CS554 Geometric Modeling in Computer Graphics

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Prerequisite: Linear Algebra, Trigonometry

Description:
Advanced course in computer graphics focusing on representation and processing of polygonal models, and their applications in computer graphics. Topics include:

- Curves and Surfaces
- Surface fundamentals: discrete differential geometry and topology.
- Data structures for representing 3D surfaces.
- Surface subdivision and smoothing.
- Mesh simplification and multi-resolution representation of 3D surfaces.
- Geometry compression.
- Surface segmentation and parameterization.
- Global surface parameterization.
- Geometry remeshing.
- Topological simplification.
- Mesh editing and deformation transfer.
- Implicit surfaces.
- Surface traversal.
- Shape illustration.
- Solving PDE’s on surfaces.

Learning Objectives:
Through this course, I expect students to achieve the following:

- Articulate important problems and applications in 3D modeling, such as shape representation, surface fairing, geometry compression, mesh parameterization, and geometry remeshing.
- Develop proficiency with working on triangular meshes.
- Articulate the theory behind Laplacian smoothing, and perform surface fairing based on discrete Laplacian.
- Perform Loop-subdivision on triangular meshes.
- Articulate the process of mesh simplification and error metrics that are often used.
- Implement efficient data structures and algorithms that support surface traversal.
- Articulate how geometry compression is performed.
- Perform mesh parameterization.
- Perform discrete curvature estimation on surfaces
- Articulate the process for anisotropic remeshing.
- Articulate how surface topology, such as the Euler characteristic, is related to geometry processing on surfaces.

Topics:
- Surface fundamentals:
  - Surface topology.
  - Discrete differential geometry.
- Triangular mesh representation of 3D surfaces:
- Subdivision and Smoothing:
  - Loop subdivision.
  - Smoothing based on Gauss filtering.
- Mesh simplification and level-of-detail presentation:
  - Edge collapse and quadric measure.
  - Progressive mesh presentation.
- Compression:
  - Edgebreaker compression and decompression.
- Surface parameterization:
  - Surface segmentation.
  - Local parameterization.
  - Global parameterization.
- Geometry remeshing:
  - Triangulation.
  - Quadrangulation.
- Surface topology:
  - Morse theory and Reeb graph.
  - Topological simplification.
- Implicit surfaces:
  - Representation.
  - Morphing.
- Mesh editing and deformation transfer.
- Solving PDE’s on surfaces:
  - Laplacian smoothing.
  - Lagragian tracing.

Textbooks:
- Polygon Mesh Processing [Botsch, Kobbelt, Pauly, Alliez, Levy] (Required)

Reading Materials:
A collection of recent papers in the field of geometric modeling.

Projects and Grading:
This course is primarily project based. Each student will complete 4 independent projects, a midterm, plus a term project to be discussed later. Class attendance is mandatory.
Term Project Ideas (some examples):

- Heat diffusion over 3D surfaces and conformal parameterizations.
- Topological noise removal.
- Shape matching.
- View-dependent hatching on surfaces.
- Example-based texture synthesis, such as “lapped textures”.
- Subdivision surfaces.
- Mesh editing.
- Implicit surfaces.

**Late Policy**
Late assignments will be marked off 10% for each weekday that it is late.

**Academic Dishonesty**
Please do your own work. The default consequence for academic dishonesty is a failure for the course. It is okay to discuss with other students general ideas about implementing a program. It is not okay to copy another student's program. It is okay to discuss possible program bugs. It is not okay to debug another student's program.

**Expectations**
Students are expected to attend lectures, participate in the discussions, and work with their group members on group projects. You should come to class prepared and speak up when something is not clear. Being prepared means completing the assigned reading and assignments. Students are expected to be creative and have fun!

Students with documented disabilities who may need accommodations, who have any emergency medical information the instructor should be aware of, or who need special arrangements in the event of evacuation, should make an appointment with the instructor as early as possible, and no later than the first week of the term. Class materials will be made available in an accessible format upon request.