Fundamentals of Spatial Computing

MAT 594CM S2009

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/// Description

This course provides a foundation for computing in multidimensional spaces, investigating the synthetic and generative potentials of elementary geometric constructs. Subjects covered will include vector and matrix math, space partitioning, collision detection, and kinematics. We will focus both on mathematical foundations and practical computational techniques for creating real-time 3D graphics via OpenGL.

Students will produce a number of investigations into the topics covered, culminating in a final programming project. No prerequisites are required, although some basic knowledge of programming is assumed. The course will consist of one lecture class and one lab class per week.

/// Points and Dynamics: traces of locality

The basics of 2D and 3D transformations and their relation to the rendering pipeline. Numerical simulations for moving objects in space and how the traces they make can be constructed into curves and interpolated.

Week 1: Transformations and Graphics

Topics: Introduction to OpenGL, vectors, matrices, homogenous coordinates, affine and perspective transformations.

Week 2: Dynamics

Topics: Runge-Kutta, Verlet integration, Implicit/Explicit Euler. Physical simulation.

Week 3: Curves and Interpolation

Topics: Parametric curves, Bezier curves, Cubic Splines, NURBS Curves, animation over curves, easing, tweening, parametric surfaces

Week 4: Rotations and Orientation

Topics: Rotation matrices, Euler angles, axis-angle, quaternions, rotation interpolation.

>>>> Project #1 Due Thursday

/// Space and Division: structure contingent on information distribution

Examination of techniques for decomposing space in order to encode spatial relationships. Reasoning efficiently about geometric relationships in 2D space. Algorithms for bounding, intersecting, and partitioning simple polygons.

Week 5: Thinking in the Plane

Topics: Convex hull algorithms, Voronoi diagrams and Delaunay triangulation.

Week 6: Partitioning Space and Collisions
Topics: Quantization, Binary Space Partitioning, Axis-Aligned Bounding Boxes, Octrees, Quadtrees

/// Elaborations and Mutations: amorphousness, recursion, connectivity, ...
Techniques beyond partitioning for hashing and indexing space.
Amorphous tessellations in 3D for encoding spatial neighbor relationships and global structure

Week 7: 3D Delaunay/Voronoi
Topics: 3D Delaunay triangulations and 3D Voronoi diagrams

>>>> Research Presentations Thursday

Week 8: Surfaces and Topology
Topics: Subdivision surfaces, topological properties and representation

Week 9: Open Topic
Topics: TBD

Week 10: Lab sessions
Work on final project. Project-specific discussions

>>>> Final Presentations Thursday

/// Assignments
Project 1: Using the concepts and techniques presented on *points and dynamics*, develop a generative drawing system.

Research Project: The goal of this assignment is to bring in knowledge from disparate fields into the conversation about computation in space and broaden the territory for exploration. Scientific and even humanities fields are increasingly instrumenting the search for and processing of information as well as the material of the field itself with computation. Examples include Computational chemistry and Bio Computing. Possible points of departure could be questions regarding how these fields employ spatial computation or what classes of algorithms and computational constructs they employ. The end result will be a short presentation and either a short paper or programming project implementing one of the concepts researched.

Final Project: Develop a computational dynamical system employing concepts of spatiality in the various modes covered in the course. The project can take many forms from interactive to self-generating to procedural but should be exist as a program of some sort.