Computer Graphics

CSCI 272

California State University, Fresno

Who am I

- Dhanyu Amarasinghe
- Visiting Professor in Computer Graphics
- Ph.D. in Computer Science

  at University of North Texas, 2013
- Field of expertise in *Gaming,*

  Graphics & GPGPU
- Member of Larc

  (Laboratory for Recreational Computing)
- Lead Tech at Apple inc. 2013 - 2015

Contact Infomation

- Office: Science 2, Room 249
- Email: dhanyu@csufresno.edu
- Office hours:
  - See the Syllabus

About this Course

- Linear Algebra and Trigonometry
- C/C++-programming
- Syllabus

Introduction

Computer Graphics is a subfield of computer science concerned with the creation and manipulation of images. It differs from image processing in that the emphasis is on image generation.

Modern graphics APIs include OpenGL, Direct3D, Java3D, Matlab, and others. Our programming environment will include C or C++, OpenGL, and GLUT (system-independent interface to OpenGL) on a workstation or laptop computer running Windows, Linux, or OS X. Graphics lends itself well to object-oriented programming, but since OpenGL is not object oriented, and we do not want to hide low level details, procedural code is preferred.

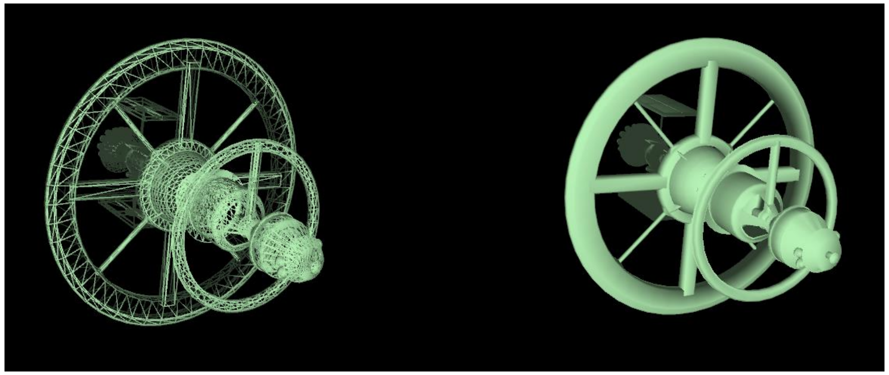
About Computer Graphics

The study of computer graphics can be partitioned into three subfields.

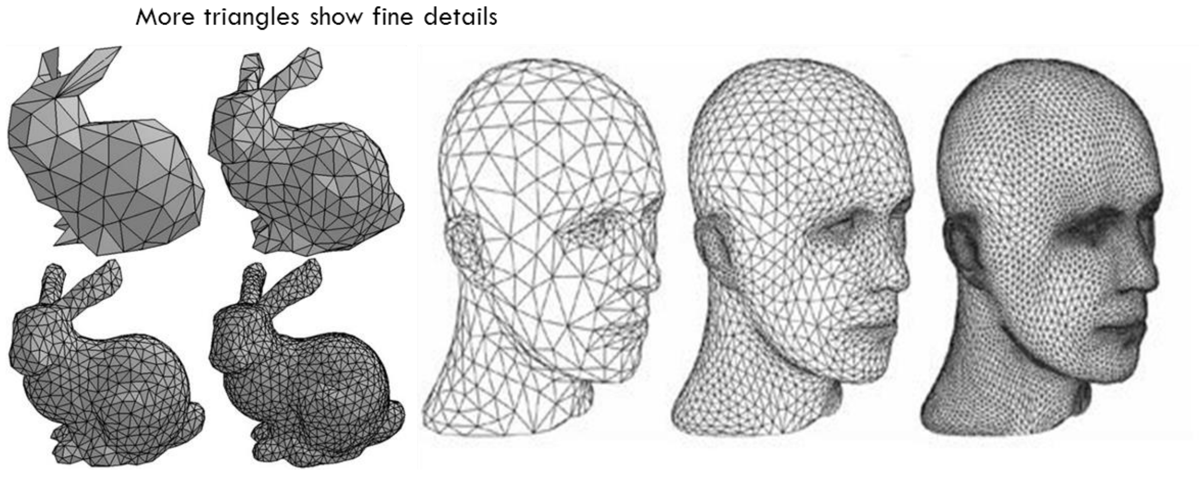
- Modeling: Mathematical specification of shape and appearance, such as a triangle mesh surface and reflection model.
- Rendering: Creation of shaded images from 3-D computer models.
- Animation: A technique to create the illusion of motion by time-sequencing rendered images.

Modeling

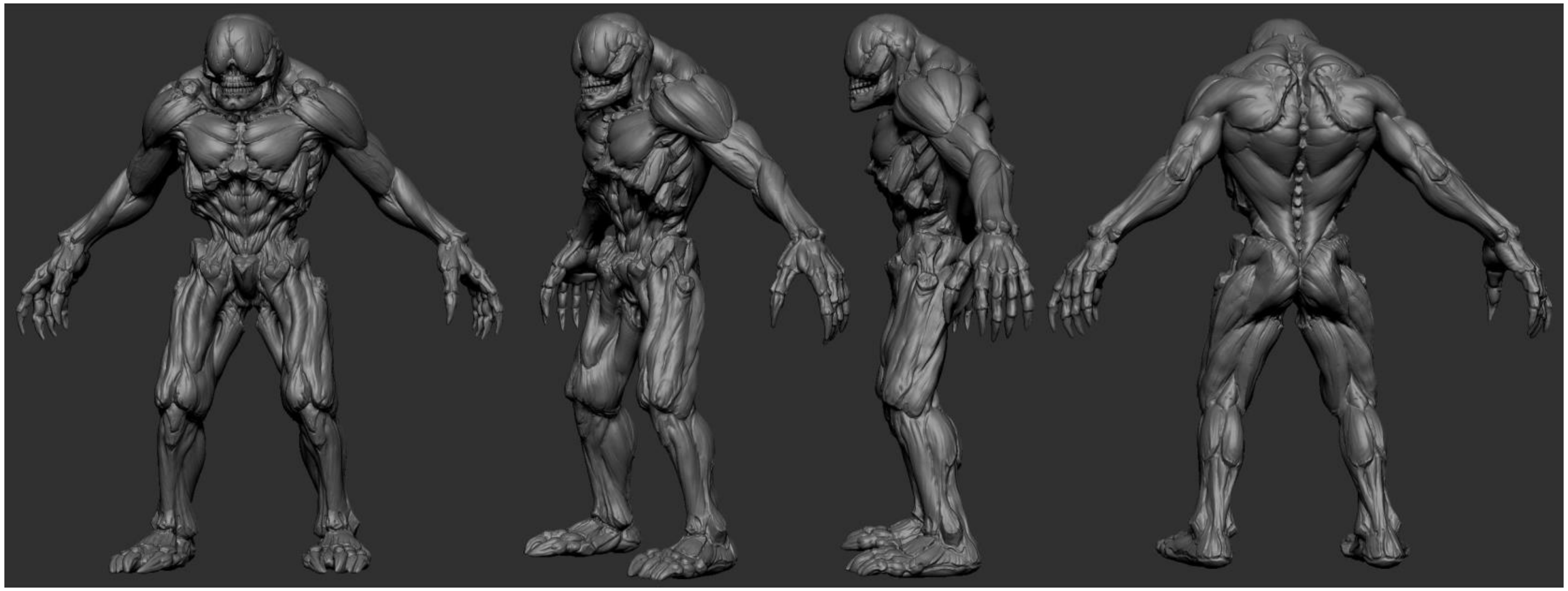
3D Model with Triangles



12,000 – 15,000 Wireframe of Triangles



Rendering


High poly model of Hell Knight - Doom 4

Proper lighting and
Texture provide our
Mesh model a fine realistic outlook.

Images from www.baypins.com

Animation

www.mdl3d.com

Related Fields

Related fields include the following.

User Interaction Interface between user input devices and an application program.

Virtual Reality Attempt to immerse the user in a 3-D virtual world using stereo graphics, response to head motion, sound, haptics (force feedback), etc.

Visualization Provide insight into data via visual display.

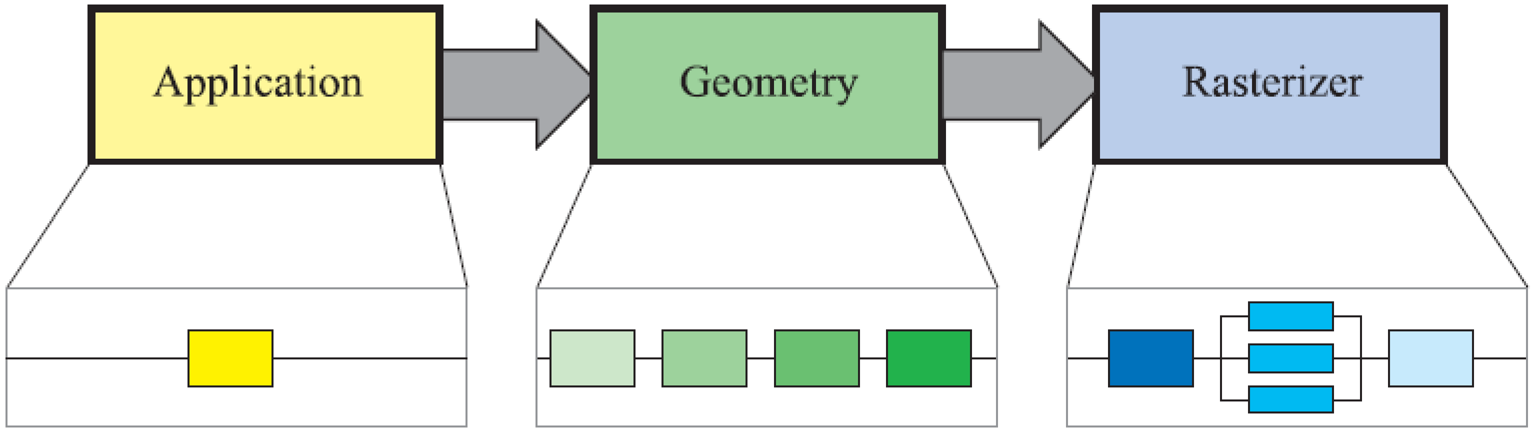
Image Processing Manipulation of 2-D images.

3-D Scanning Use of range-finding to create 3-D models.

Applications

- Video games: simulations without the need for high accuracy.
- Movie special effects such as digital compositing (superimposed backgrounds with separately filmed foregrounds) or computer-generated foregrounds. The first full-length computer-generated film was Toy Story in 1994.
- CAD/CAM (Computer-aided Design/Manufacturing) mechanical parts and products are designed by a 3-D modeling package and produced by a computer controlled milling machine.
- Simulation
- Medical imaging creation of shaded images from scanned patient data
- Visualization
- Paint programs, Art
- Word processing and desktop publishing
- Business graphics: graphs and charts
- GUI's

Graphic Pipeline Overview



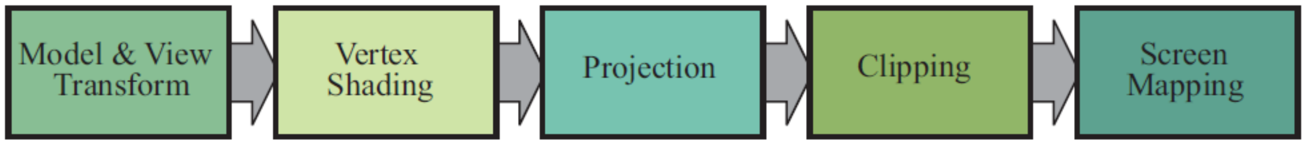
The basic construction of the rendering pipeline, consisting of three stages: application, geometry, and the rasterizer. Each of these stages may be a pipeline in itself, as illustrated below the geometry stage, or a stage may be (partly) parallelized, as shown below the rasterizer stage. In this illustration, the application stage is a single process, but this stage could also be pipelined or parallelized.

Application Stage

- The developer has full control over what happens in the application stage.
- A consequence of the software-based implementation of this stage is that it is not divided into substages
- In order to increase performance, this stage is often executed in parallel on several processor cores.

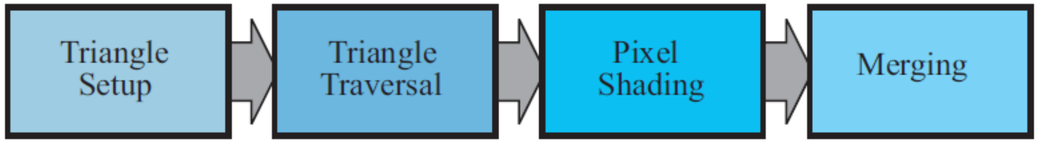
Geometry Stage

- The geometry stage is responsible for the majority of the per-polygon and per-vertex operations.



The geometry stage subdivided into a pipeline of functional stages.

Rasterizer Stage



The rasterizer stage subdivided into a pipeline of functional stages.

Triangle Setup

In this stage the differentials and other data for the triangle's surface are computed. This data is used for scan conversion, as well as for interpolation of the various shading data produced by the geometry stage. This process is performed by fixed-operation hardware dedicated to this task.

Rasterizer Stage

Triangle Traversal

Here is where each pixel that has its center (or a sample) covered by the triangle is checked and a *fragment* generated for the part of the pixel thatoverlaps the triangle. Finding which samples or pixels are inside a triangle is often called *triangle traversal* or *scan conversion*. Each triangle fragment's properties are generated using data interpolated among the three triangle vertices.

Pixel Shading

Any per-pixel shading computations are performed here, using the interpolated shading data as input. The pixel shading stage is executed by programmable GPU cores. A large variety of techniques can be employed here, one of the most important of which is texturing.

Merging

The information for each pixel is stored in the color buffer, which is a rectangular array of colors (a red, a green, and a blue component for each color). It is the responsibility of the merging stage to combine the fragment color produced by the shading stage with the color currently stored in the buffer.