EE575: Computational Differential Geometry for Engineers

Instructor: Anand A Joshi **Office**: EEB 426 **Email**: ajoshi@usc.edu **Office Hours:** Fri 12-2pm

Schedule: Tu, Th; 12:30- 1:50 pm **Location**: THH 110 **Units:** 3 + 1 (EE690 DR)

Course Outline

Introduction, Partial differential equations, heat and Laplace equation, Numerical methods for their solutions. Theory of Curves tangents, arc-length, curvature, torsion, fundamental theorem of curves. Numerical representations of surfaces, Local theory of surfaces, parametric representation of surfaces, tangent plane. Mesh generation, marching cubes algorithm, surface parameterization, harmonic maps, conformal maps. Local theory of surfaces gauss map, Gaussian, mean and principal curvature. Some results on surfaces, curvature and geodesics. Conjugate gradient method, numerical methods for solving PDEs on surfaces. Laplacian on manifolds and its properties. Numerical spectral geometry, GPS surface representation. Smooth manifold, definition, properties, examples, theorems, differentiation on manifolds, integration. Riemannian metric, geodesics, tensors, covariant and contravariant tensors. Groups, Lie groups. Lie groups, SO3, Grassmannian, statistical manifold. Level Set Methods, geodesic active contours, geodesic curvature flow. Manifold learning methods, linear approaches, principal component analysis, multidimensional scaling, non-linear approaches, local linear embedding, ISOMAP. Shape analysis, Kendall's shape space and applications. Manifold Learning. Geometric deep learning, graph and geometric CNNs. Nonlinear dimensionality reduction.

Recommended Preparation: The course is self-contained; however, students should have a good background in calculus and familiarity with Matlab, Python or C++.

Grading

1. *Homework 30%* 2. *Mid-Term Exam: 30%* (take home) 3. Class Project: 35%, 4. Participation: 5%

There is no required text, the following texts are recommended references.

A. M. Bronstein, M. M. Bronstein, R. Kimmel, Numerical geometry of non-rigid shapes, Springer, 2008.
B. Lee, John M. Introduction to smooth manifolds. Vol. 218. Springer, 2012.
C. Shifrin T, Differential Geometry: A First Course in Curves and Surfaces by. The book is free, and available online from http://alpha.math.uga.edu/~shifrin/ShifrinDiffGeo.pdf

Notice: Instructors reserve the right to make changes on this syllabus as needed