

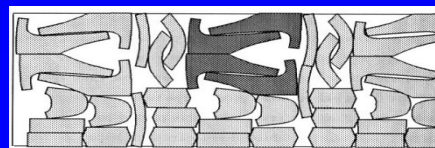
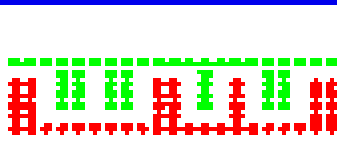
Applied Algorithms Research Assoc. Prof. Karen Daniels



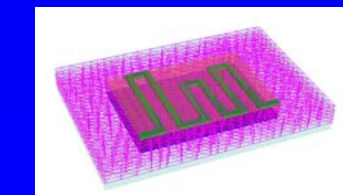
Channel Assignment for Telecommunications



Data Mining, Clustering, for Bioinformatics

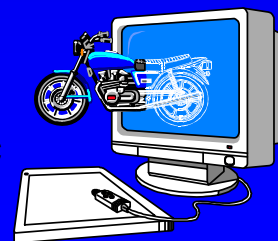


Packing for Manufacturing

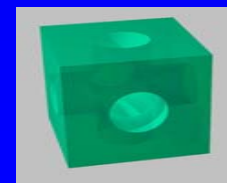


Courtesy of Cadence Design Systems

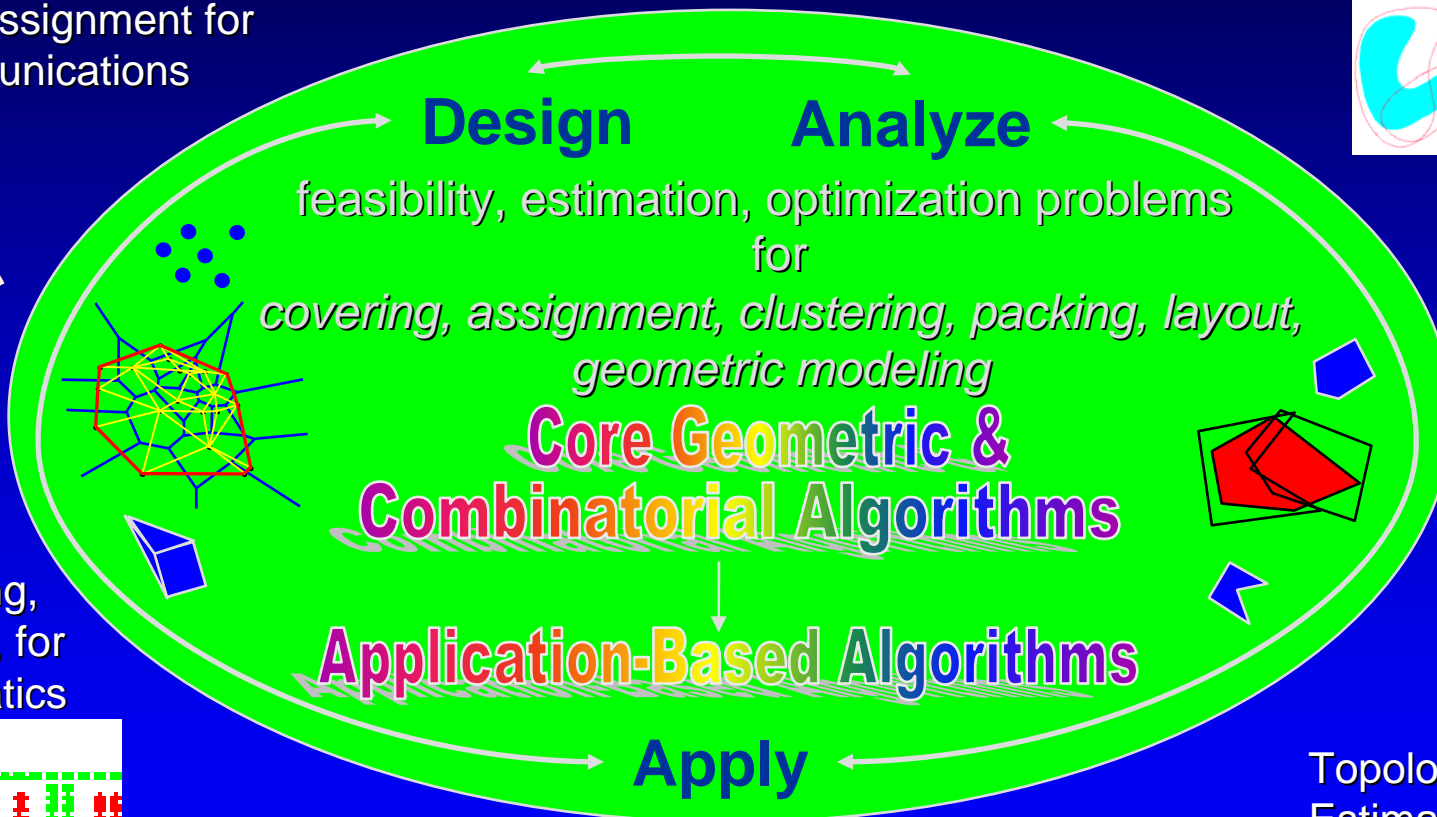
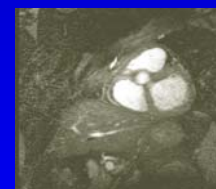
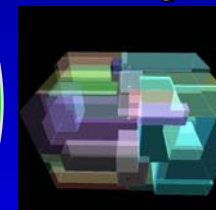
Meshing for Geometric Modeling

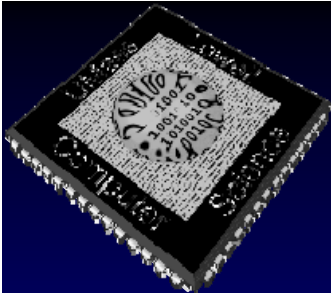


Topological Invariant Estimation for Geometric Modeling



Covering for Geometric Modeling





Covering: 2D Polygonal Covering

[CCCG 2001,CCCG2003]

➤ Input:

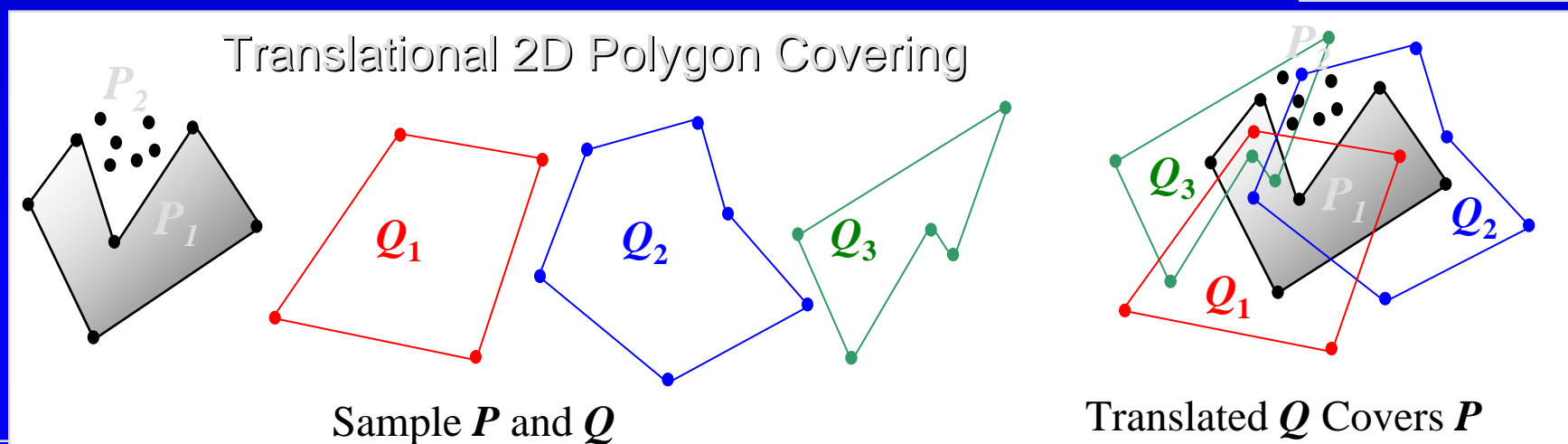
Supported under NSF/DARPA CARGO program

➤ Covering polygons $Q = \{Q_1, Q_2, \dots, Q_m\}$

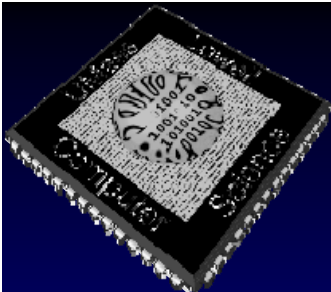
➤ Target polygons (or point-sets) $P = \{P_1, P_2, \dots, P_n\}$

➤ Output:

➤ Translations $\gamma = \{\gamma_1, \gamma_2, \dots, \gamma_m\}$ such that $P \subseteq \bigcup_{1 \leq j \leq m} \gamma_j(Q_j)$



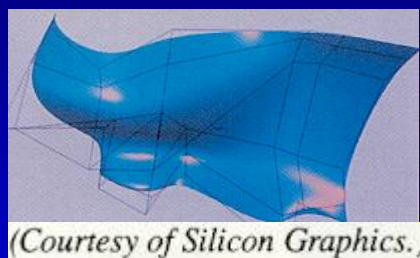
With graduate students R. Inkulu, A. Mathur, C. Neacsu, & UNH professor R. Grinde



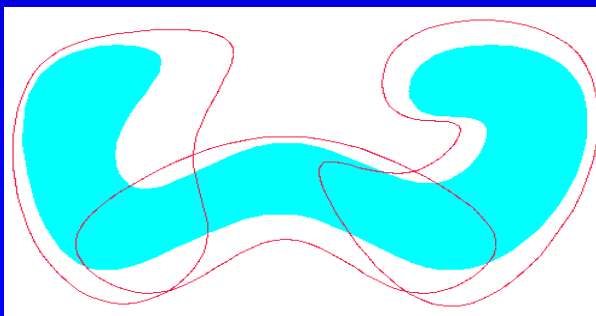
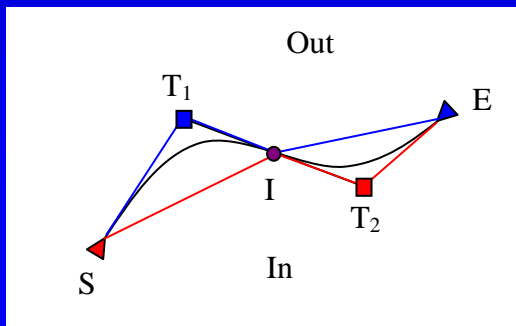
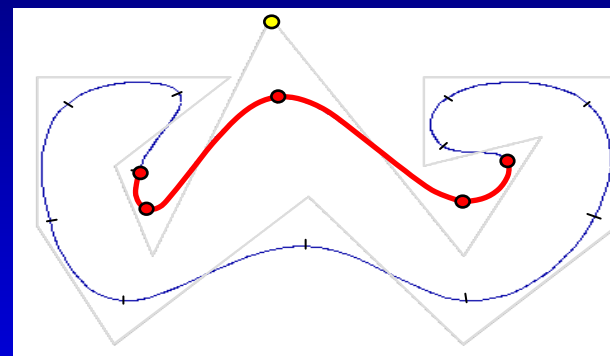
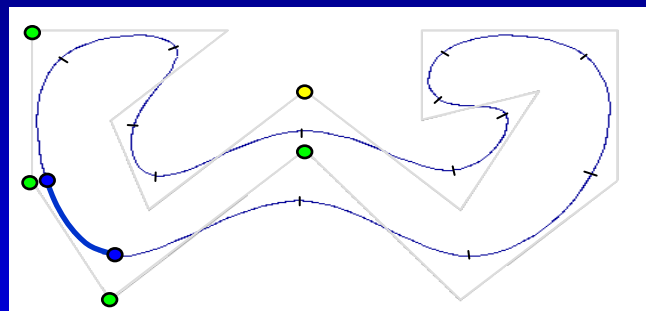
Covering: 2D B-Spline Covering

[CORS/INFORMS2004, UMass Lowell Student Research Symposium 2004, *Computers Graphics Forum*, 2006]

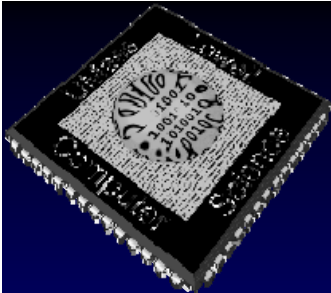
Supported under NSF/DARPA CARGO program



(Courtesy of Silicon Graphics.)



With graduate student C. Neacsu



Covering: Box Covering

[12th WSEAS Int. Conf. on Computers, 2008]

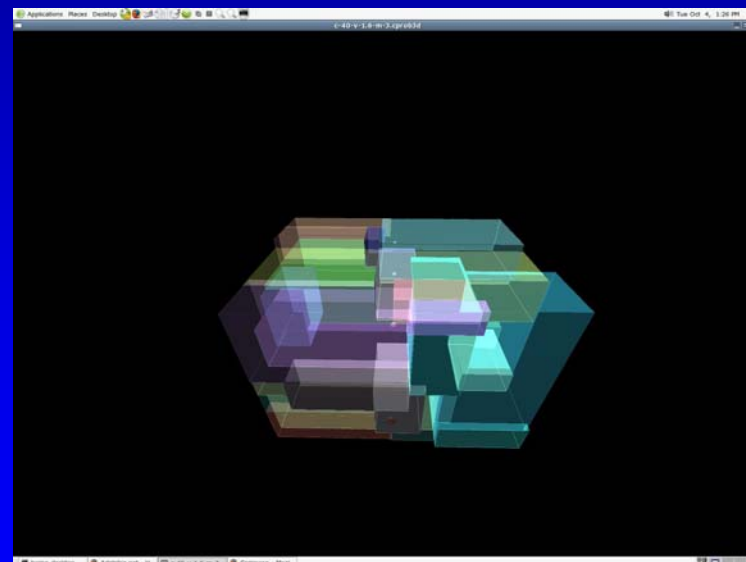
Supported under NSF/DARPA CARGO program

- Goal: Translate boxes to cover another box
- Orthotope (box) covering in 2D, 3D, ...



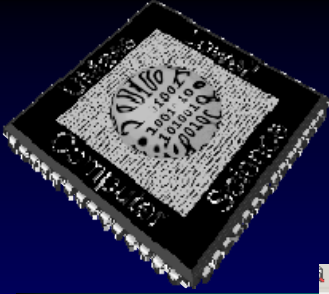
Partial cover (red part uncovered)

*2D views
of 3D
covering*



Full cover

With Masters student B. England



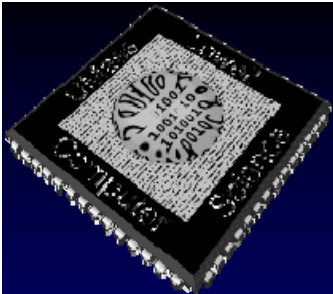
Covering: Covering Web Site

<http://www.cs.uml.edu/~kdaniels/covering/covering.htm>

The screenshot shows a Mozilla browser window with the URL http://www.cs.uml.edu/~kdaniels/covering/polygon_results.htm. The page content is as follows:

- Two Contacts Covering Results**
Definition: Given two polygons A and B, A trying to cover B, they are in a **two contact position** if they either share a vertex or have two vertex-edge contacts.
- Lagrangian**
The approaches of \cite{Daniels01a} and \cite{Daniels01} work well for problem instances in which the number of points in the convex hull of SP is small, the entire convex hull can be covered by the covering shapes, and the number of faces of a convex decomposition of Q is small. In such cases these algorithms can often find a cover by examining only a small number of candidate assignments. However, these methods lack a strong mechanism for deciding which covering polygon should cover which parts of SP . The goal of this paper is to reduce this limitation. The new heuristic uses the combinatorial covering method of \cite{Grinde99} to maximize coverage of SP .
- Approach**
Incrementally constrained
An assignment constrains each covering polygon to cover a particular point in the target set. An initial subset of target points is selected, assignments are generated, and the result is tested to see if the assignments guarantee coverage of the entire target set. If the entire target set is not covered, the subset of target points is augmented and the process repeats. The convex hull of the target set is selected as the initial subset of target points. A assignments for a small collection of target points can sometimes guarantee coverage of the entire target set using a convexity coverage property.
- Approach**
Intersection graph
\cite{Daniels01} builds on \cite{Daniels01a} using intersection graphs. Given polygonal SP , Q , and a translation vector for Q , let SR be the partition of SP induced by the boundaries of the translated items of Q . An intersection graph^{footnote} (Intersection graphs have been used previously in the context of covering (see \cite{Fowler81}, for example).) for a cover is an undirected graph containing one node for each region of SR and an edge connecting each pair of nodes whose regions of SR share an edge in SR . \cite{Daniels01} seeks covers having particular intersection graph topologies.

With graduate student C. Neacsu and undergraduate A. Hussin



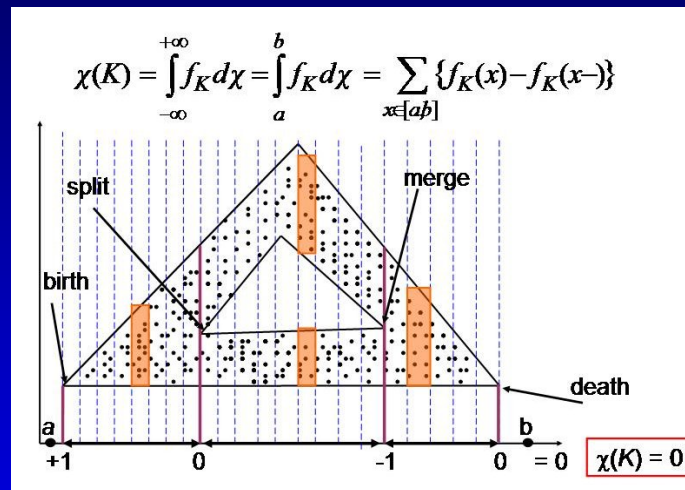
Geometric Modeling: Estimating Topological Properties from a Point Sample [4th Int. Symp. on 3D

Data Processing, Visualization and Transmission, 2008]

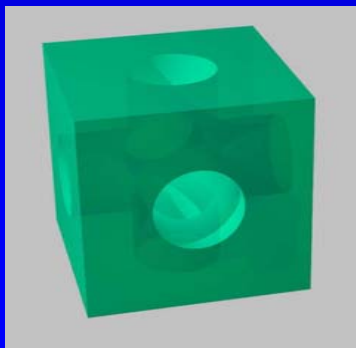
Supported under NSF/DARPA CARGO program

➤ Euler characteristic:

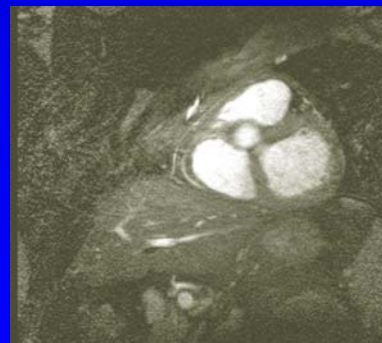
$$\chi = \#(\text{components}) - \#(\text{tunnels}) + \#(\text{bubbles})$$



Cube with 3 crossing tunnels: $\chi = -4$



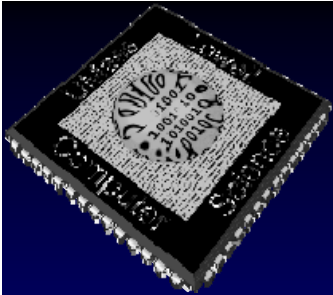
Heart MRI data



Stanford bunny



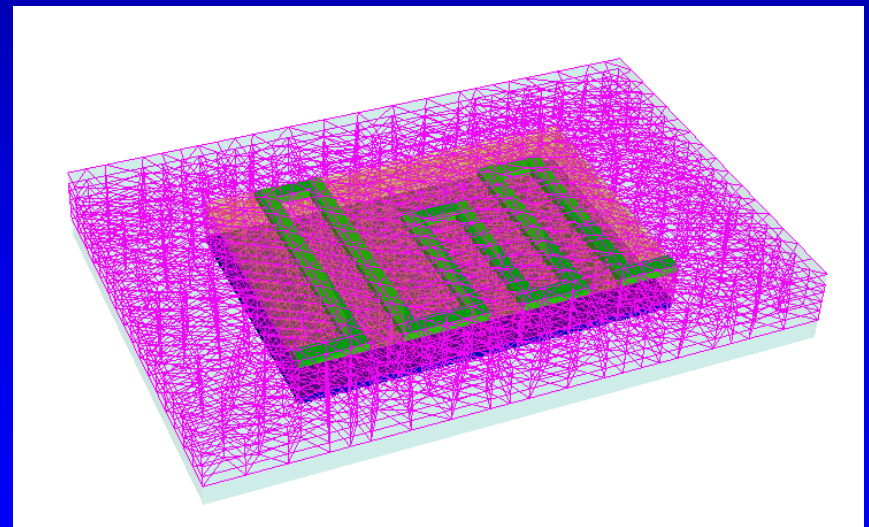
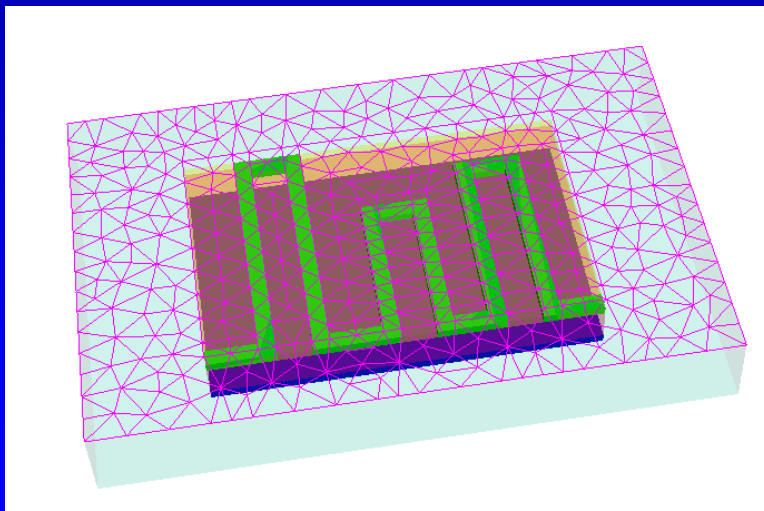
With graduate student C. Neacsu, UMass Amherst student B. Jones, UML Math Profs. Klain, Rybnikov, students N. Laflin, V. Durante



Geometric Modeling: Mesh Generation for Finite Element Modeling

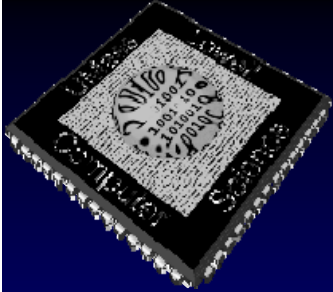
[Research Note for 17th Int. Meshing Roundtable, 2008; also presented at 2009 Fall CG Workshop]

- Needed for signal integrity in printed circuit board interconnect routing
- 2D constrained Delaunay triangulation is extruded into 3D to form triangular prism mesh



Courtesy of Cadence Design Systems

Doctoral student S. Ye

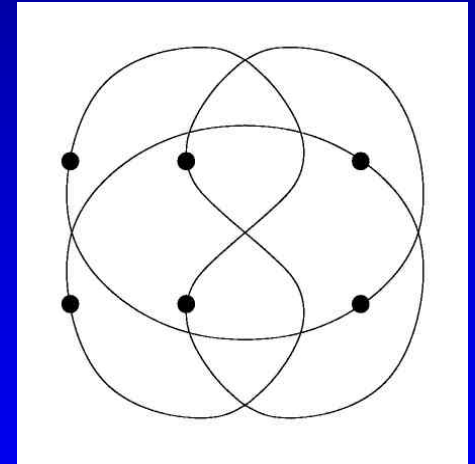


Computational Geometry: Thrackle Extensibility [CCCG 2006]

➤ Thrackle:

➤ Drawing of a simple graph on the plane:

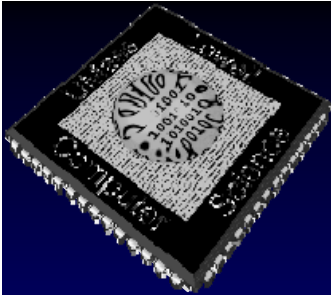
- each edge drawn as a smooth arc with distinct end-points,
- every two edges have exactly one common point,
- endpoints of each edge are two vertices;
- no edge crosses itself.



➤ Conway's thrackle conjecture:

- Number of edges for n vertices is at most n .

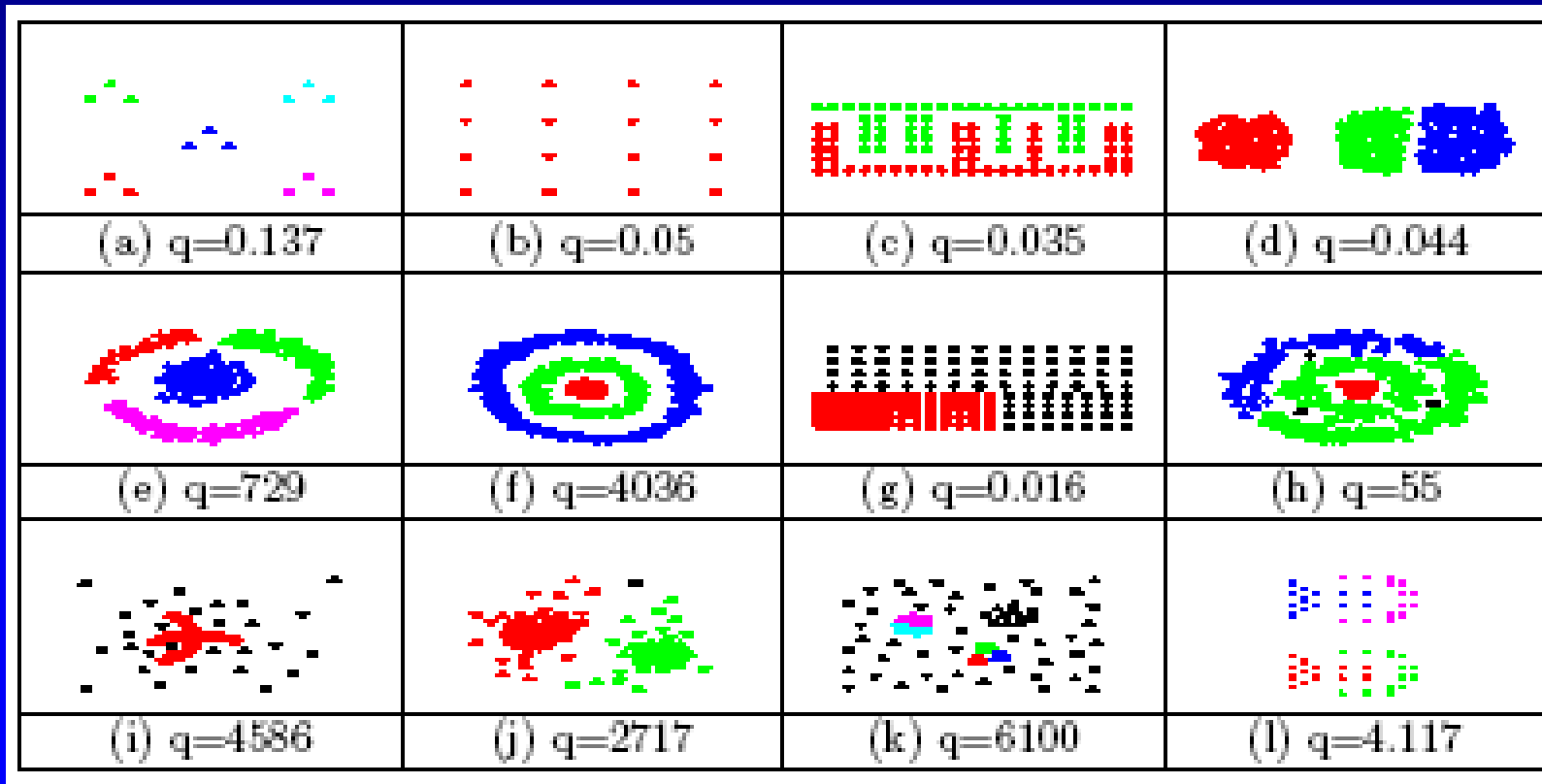
With graduate student W. Li and Math Prof. Rybnikov



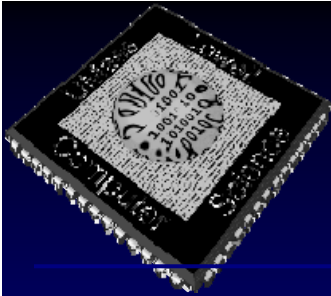
Bioinformatics: Improved Support

Vector Clustering [ICBA2004, SIAM Data Mining 2006, UMass Lowell Student Research Symposium 2003]

- Goal: Find natural groupings of data points
- Support Vector Clustering based on machine learning method

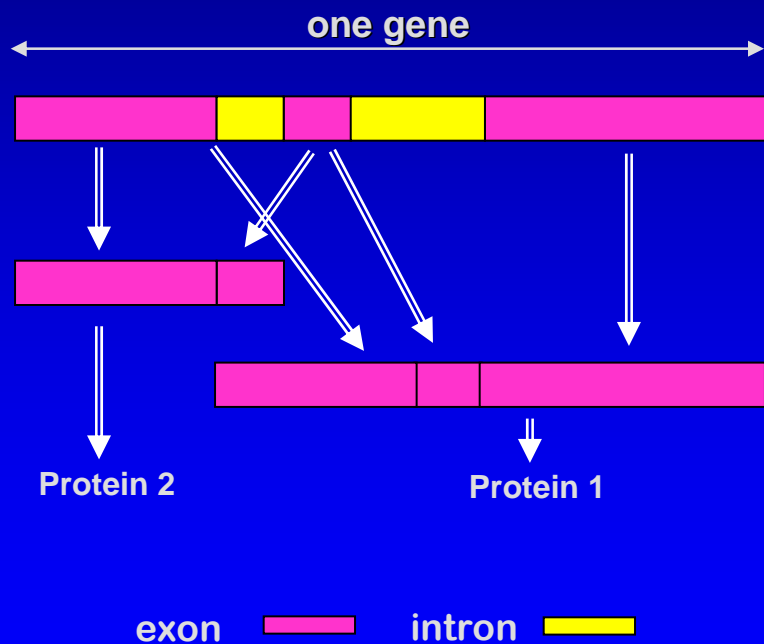


With doctoral student S. Lee

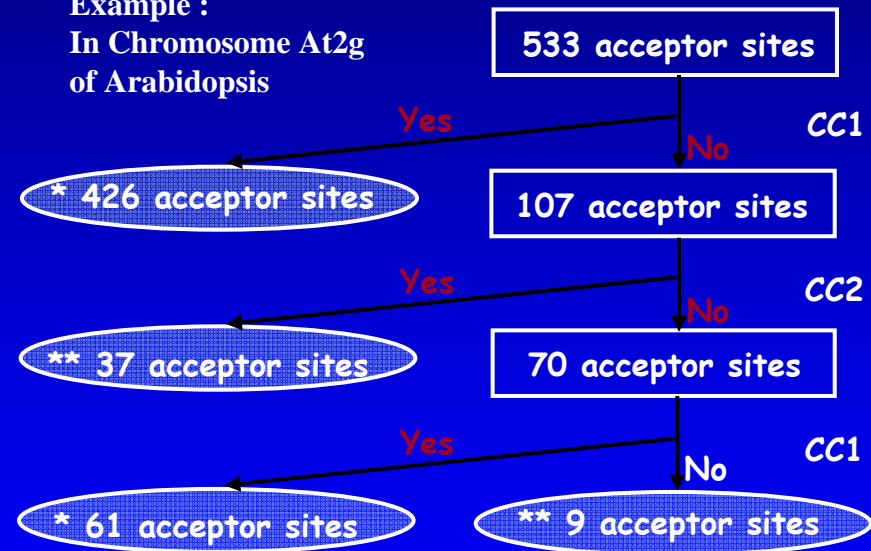


Bioinformatics: Alternative Splicing [IEEE 7th Int. Symp. Bioinformatics & BioEngineering 2007, *Int. Journal Computational Biology and Drug Design* (in press), UMass Lowell Student Research Symposium 2007, 2008]

Purpose: Find patterns for alternative splicing, and predict splicing sites directly in genome.

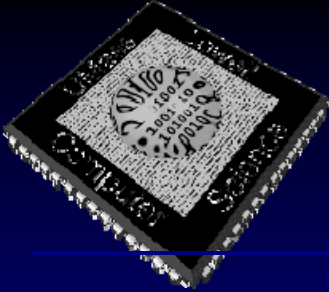


Example :
In Chromosome At2g
of Arabidopsis



*Normal splicing, ** alternative splicing
CC1: codons for normal splicing
CC2: codons for alternative splicing

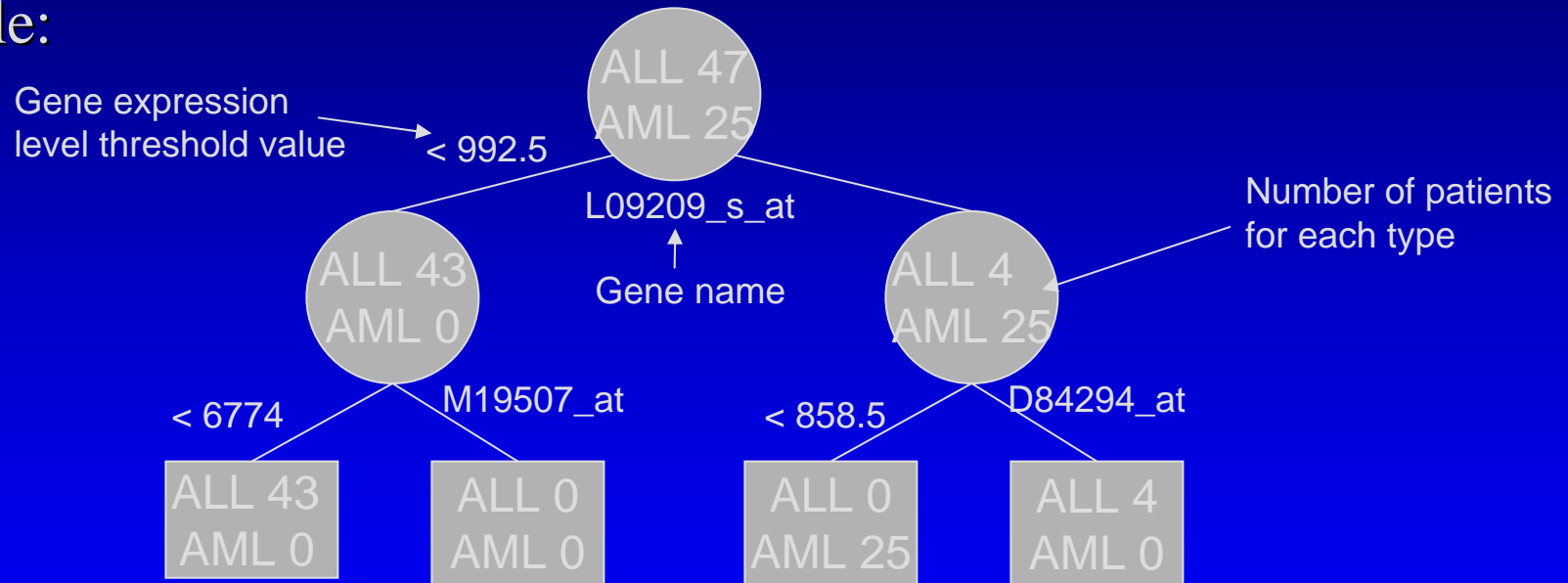
With graduate student M. Park, Biology Prof. Falcone and postdoc K. Yun



Bioinformatics: Constructing Random Forests [UMass Lowell Student Research Symposium 2006]

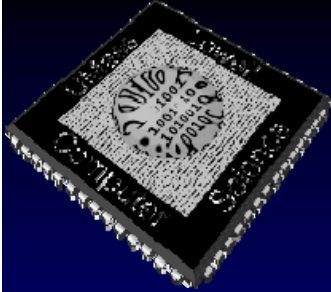
Purpose: Classify patients and allow prediction errors to be calculated.

Example:



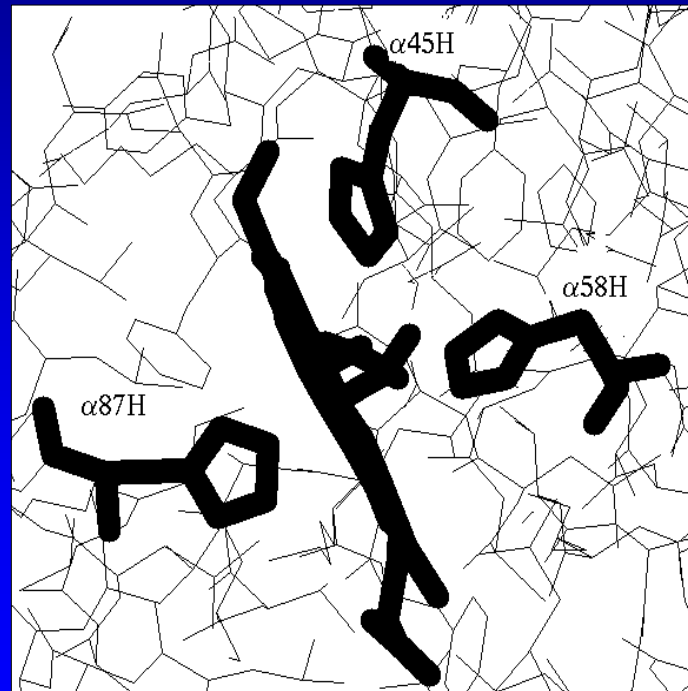
- 20 Genes will be selected to be the gene to split on at the root.
- 3 Genes will be selected to be the gene to split on at each other internal node.
- Constructing the trees using different combinations of the gene at the root and at the leaf, the total number of trees is $180 = (20 \times 3 \times 3)$.

With undergraduate student L. Liang, Math Prof. Jones and CS Prof. Livingston



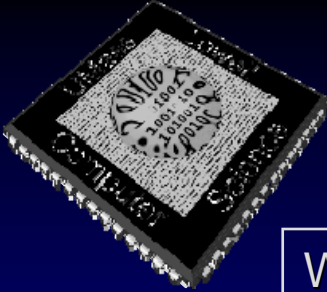
Bioinformatics: Hemoglobin Assembly Simulation

- Model molecular environment
- Can a molecular complex “fit” into environment?



from NSF proposal

With students S. Kundu, S. Rathi, Biochemistry Prof. McDonald and postdoc Vasudevan



Dynamic Channel Assignment for Wireless Networks

[GLOBECOM 2001, INFORMS TELCOM 2004, UMass Lowell Student Research Symposium 2003, 2004, ACM SIGMOBILE's Mobile Computing & Communications Review]

With ECE Prof. Chandra & graduate students S. Liu, S. Widhani, H. Rathi

➤ Input:

- Number of time periods
- 7 x 7 square cell grid
- Set of channels
- Co-channel interference threshold
 $B = 27234$
- Demand for each time period

➤ Output:

- For each time period
 - Feasible assignment of channels to cells satisfying:
 - Demand model
 - Co-channel interference constraints
 - $(\text{SignalStrength}/\text{Interference}) > B$
 - Computation time limit
 - Minimize number of channels used
 - Minimize reassignments across time

Demand

○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○

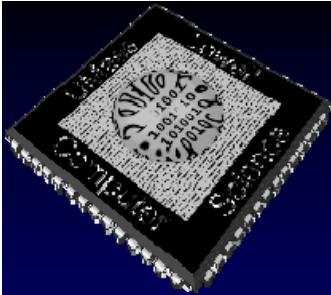
Sample solution for 1 time period

●	●	●	●	●	●	●
●	●	●	●	●	●	●
●	●	●	●	●	●	●
●	●	●	●	●	●	●
●	●	●	●	●	●	●
●	●	●	●	●	●	●
●	●	●	●	●	●	●

Assignment

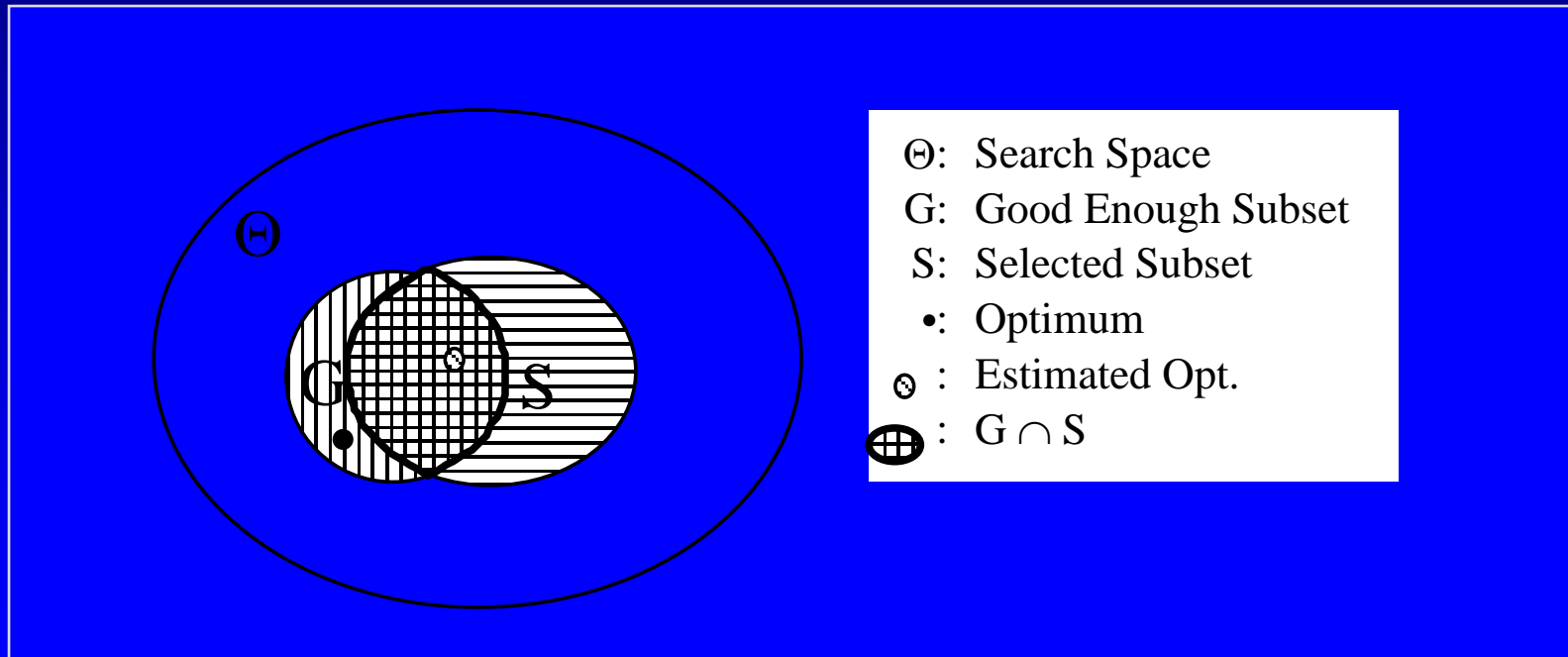
5 different channels are used

solution assumes no channel repetition within any 2 x 2 square

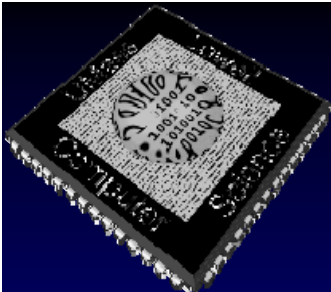


Manufacturing: Inventory Optimization

➤ Using Ordinal Optimization [Ho, Harvard]
to schedule factory production



With PhD student S. Bouhia in Harvard's Division of Engineering & Applied Sciences and Center for Textile & Apparel Research; also UMass Lowell graduate students S. Gupta & S. Banker



Information Sciences, Engineering and Technology

ISET Research Scholars Program

Research Projects

- Optimizing Channel Allocation in Wireless Networks
 - H. Rathi (2002-2003)
- Modeling Hemoglobin Formation
 - S. Kundu (2003)
 - S. Rathi (2003)
- Flow Networks
 - S. Casey (2005)

Faculty mentors

Scholarship support

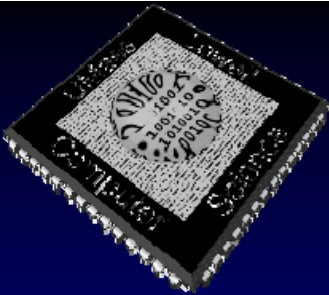
Sponsored by National
Science Foundation



Research Projects

- Polygonal Covering
 - S. MacFarland (2005)
 - A. Hussin (2005)
- Algorithm Efficiency
 - A. Singh (2006)
- Random Forests for Cancer Classification
 - L. Liang (2006)
- Bioinformatics
 - N. Laflin (2006)
- Topological Estimation
 - N. Laflin, V. Durante (2006)

This program was funded by NSF from Fall, 2001 - Summer, 2007.



Key Partners & Resources

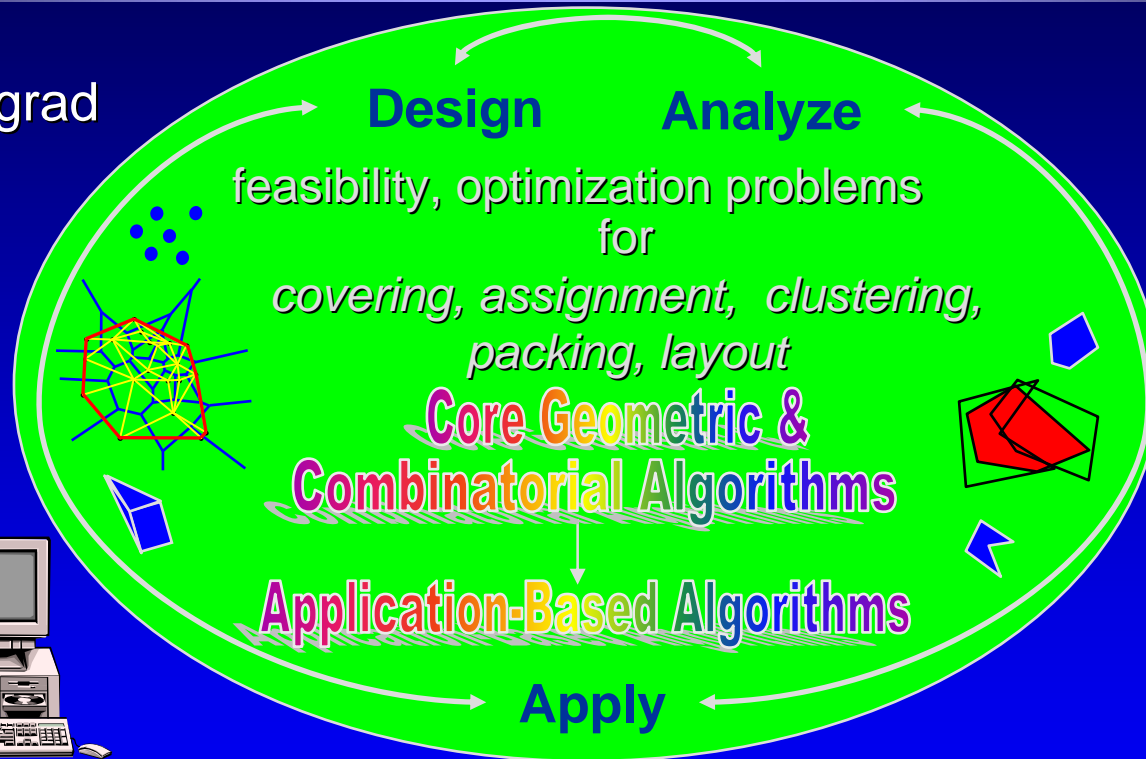
Students:
ScD, MS, undergrad



Computers:
SparcUltras,
Sun Blades,
PCs



Software Libraries:
CPLEX, CGAL, LEDA



Affiliations:

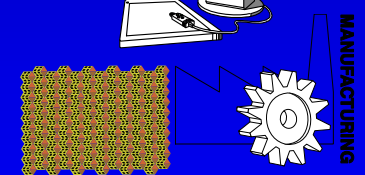
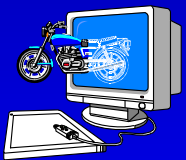
CACT



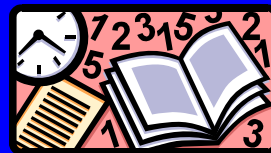
IVPR



HCTAR



Algorithms Courses:
91.503, 91.504, 91.404



Applied
Algorithms
Lab:
OS 220B

