

Course Topics for CPSC 542D, Fall 2004
Level Set Methods
Dynamic Implicit Surfaces & Hamilton-Jacobi Equations

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- Introduction: surfaces, sets, representations. Course details (prerequisites, assessment, text).
- Implicit surface functions, signed distance functions and constructive solid geometry. Computing geometric properties.
- Dynamic implicit surfaces (time-dependent Hamilton-Jacobi):
 - Motion by: convection, mean curvature, normal speed, combinations and constraints.
 - Computational details: boundary conditions, temporal and spatial derivatives, high order accuracy, timestep restrictions.
 - Reinitialization and construction of signed distance functions.
- Dynamic implicit surface applications:
 - Mesh generation.
 - Image restoration and segmentation.
 - Constructing surfaces from point clouds.
 - Free surface fluid flow.
- Advanced level set methods:
 - Narrow banding for efficient computation.
 - Particle level set method for accuracy.
 - Velocity extension for motion defined only on the front.

- Vector level sets for curves in 3D.
 - Unstructured and adaptive computational meshes.
 - Implicit and semi-Lagrangian timestepping.
- The static Hamilton-Jacobi equation for first arrival:
 - Fast marching method for signed distance functions.
 - Dynamic programming.
 - Ordered upwind and sweeping methods for general equations.
- The time-dependent Hamilton-Jacobi:
 - Approximating general first-order terms.
 - Optimal control and zero-sum differential games.
 - Other terms: forcing, discounting, uncertainty.
 - Generating static HJ solutions.
- Theory: viscosity solution properties, other types of weak solution.
- Hamilton-Jacobi applications:
 - Option and derivative pricing.
 - Population dynamics.
 - Robotic path planning.
 - Reach sets for verification.