Overview

- Geometric and solid modeling
- Mathematics and Geometry
- Deformable models
- Physics-based modeling
- Numerical Solutions
- Visual computing applications
  - Graphics
  - Vision
  - Computer Aided Geometric Design
  - Visualization
  - Virtual environments

Geometric and Solid Modeling

- Polygonal meshes
- Polynomials and splines
- Parametric curves and surfaces
- Bezier Splines
- B-splines and NURBS
- Triangular & irregular patches
- multisided surfaces
- Subdivision objects
- Manifold splines
- Implicit functions
- CSG and volumetric models

- **Wavelets and hierarchical models**

- **Special shapes**
  - **ruled surface**
  - **developable surface**
  - **offset**
  - **sweeping**
  - **swung surface**
  - **surface of revolution**

- **Solid Models**
  - **Constructive solid geometry (CSG)**
  - **Boundary representation (B-rep)**

Geometric Operations and Techniques

- Trimming
- Intersection
- Approximation
- Interaction
  - control point
  - weight
  - knot vector
- Interpolation
  - scattered data
  - curve network
  - regular dataset
- Constraints
  - shape-preserving
  - convex-preserving

- Fitting
- Continuity
- Optimization
- Computation Geometry
- Differential Geometry
- Dynamic geometric design
- Forces — dynamic sculpting
- Efficient Algorithm
- Hierarchical techniques
- Level of Details
- Simplification

Physical Models

- Discrete modeling: mass-spring lattices
- Hybrid models: rigid & nonrigid components
- Articulated models
- Parameterized models
- Deformable models
- Models with local and global deformations
- Elastic & inelastic bodies
- Physics-based splines and fractals
- Dynamic B-splines & NURBS
- Dynamic subdivision models
- Particle systems & fluid models

- **Superquadric geometry: deformable part models**
- **Snakes: dynamic contour models**
- **Topologically adaptive snakes**
- **3D Symmetry-seeking models**
- **Finite elements**
- **Adaptive models and sampling**
- **Constrained fractals**
- **Deterministic vs nondeterministic models**

Dynamic Modeling

- Mass, damping, elastic Energy
- Internal and external forces
- Physics of elastically deformable bodies
- Energies of deformation
- Lagrange equations of motion
- Rigid body dynamics
- Elastic and inelastic deformation
- Geometric constraints & constrained dynamics
- Optimal control of physical models
- Lagrange mechanics
- mathematical physics

- **Multi-body (rigid and nonrigid) simulation**
- **local and global deformations**
- **Viscoelasticity, plasticity, fracture**
- **Thermoelasticity, heat equations, Melting**
- **Fluid dynamics**

Numerics

- Linear algebra & matrix computation
- Linear & nonlinear systems
- Static & dynamic problems
- Discrete modeling and approximation
- Numerical grid generation
- Initial-value & boundary-value problems
- Direct methods
  - matrix factorization
  - sparse matrix techniques
- The finite difference method
- The finite element method
- Iterative methods

- gradient methods
- relaxation methods
- conjugate gradient method
- multigrid methods

- Calculus of Variations
- Variational problems and formulation
- Differential equations of equilibrium
- Numerical analysis
- Dynamic simulation
  - Euler methods
  - Runge-Kutta methods
  - Predictor-corrector methods
- Multiresolution algorithms
- Optimization
- Simulated annealing

- **Differential geometry: Metric and curvature tensors**
- **Multiresolution stochastic relaxation**
- **Multiresolution algorithms**
- **Recursive estimation**
- **Kalman filtering theory**

Visual Computing Applications

- Morphing and image warping
- Surface blending and solid rounding
- Animation and simulation
- Freeform deformation
- Reverse engineering
- Shape reconstruction
- Parameter estimation
- Sparse data fitting
- Stereo and motion correspondence matching
- Boundary detection
- Motion and feature tracking

- **Motion/stereo reconstruction**
- **Interactive sculpting**
- **Model simplification**
- **Object motion tracking**
- **Feature extraction and segmentation**
- **Visualization**
- **Variational design**
- **Shape interrogation and control**
- **Biomedical imaging**
- **Interface and virtual environments**
- **Texture mapping**
- **Artificial Life**
- **Facial modeling and animation**

- **Modeling and physics of artificial animals**
- **Muscle modeling**
- **Learning locomotion**
- **Modeling perception: Active vision, animat vision**
- **Modeling adaptive behavior**
- **Plastic surgery**
- **Natural phenomenon**
- **Terrain modeling**