University of Southern California
Daniel J. Epstein Department of Industrial and Systems Engineering

ISE 599: Point-Sampled Geometry for Product Design and Manufacturing
Class Number 599, Units 3
Spring 2011

Course Syllabus

Course General:
The course meets Monday 6:30 ~ 9:10 pm at KAP-141.

Course Instructors:
Dr. Charlie C. L. Wang
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Dr. Yong Chen, GER-201
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Office Hours: Monday & Wednesday from 1:00 to 3:00pm or by appointment.

Course Description:
Rapidly advancing 3D sensing technologies provide us with dense and accurate point cloud data. Reverse engineering techniques are based on point clouds scanned from the real-world objects such as human bones and teeth. The scanned digital data is essential for future biomedical product design and the revolutionary development on mass customization. In addition, the increasingly complex 3D geometric models, which are widely used in product development, have spurred the growing need for point-based geometric modeling and processing techniques. Point-based computational techniques support the use of points as a basic geometric primitive in Computer-Aided Design (CAD), analysis (CAE) and manufacturing (CAM). This course aims to help students in understanding the concept of point-sampled geometry and its applications in CAD/CAE/CAM, and provide students with deep understanding of computation techniques and practical experience in developing novel CAD/CAE/CAM applications by using point-sampled geometry.

The point-sampled geometry will be introduced in the aspects of mathematical formulation, computational representation, algorithm, and their applications in computer-aided design, analysis, and manufacturing. It will also train the students with hands-on computational skills by working on application development projects. In addition, the course will prepare the students to read literature, understand current research problems, and identify possible contributes to the field.

This is a graduate level course that will be co-taught by two professors (Dr. Wang and Dr. Chen). The course is designed to prepare the students for advanced careers in the fields of CAD/CAE/CAM, robotics, design and manufacturing automation, virtual reality, human factors, and health systems. The targeting audience of the course includes but not limited to the students in ISE PhD program, Master of Science in Industrial and Systems Engineering, Master of Science in Product Development Engineering, and Master of Science in Manufacturing Engineering.

The course will consist of four parts: (1) preparation with introduction and data acquisition, (2) discussion on unorganized point samples, (3) discussion on organized point samples, and (4) real-world applications related to the point-based geometry such as customized product design, CNC machining, Rapid Prototyping, and shape inspection, etc. Source codes of a testbed will be provided in the class for students to gain hands-on experience.

Prerequisites:
No formal prerequisites. Students are desired to be familiar to C++ or Matlab programming.

Textbook
Lecture notes will be given before classes.

Reference Books
- Gross, M. and H. Pfister, *Point-based Graphics*, Morgan Kaufmann Publishers, 2007.
- M. de Berg, et. al. *Computational Geometry – Algorithms and Applications*. Springer, 2000.
- Mortenson, M. E. *Geometric Modeling*. Wiley Computer Publishing, 1997.
- Shah, J. and M. Mantyla, *Parametric and Feature-Based CAD/CAM*, John Wiley and Sons, 1995.
- Hoffmann, C. M. *Geometric and Solid Modeling*. Morgan Kaufman Publishers, 1989.
- Mantyla, M.. *Introduction to Solid Modeling*. Computer Science Press, 1988.

Grading Policy:
The grading for the class will be determined using the following weights:

- Problem assignments…… 25%
- Mid-term exam ……..……20%
- Development projects……...……..50%
- Participation…… 5%

Total Score…….100%

Problem Assignments: Students will be given ~2 weeks for each assignment, which will consist of solving problems that correspond to the materials covered in class in the previous weeks.

Mid-term exam: A mid-term exam will be given during the semester with notice.

Development projects: The objective of the development projects is to help the students to gain hands-on experience and to use learned materials to solve real world problems. Two development projects will be given during the semester. Possible projects will be discussed with the professors. The final project should be done with a demonstration, a presentation, and a technical report.

Participation: Participation in the class is required and will be taken into account. Bonus points are available for enthusiastic participation in class. If you miss a class, please work with your fellow students to catch up on what you missed. Please turn cell phones and pagers off or put them in vibrate mode before coming to class.

Academic integrity:
"The Department of Industrial and Systems Engineering adheres to the University's policies and procedures governing academic integrity as described in SCampus. Students are expected to be aware of and to observe the academic integrity standards described in SCampus, and to expect those standards to be enforced in this course."

Disability Accommodation:
"Any Student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA)

as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776."

Tentative Course Schedule:

Week #	Monday (6:30~9:10 pm)	Assignment	Reading / Project
1	Jan. 10 – Course Introduction & Preliminary • Course Overview • Programming environment and testbed • Matlab and C++ programming • Data Acquisition o Acquisition methods o Data representation	HW1	Self-study on related prerequisites
2	**Jan. 17 – Martin Luther King Day (No Class)**		
3	Jan. 24 – Preprocessing o Denoising o Robust statistics based on outliner removal o Normal reconstruction	HW2	
4	Jan. 31 – Direct Surface Reconstructing o Direct triangulation o Voronoi methods o Adaptive Spherical Cover (ASC) based method o Meshless Surface Parameterization o Direct Rendering		Course Project Assigned
5	Feb. 7 – Implicit Surface Reconstruction o Distance field o Radial Basis Function o Multi-level Partition Unity (MPU) implicit o Poisson Reconstruction	HW3	
6	Feb. 14 – Moving Least Square-based Surface Reconstruction o Mathematical formulation o Point sampled surface (PSS) o Algebraic Point Samples Surface (APSS) o Point Consolidation		
7	**Feb. 21 – Presidents' Day (No Class)**		
8	Feb. 28 – Layered Depth-Normal Images o Representation for Solids	HW4	

	○ Sampling ○ Solid Modeling ○ Surface Reconstruction	
9	Mar. 7 – *Mid-Term* ○ Course Project Update	
10	**Mar. 14 – Spring Recess (No Class)**	
11	Mar. 21 – ***Paper Presentation (25min/team)***	Course Project Due
12	Mar. 28 – Advanced Topics in Solid Modeling using LDNI ○ GPU based sampling ○ Parallel B-rep Reconstruction ○ Resampling of Deformed LDNI ○ GPU based Rendering	Implementation Project Assigned
13	Apr. 4 – **Applications in CAD/CAM/CAE** • LDNI in Rapid Prototyping and NC path planning	
14	Apr. 11 – **Applications in CAD/CAM/CAE** • Offsetting • Minkowski Sum	
15	Apr. 18 – **Applications in CAD/CAM/CAE** • Model Repair • Fast Mesh Boolean Operation based on LDNI	
16	Apr. 25 – **Applications in CAD/CAM/CAE** • Multi-material Volumes • Others	
17	May 2 - Study Day	
18	May 9 – ***Implementation Project Presentation*** (7pm)	Implementation Project Due