School of Computing and Information Sciences

Course Title: Geometric Modeling and Shape Analysis **Date:** March 13, 2014

Course Number: CAP 6736

Number of Credits: 3

Subject Area: Computer Science and Computing Technologies	**Subject Area Coordinator:** **Email:**
Catalog Description: Techniques for 2D/3D geometric modeling and analysis, including representation, reconstruction, processing, modeling and shape analysis, and applications in science and engineering.	
Textbook: None	
References: Geometry processing, modeling, and shape analysis: 1. *Ricci Flow for Shape Analysis and Surface Registration: Theories, Algorithms and Applications*. Wei Zeng and Xianfeng David Gu. Springer, 2013. 2. *Polygon Mesh Processing*. M. Botsch, L. Kobbelt, M. Pauly, P. Alliez, and B. Levy. A. K. Peters, Ltd. Natick, MA, 2010. 3. *Computational Conformal Geometry*. Xianfeng David Gu and Shing-Tung Yau. International Press, 2008. 4. *https://www.cgal.org/*. CGAL - Computational Geometry Algorithms Library. 5. *http://meshlab.sourceforge.net/*. MeshLab. 6. *3D Computer Vision: Efficient Methods and Applications*. Christian Wöhler. Springer, 2nd ed., 2013. 7. *An Introduction to 3D Computer Vision Techniques and Algorithms*. Boguslaw Cyganek and J. Paul Siebert. Wiley, 2009. **Other Related Material:** Lecture notes; Related journal articles (e.g., TOG, TVCG, TPAMI, and IJCV) and conference papers (e.g., SIGGRAPH, ICCV, CVPR, ECCV, IPMI, and MICCAI).	
Prerequisites Courses: SCIS Graduate Standing or by Permission of Instructor	
Corequisites Courses: N/A	

Type: Elective for MSCS, MSIT, MSTN, and Ph.D. students

Prerequisites Topics:

- Data structure, Algebra.
- Basic programming skills.

Objectives:

Students will learn fundamental techniques for dealing with geometric models and their applications in graphics, vision, animation, medical imaging, and other fields in science and engineering.

Major Topics:

- Introduction to Geometry, Topology and Shape Analysis
- Representations of 3D Objects: raw data, surface reps, solid, high-level reps.
- Discrete Structures on Meshes: polygonal meshes (half edge data structure)
- Reconstruction: range images, polygon soups, sensor data, point clouds.
- Processing: Smoothing, Simplification, Remeshing
- Modeling: Parameterization, Mapping, Deformation, Morphing, Subdivision
- Shape Analysis: similarity criteria; matching, registration, recognition, retrieval, classification, clustering, synthesis, indexing.
- Applications
- Project Discussion

Learning Outcomes:

1. Understand the basic concepts and theorems of geometry and topology.
2. Master the discrete representations and data structures of geometric objects.
3. Learn the geometric processing pipeline from reconstruction to shape analysis.
4. Master the fundamental methods for 3D reconstruction.
5. Master the fundamental tools for 3D mesh processing, modeling and analysis.
6. Understand the usage of geometric analysis techniques in solving real-world problems.

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Course Outline

Major Topics	Number of Lecture Hours	Outcome
Introduction to Geometry, Topology and Shape Analysis	1	**1**
Representations of 3D Objects	1	**2**
Discrete Structures on Meshes	1	**2**
Reconstruction	4	**3, 4**
Processing: Smoothing, Simplification, Remeshing	4	**3, 5**
Modeling: Parameterization, Mapping, Deformation, Morphing, Subdivision	8	**3, 5**
Shape Analysis	6	**3, 5**
Applications	3	**6**
Project Discussion	4	**1-6**

Course Outcomes Emphasized in Laboratory Projects / Assignments

Outcome	Number of Weeks
• 5 two-week period assignments (paper reading and presentation) to evaluate the students' understanding and learn classical and latest research results. • 1 term project on developing a program with a selective topic.	
1, 2	2 week: Assignment 1
3, 4	2 week: Assignment 2
3, 5	2 week: Assignment 3; 1 week: Term Project.
3, 5	2 week: Assignment 4; 1 week: Term Project.
5, 6	2 week: Assignment 5; 1 week: Term Project.

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Oral and Written Communication:

- Number of written reports: **1** for the term project.
- Approximate number of pages for term project report: **10** (including figures, tables, references).
- Number of assignments: **5** (each is due in two weeks from the day of assignment).
- Number of required oral presentations: **1** for the term project.
- Approximate time for each presentation: **20 minutes** for each group (each has at most 4 students).

Grading Policy:

- Assignments: 50%
- Term Project Presentation: 20%
- Term Project Report and Program: 25%
- Participation: 5%