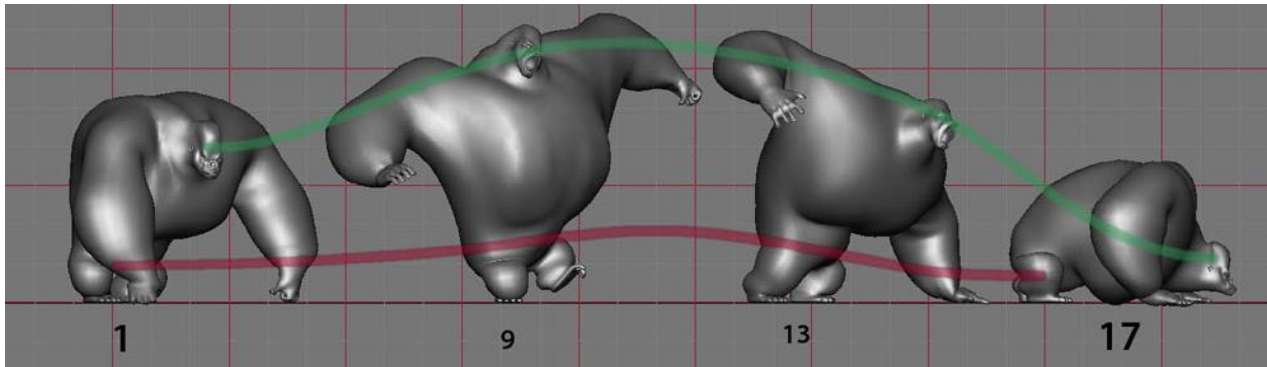
Computer Graphics Areas

- **<u>Rendering:</u>** Term inherited from art – create shaded images from 3D computer models.
  - Many techniques and styles of rendering.

Computer Graphics Areas

- **<u>Animation:</u>** technique to create an illusion of motion through sequences of images.
  - Time is a key issue, not usually dealt with in basic modeling and rendering.
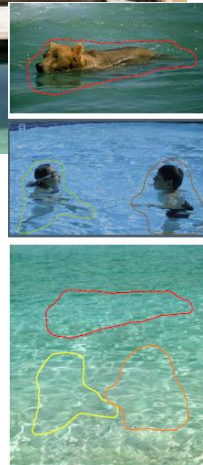

Actor   Cappellini   Oliver

Computer Graphics Areas

- **Image processing:** deals with the manipulation of 2D images and is used in both the fields of graphics and vision.

sources/destinations   cloning   seamless cloning

Computer Graphics Areas

- **<u>Virtual reality:</u>** attempts to immerse the user into a 3D virtual world.
 - Typically requires at least stereo graphics and response to head motion.

Computer Graphics Areas

- **3D scanning:** uses range-finding technology to create measured 3D models.

Computer Graphics Areas

- **<u>Computational photography:</u>** explores the use of computer graphics, computer vision, and image processing methods to enable new ways of photographically capturing objects, scenes, and environments.
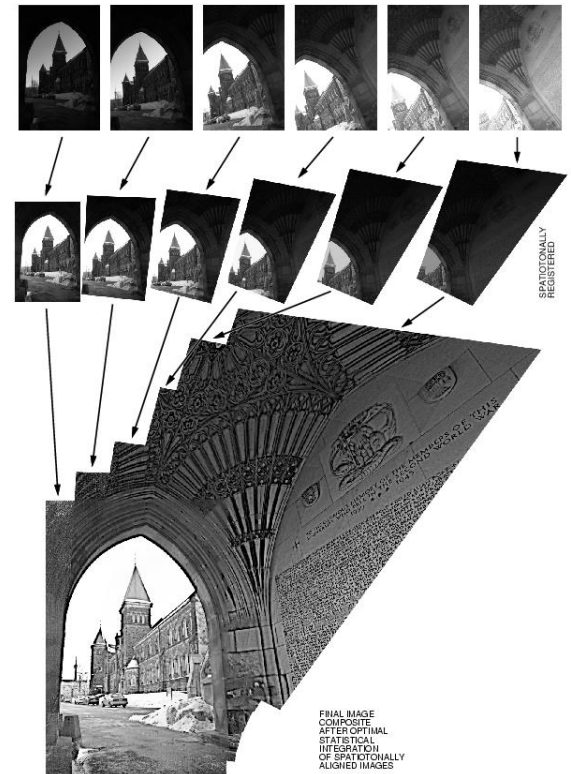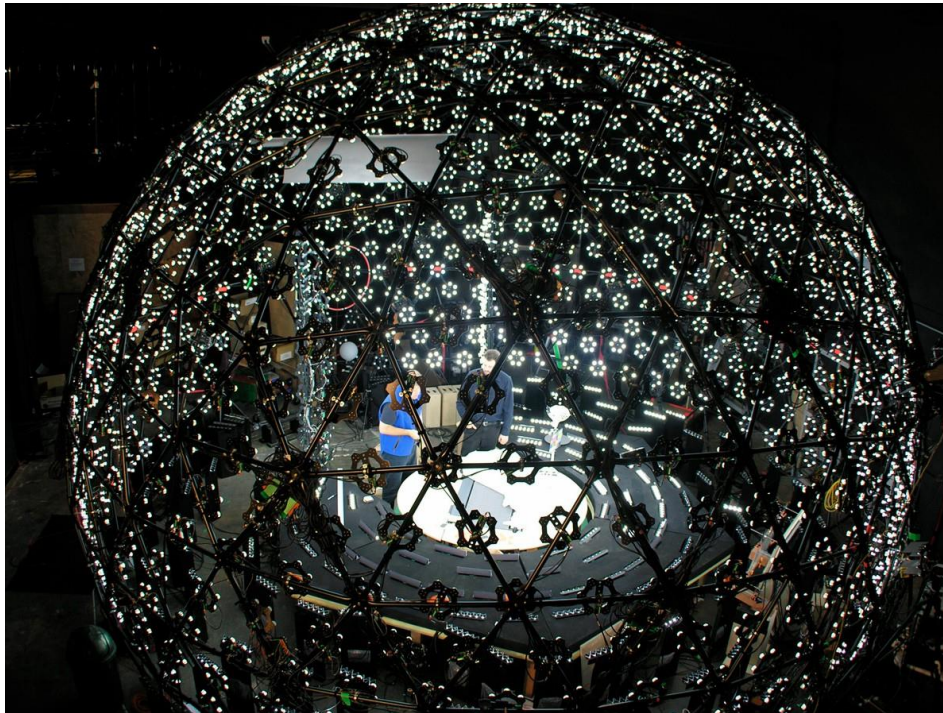
Applications – Video Games

- Video games increasingly use sophisticated 3D models and rendering algorithms.

Applications – Cartoons

- Cartoons are often rendered directly from 3D models.
  - Many traditional 2D cartoons use backgrounds rendered from 3D models.

Applications – Visual Effects

- Visual effects use almost all types of computer graphics technology.
    - Superimpose backgrounds with separately filmed foregrounds.
   - Synthetic environments, objects, and even characters.

Applications – Animated Films

- Animated films use many of the same techniques that are used for visual effects, but without necessarily aiming for images that look real.
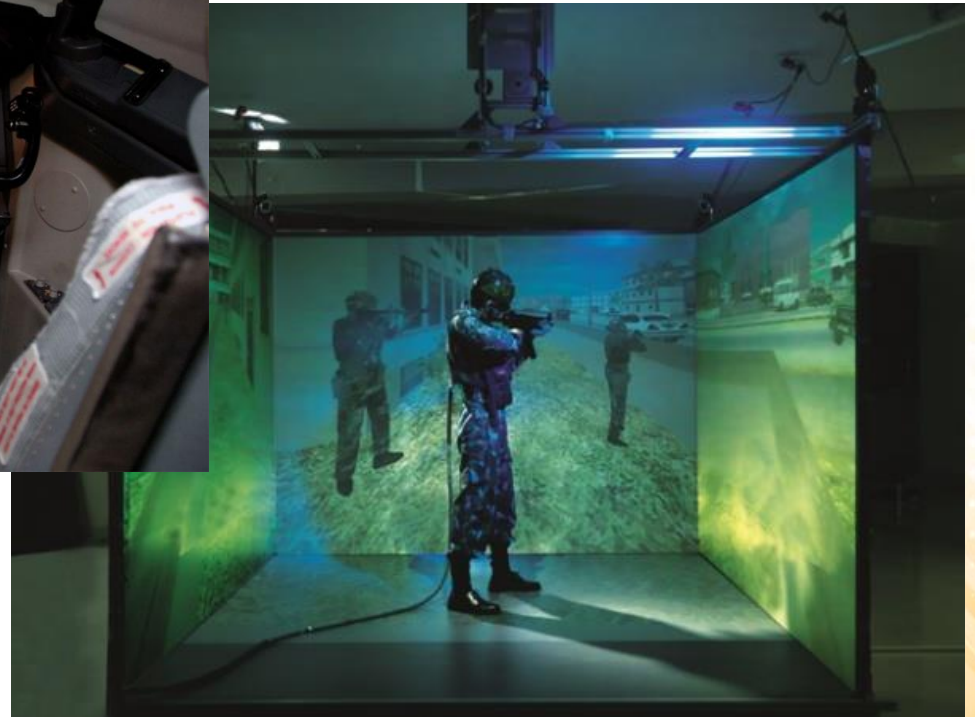
Applications – CAD/CAM

- Computer-Aided Design and Computer-Aided Manufacturing use computer technology to design parts and products on the computer to guide the manufacturing process.
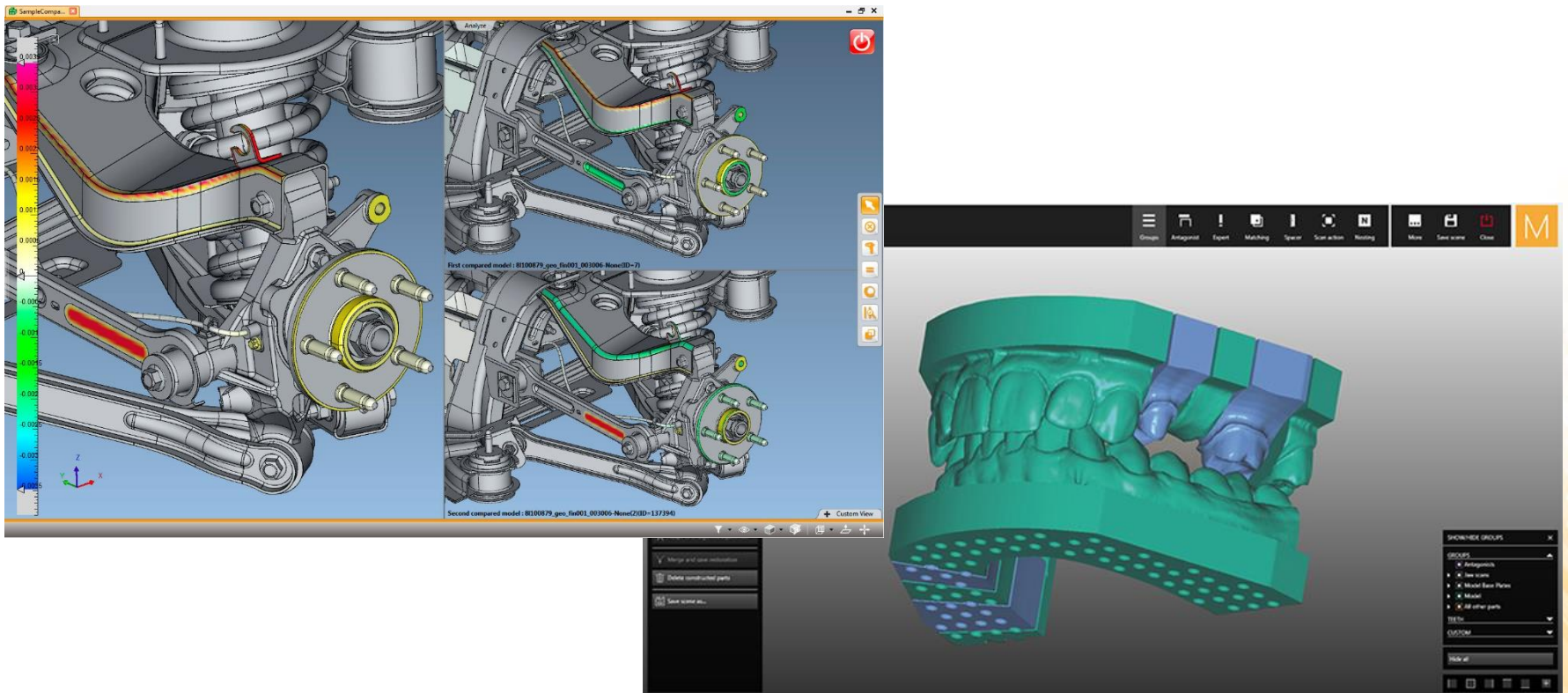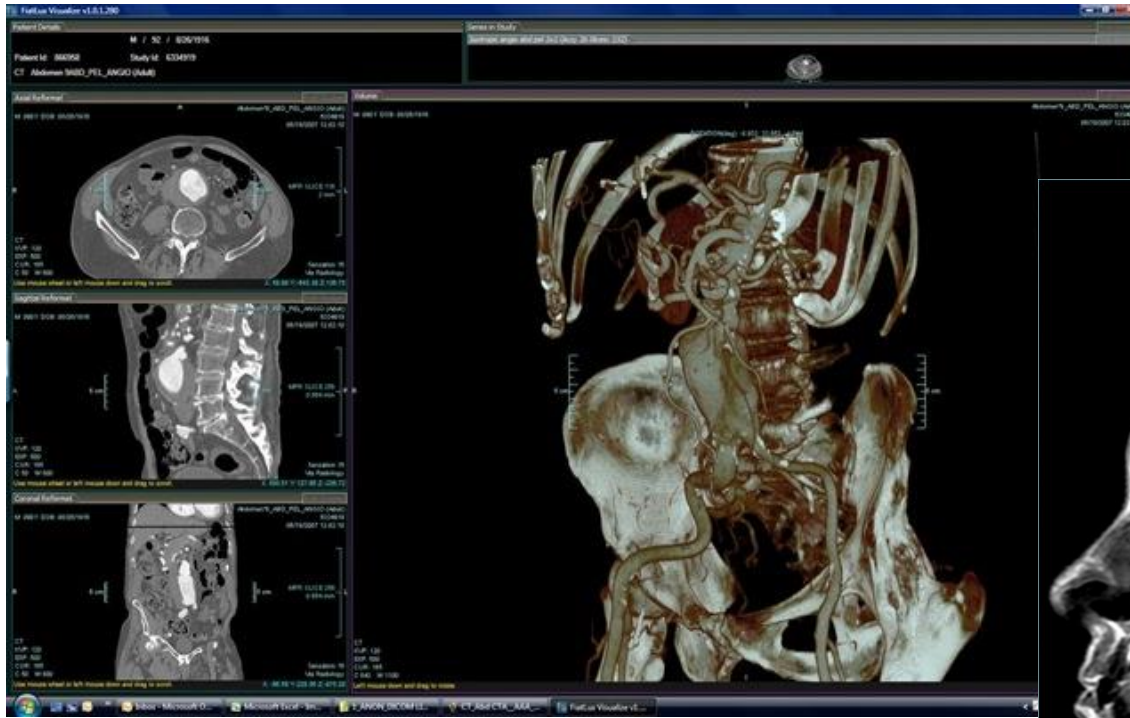
Applications – Simulation

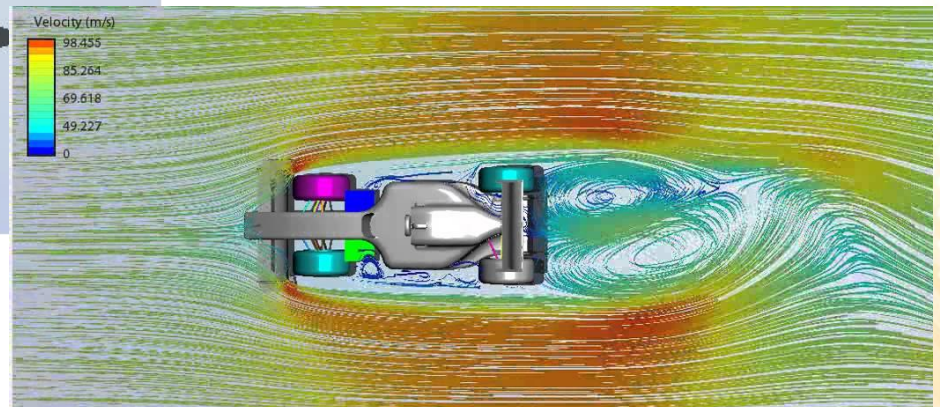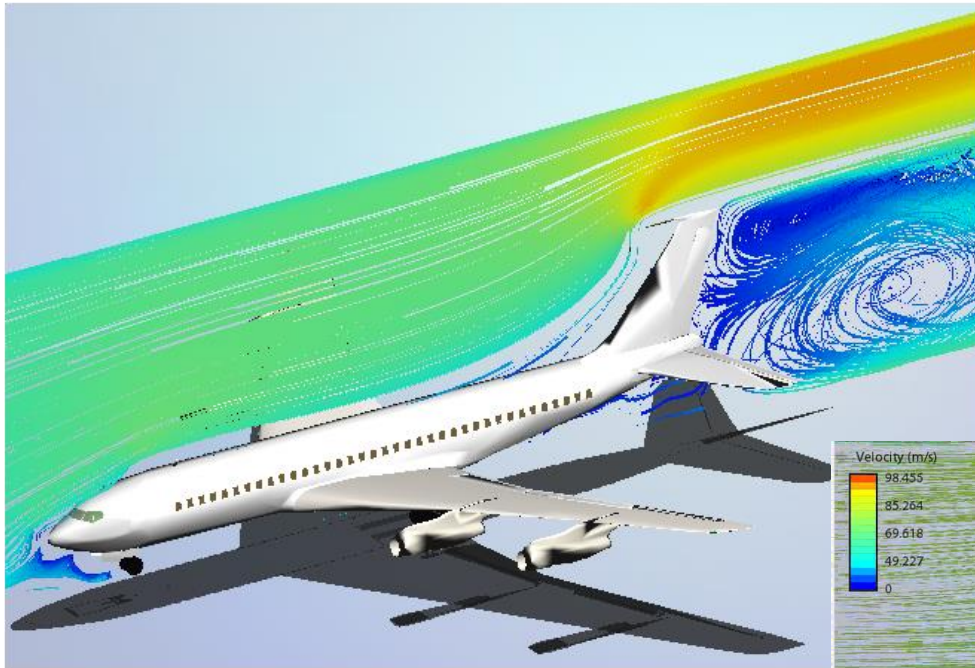- Simulation can be thought of as accurate video gaming.

Applications – Medical Imaging

- Medical imaging creates meaningful images of scanned patient data.

Applications – Information Visualization

- Information visualization creates images of data that do not necessarily have a "natural" visual representation.
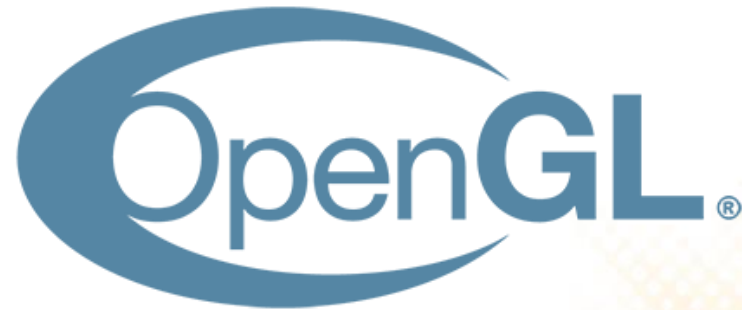
Graphics Hardware

- Computer hardware and software (<u>graphics card</u> and <u>device driver</u>) that generates computer graphics and allows them to be shown on a display.

- The processors on GPUs are <u>highly parallel</u> and support thousands of concurrent threads.
  - The hardware is designed to process larger numbers of pixels and vertices in short amounts of time.

Graphics APIs

- A graphics API (Application Program Interface) is a set of functions that perform <u>basic operations</u> such as drawing images and 3D surfaces into windows on the screen.
  - Graphics APIs *vs* User-Interface APIs.

- Dominant Graphics APIs: <u>Direct3D</u> and <u>OpenGL</u>.

Graphics Pipeline

- The Graphics Pipeline is a special software/hardware subsystem that <u>efficiently draws 3D primitives on screen</u>.
  - Is optimized for processing 3D triangles with shared vertices.

- The basic operations in the pipeline <u>map the 3D vertex locations to 2D screen positions</u> and shade the triangles so that they both look realistic and appear in proper <u>back-to-front order</u>.
  - Geometric manipulation using matrices and vectors.

- The <u>speed</u> at which images can be generated depends strongly on the number of triangles being drawn.

Raster Images

- Most computer graphics images are presented to the user on some kind of <u>raster display</u>.

  - Raster displays show images as rectangular <u>arrays of pixels</u>.

  - Different colors are achieved by mixing varying intensities of red, green, and blue light.

- A raster image is simply a <u>2D array that stores the pixel value</u> for each pixel—usually a color stored as three numbers, for red, green, and blue (<u>RGB model</u>).
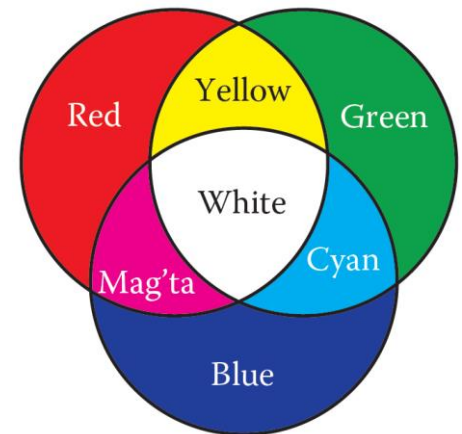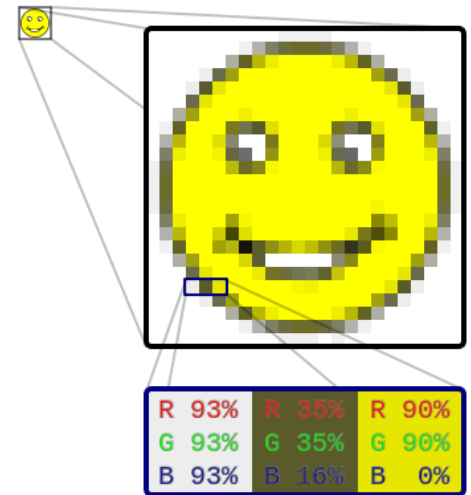
Graphics Coding Tips

- **Class Design:** vector2, vector3, vector4, matrix4x4, transform, …

- **Float vs. Double:** tradeoff between performance and precision.

- **Optimizations** are important, but unnecessary "optimizations" make the code harder to read without speeding things up.

- **Debugging Graphics Programs:**
  – Images as coded debugging output;
  – Traditional debugger;
  – Data visualization for debugging;

Further Reading

- Hughes, J. F., et al. (2013). **Computer Graphics: Principles and Practice** (3rd ed.). Upper Saddle River, NJ: Addison-Wesley Professional. ISBN: 978-0-321-39952-6.

  – **Chapter 1: Introduction**
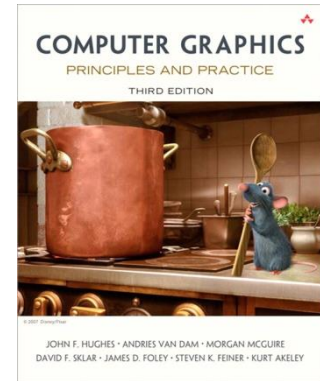
- Marschner, S., et al. (2015). **Fundamentals of Computer Graphics** (4th ed.). A K Peters/CRC Press. ISBN: 978-1482229394.

  – **Chapter 1: Introduction**
  – **Chapter 3: Raster Images**