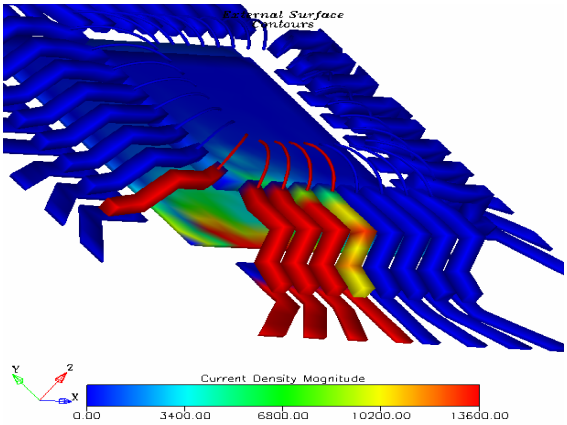
EECS 219A: Computer-Aided Verification of Electronic Circuits and Systems

Spring 2006, Friday 2:00-5:00

Professor Robert Brayton



This course is an introduction to computational techniques for the simulation of electrical circuits and systems with various applications being drawn from aerospace, mechanical, chemical and biological engineering, and materials science. Topics include: mathematical formulations; network problems; sparse direct and iterative matrix solution techniques; Newton methods for nonlinear problems; discretization methods for ordinary, time-periodic and partial differential equations, fast methods for partial differential and integral equations, techniques for dynamical system model reduction, approaches for molecular dynamics, and random simulation of digital systems under constraints and target objectives.

Although the title is verification, the specific focus is on verification through numerical simulation and in particular on the special numerical methods which allow efficient computation. This course covers the underlying methods used in the electrical simulation program SPICE. About 90% of the course deals with analog simulation, while the remainder is about recent methods used in the simulation of discrete systems.

Grades will be based on class participation, homework, a midterm exam, and a final project. Homework will involve some programming in MATLAB.

For additional info, email
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http://www.eecs.berkeley.edu/~alanmi/courses/2006_219A

Among the topics to be covered are:

1. Introduction
    a. examples of problems
        i. electrical
        ii. thermal
        iii. structural
2. Equation formulation
    a. nodal
    b. modified nodal
    c. sparse tableau analysis
3. Gaussian elimination
    a. pivoting and conditioning
4. Sparse matrix methods and data structures
5. QR and Generalized Conjugant Residual methods
    a. GCR convergence and preconditioning
    b. Krylov methods
6. Newton methods
    a. modifications, and
    b. convergence
7. Solution of ordinary differential equations
    a. multi-step methods
        i. convergence
        ii. consistency
        iii. stability
8. Adjoint equations
    a. computations of sensitivities
9. Simulation of discrete systems
    a. event driven versus compiled code methods
    b. random inputs with constraints
    c. targeting particular objectives
10. Periodic steady state solutions
    a. time domain
    b. spectral methods
11. Integral equations
    a. simulation of package, signal lines and MEMS
    b. Poisson and Laplace equations
    c. exterior and interior methods
    d. collocation and Galerkin methods
12. Hierarchical methods
13. Finite element methods
    a. Hat basis functions
    b. Galerkin methods
14. Boundary value problems and finite differences
    a. 2D and 3D problems
15. Model order reduction
    a. Eigenmode analysis
    b. rational function matching
    c. moment matching