ENGN2501 DIGITAL GEOMETRY PROCESSING

Tue & Thu 2:30-3:50 @ Barus&Holley 157

Instructor: Gabriel Taubin <taubin@brown.edu>

Polygon Meshes / Point Clouds
Representation / Data Structures
Iso-curves / Iso-surfaces
Surface Reconstruction
Simplification / Compression
Smoothing / Parameterization
Remeshing / Segmentation
Optimization / Resampling
Out-of-Core Algorithms

http://mesh.brown.edu/DGP

FIRST CLASS: Thu Jan 24

Course Web Site

• http://mesh.brown.edu/DGP

• Lecture notes and/or slides will be provided for some lectures. Students are supposed to read the lecture notes before each class. Papers will be available for download from this web site to complement some lectures.

• Programming assignments must be submitted through the Canvas course web site.
Digital Geometry Processing

- Discrete Signal Processing for geometric data
- Point Clouds
- Polygon meshes (typically triangular)
- Why Discrete?
  - Simplicity
  - Representation for software/hardware rendering
  - Representation for simulation and analysis tools
  - Output of most acquisition tools

3D Geometry Data

- Industry
  - Reverse engineering
  - Fast metrology
  - Physical simulations
- Entertainment
  - Animating digital clays for movies or games
- Archeology and Art
  - Digitization of cultural heritage and artistic works
- Medical Imaging
  - Visualization
  - Segmentation
Multiple Application Domains

- Medical
- Engineering
- Topography
- Simulation

- Games/Movies
- E-commerce
- Art history

DGP Software for 3D Printing

Autodesk Meshmixer
free software for making awesome stuff

Meshmixer is state-of-the-art software for working with triangle meshes.

Do you need to clean up a 3D scan, do some 3D printing, or design an object that "fixes" something else? Meshmixer can help. Think of it as a sort of "Swiss Army Knife" for 3D meshes.

Here are a few examples of how Meshmixer is being used today:
Autodesk Meshmixer

Selection Tool
- Hotkey: Press Select All
- Invert:
- Expand to Connected
- Invert Connected

Brush Select
- Paint
- Unpaint
- Brush Size:

Surface Lasso Select
- Select a contiguous area on the surface to select the enclosed area.

Grow/Shrink
- Drag the brush to expand or contract the boundary of the selected area.

Crease Filter
- Select a crease on the model.

DGP Software for 3D Printing

Autodesk Netfabb

Netfabb Features
- Allows parts to fill up the capabilities of your 3D printer and software combination.
- Produces support structures with a variety of options.
- Allows parts to fill up the capabilities of your 3D printer and software combination.
- Produces support structures with a variety of options.
Reverse Engineering Software

Full Body 3D Scanning
Photogrammetry

Surface Reconstruction from Multi-View Data
Surface Reconstruction

Simplification

20,000  8,000  2,000
Deformation

Smoothing / Fairing
Parameterization

Remeshing
Subdivision

Completion
IBM Pietà 3D Scanning Project: 1998-2000

http://www.research.ibm.com/pieta

http://mesh.brown.edu/DGP + Canvas
Course Description

• Syllabus @ http://mesh.brown.edu/DGP
• Computer representations of piece-wise smooth surfaces have become vital technologies in areas ranging from interactive games and feature film production to aircraft design and medical diagnosis.
• One of the fundamental requirements for all computer graphics applications is the need for sophisticated techniques for representing and processing geometric object models.
• Two dominant surface representations are polygon meshes and point clouds.
• We will explore some of the more important techniques for working with non-trivial surface meshes and point clouds.
• Most of the material we will discuss is taken from the recent research literature.

Prerequisites / Who should take this course

• This course is aimed at graduate students from Engineering, Computer Science, Applied Mathematics, Physics, Cognitive Science and Neuroscience, with some knowledge of Vector Calculus, Linear Algebra, and Data structures, and some exposure to computer programming.
• All the programming will be in C++
• Exposure to Java might be sufficient, but may require additional effort.
Textbook

- There is no required book, but this one can serve as a reference:
- Slides and/or lecture notes will be provided for all the lectures. Students are supposed to download and read the lecture notes, which will be available before each class.
- A number of papers will be available for download from the course web site to complement the lectures.

Grading

- The course evaluation will be is based on class participation, a number of programming assignments, and a final project.
- There will not be homework assignments other than the programming assignments and the final project, and there will be neither midterms nor final exam.
- This year all the programming will in C++.
- As new concepts and techniques are introduced in the lectures, the programming assignments will expose the students to concepts of increasing complexity.
- The final project will probably span several weeks.
Papers

- During the course of the semester, we will read a number of papers drawn from the research literature, and we will discuss them in class.
- The required reading for each class will generally be 1–2 papers.
- Prior to each class each student should write a brief summary of each paper describing the key points in 2-3 sentences, as well as a list of biggest question to discuss in class
- Every student will present probably two of these papers in-class. These 20-30 min presentations should include powerpoint slides.

Programming Assignments

- Programming assignments are to be submitted electronically through the Canvas course web site by midnight on the specific deadline.
- Students must be logged in using their Brown user id to submit their assignments.
- Submissions are only accepted as zip files containing your source code, configuration files, and documentation.
- Further details on how to submit homework assignments will be given with each assignment.
Class Attendance and Participation

• Class attendance and participation in the class discussions is mandatory, and will contribute to the final grade as follows:
  • Class participation: 15%
  • Programming assignments: 60%
  • Final project: 25%

Tentative Topics To Be Covered

• Discrete Curves and Surfaces
• Discrete Representations: Point Clouds, Polygonal Curves and Polygon Meshes
• Connectivity, Topology, and Geometry
• Efficient Data Structures to operate on Discrete Curves and Surfaces
• File Formats to store and transmit Discrete Curves and Surfaces
• Elements of Differential Geometry of Curves and Surfaces
• Isocurve and Isosurface Extraction Algorithms
• Surface Reconstruction Algorithms
• Curve and Surface Smoothing Algorithms
• Signal Processing on Curves and Surfaces
Tentative Topics To Be Covered

- Parameterization
- Remeshing
- Approximation
- Point Cloud Decimation
- Polygon Mesh Simplification
- Optimization
- Model Repair
- Deformations
- Geometry Compression
- Numerical Methods
- In-core and Out-of-Core Methods
- Geometry Processing for 3D Printing

2013 Software Environment: Java
Qt

- **Qt** is a cross-platform application framework that is widely used for developing application software that can be run on various software and hardware platforms with little or no change in the underlying codebase, while having the power and speed of native applications.
One Qt Code
Create Powerful Applications & Devices

We believe modern software development must include a cross-platform user experience and that your tech strategy should be based on easy creation of connected devices, UIs and applications that run anywhere on any device, on any operating system at any time – making your end users’ life easier. With Qt, you can do this and more.

Before you begin, make the right license choice.

 assignment 0

• Set Up Qt Development Environment
  • Windows
    – Visual Studio
    – Cygwin
  • OSX
    – Xcode
    – Homebrew package manager http://brew.sh
Command Line Tools

- Windows: Cygwin
- OSX / Linux: built-in
- Linux Tutorial for Beginners
- [http://www.ee.surrey.ac.uk/Teaching/Unix/](http://www.ee.surrey.ac.uk/Teaching/Unix/)

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UNIX Tutorial for Beginners

A beginners guide to the Unix and Linux operating system. Eight simple tutorials which cover the basics of UNIX / Linux commands.

**Introduction to the UNIX Operating System**
- What is UNIX?
- Files and processes
- The Directory Structure
- Starting an UNIX terminal

**Tutorial One**
- Listing files and directories
- Making Directories
- Changing to a different Directory
- The directories . , ..
- Pathnames
- More about home directories and pathnames

**Tutorial Two**
- Copying Files
- Moving Files
- Removing files and directories
- Displaying the contents of a file on the screen
- Searching the contents of a file

**Tutorial Three**
- Redirection
- Redirecting the Output
- Redirecting the Input
- Pipes

**Tutorial Four**
- Wildcards
- Filename Conventions
- Getting Help
Package Managers

• OSX
  – Homebrew
• Windows 10
  – OneGet (new)
  – Chocolatey (?)
• Linux (Raspberry PI)
  – apt-get
CMAKE

- An extensible, open-source system that manages the build process in an operating system and in a compiler-independent manner.
- http://www.cmake.org
- http://www.cmake.org/Wiki/CMake
- Instructions will be provided to configure your development environment to use Cmake together with Qt to generate project files for your native IDE (Xcode, VisualStudio, make, etc.)
Distributed Video Wall DGP Viewer
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