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October 1997 Seminars

October 3

Combinatorics Seminar

Alexander Kostochka, Novosibirsk State University and Emory University
``On the number of edges in colour-critical graphs and hypergraphs''
4:00 pm in Skiles 269

ABSTRACT: In order to understand why some graphs have high chromatic number, one needs to study k-critical graphs, i.e. graphs of chromatic number k whose proper subgraphs have smaller chromatic number. The aim of the talk is to survey how small number of edges can a k-critical graph or hypergraph with given number of vertices have. Colour-critical graphs with restrictions on the clique number or girth are also considered.

October 10

Combinatorics Seminar

Mihai Ciucu, Math, Georgia Tech and Institute for Advanced Study
``An improved upper bound for the three dimensional dimer problem''
4:00 pm in Skiles 269

ABSTRACT: Let n be even and denote by f(n) the number of domino tilings of a cube of side n. The three dimensional dimer problem is to determine the limit $l_3 := \lim {}^{(\log f(n))}/_{n^3}$ (which is known to exist). The best previously known upper bound was found by Minc using a general inequality for permanents, and is ${}^{(\log 6!)}/_{12} = 0.54827....$ Using a combinatorial approach, we show how to improve this bound to 0.463107.

October 17

No seminar due to AMS conference

October 24

Combinatorics Seminar

Christopher Carl Heckman, Georgia Tech
``Independent Sets In Triangle-Free Graphs Of Bounded Degree''
4:00 pm in Skiles 269

ABSTRACT: A survey of the literature on independent sets in triangle-free graphs with fixed maximum degree will be presented. Included will be lower bounds on the independence ratio for graphs with maximum degree, algorithms for finding such independent sets with guaranteed bounds, and several open problems.

October 28

ACO Colloquium

Bart Selman, Cornell University
``Heavy-Tailed Phenomena in Combinatorial Search''
4:45 pm in Instructional Center, Room 211

ABSTRACT: Recent progress on search and reasoning procedures has been driven by experimentation on computationally hard problem instances. We propose to bridge the gap between purely random instances and highly structured ones by introducing benchmark problems derived from a structured domain but whose structure is perturbed to some degree. We will show how to obtain interesting search problems in this manner, and how such problems can be used to study the robustness of search control mechanisms. We also study the cost profiles of combinatorial search procedures using our benchmark domain. Our study reveals some intriguing properties of such cost profiles. The distributions are often characterized by long tails or ``heavy tails.'' We will show that these distributions are best characterized by a general class of distributions that have no moments (i.e., an infinite mean, variance, etc.). Such non-standard distributions have recently been observed in areas as diverse as economics, statistical physics, and geophysics. They are closely related to fractal phenomena, whose study was introduced by Mandelbrot. We believe our results are the first finding of the suitability of these distributions to study purely computational phenomena. Finally we show how random restarts can effectively eliminate heavy-tailed behavior, thereby dramatically improving the overall performance of a search procedure.

Joint work with Carla Gomes (Rome Lab / Cornell).

October 31

Combinatorics Seminar

Jan Thomson, Georgia Tech
``Excluded minors in cubic graphs and edge 3-coloring''
4:00 pm in Skiles 269

ABSTRACT: Tutte conjectured that every graph with no minor isomorphic to the Petersen graph and no isthmus is 3-edge colorable. K. Kilakos and B. Shepherd found a decomposition theorem for cubic graphs with no minor isomorphic to H, the Petersen graph with one edge removed. They used the decomposition to show a weakening of Tutte's Conjecture, that every cubic graph with no minor isomorphic to H and no isthmus has a 3-edge coloring. I will give a more direct proof of the coloring result of Kilakos and Shepherd.

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November 1997 Seminars

November 3

ACO Colloquium

Alex Rosa, McMaster University
``Symmetric Graph Designs''
4:45 pm

ABSTRACT: We introduce the notion of a symmetric graph design as a common generalization of symmetric block designs and of orthogonal double covers, and examine their existence and properties.

November 6

Probability and Statistics Seminar

Prasad Tetali, Georgia Tech
``A Survey of Results on the Hard-Core Lattice Gas Model''
3:00 pm in Skiles 269

November 7

Combinatorics Seminar

Christopher Carl Heckman, Georgia Tech
``Independent Sets In Triangle-Free Cubic Planar Graphs''
4:00 pm in Skiles 269

ABSTRACT: Albertson, Bollobás, and Tucker conjectured in 1976 that every triangle-free cubic planar graph on v vertices has an independent set of size at least sv, for some $s > {}^{1}/_{3}$, with s possibly as large as ${}^{3}/_{8}$. In this talk, a proof of this result (for $s = {}^{3}/_{8}$) is presented; furthermore, s cannot exceed ${}^{3}/_{8}$, so this result is the best possible. This is joint work with **Robin Thomas**.

November 14

Combinatorics Seminar

Margaret Readdy, Cornell University
``Mixed volumes of slices of the unit cube''
4:00 pm in Skiles 269

ABSTRACT: Laplace proved the volume of the k^{th} slice of a unit cube is given by an Eulerian number. We generalize Laplace's result by giving a combinatorial interpretation for the mixed volumes of two adjacent slices from the unit cube in terms of a refinement of the Eulerian numbers. This is joint work with **Einar Steingrimsson** and **Richard Ehrenborg**.

November 20

Colloquium

Michael Monastyrsky, Institute of Theoretical & Applied Physics, Moscow
``Application of Knot Theory to Condensed Matter''
4:30 pm in Skiles 269 (Refreshments in Skiles 135 at 4:00 pm)

ABSTRACT: In this talk we report some recent advances in the application of topology to some problems in physics. We consider the classification of defects in liquid crystals and superfluid liquids and phases in He_3. We consider new representations of knot and links invariants related to special braid groups. These results are connected with explicit calculations for correlation functions in two-dimensional conformal models.

November 21

ACO/College of Computing Lecture

Steven Rudich, Carnegie Mellon University
``Discrete Mathematics for Computer Science Freshmen: Making Rigor Fun''
1:00 pm in MiRC 102 (A&B)

This talk will be a description of my Freshman course entitled ``How To Think Like A Computer Scientist.'' It is the most popular way for Computer Science majors to satisfy the Discrete Mathematics requirement at Carnegie Mellon University. Course topics include: Counting, Groups, Fields, Polya Enumeration, Stable Marriage, Multiplication Algorithms, Primality Testing, Factoring, RSA, Infinity, Undecidability, Gödel's Theorem, NP-completeness, Firing Squad Problem, Finite Probability, Probabilistic Methods, Perfect Hashing in Expected Linear Time, Zero-knowledge Proofs, Graph Theory, Perfect Secrecy, and Secret Sharing Schemes.

I have spent the past nine years thinking about how to make mathematics a fun and engaging subject. I will try and articulate my discoveries in this talk. The 84 students surveyed at the end of the last semester rated the course 4.93/5, despite the work load and rigorous grading policies.

ACO Colloquium

Steven Rudich, Carnegie Mellon University
``Reducing the Complexity of Reductions''
4:00 pm in Skiles 269

ABSTRACT: The theory of NP-completeness is based on the notion of polynomial time reduction between sets, but the same theory can be based on much weaker notions of reduction. For example, all the NP-complete sets listed in Garey and Johnson remain NP-complete under LOGSPACE reductions. In fact, they all remain NP-complete under AC^0 reductions.

One of the outstanding questions in the theory of NP-completeness is the twenty year old Berman-Hartmanis conjecture. The conjecture states that all the sets complete for NP under polynomial time reductions are polynomial time isomorphic. In this talk, we prove the Berman-Hartmanis conjecture for AC^0 reductions: all sets complete for NP under AC^0 reductions are AC^0 isomorphic. Thus, all the thousands of NP-complete sets encountered in the literature are AC^0 (depth 3) isomorphic.

What makes our result possible is a technique to reduce the complexity of any AC^0 reduction between two NP-complete sets to something almost trivial to compute and invert. The new, simpler reduction is a subtle transformation of the original, requiring application of the Hastad Switching Lemma.

We also give a construction for what is (to the best of our knowledge) the first NP-complete set for

which there is no AC^0 reduction from Satisfiability.

More formally, we show three theorems that hold for any complexity class C closed under (uniform) TC^0-computable many-one reductions.

> ISOMORPHISM: The sets complete for C under AC^0 reductions are all isomorphic under isomorphisms computable and invertible by AC^0 circuits of depth three.
>
> GAP: The sets that are complete for C under AC^0 and NC^0 reducibility coincide.
>
> STOP GAP: The sets that are complete for C under AC^0 + PARITY and AC^0 reducibility do not coincide.

These theorems hold both in the non-uniform and P-uniform settings. To prove the second theorem for P-uniform settings, we show how to derandomize a version of the switching lemma, which may be of independent interest. This is joint work with **M. Agrawal**, **W. Allender**, **R. Impagliazzo**, and **T. Pitassi**.

No **Combinatorics Seminar** due to lecture by **Steven Rudich**

November 28

No **Combinatorics Seminar** due to Thanksgiving holiday

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December 1997 Seminars

December 2

Gruia Calinescu, Georgia Tech
``Improved Approximation Algorithms for MULTIWAY CUT''
4:30 pm (room TBA)

ABSTRACT: Given an undirected graph with edge costs and a subset of k nodes called terminals, a multiway cut is a subset of edges whose removal disconnects each terminal from the rest. MULTIWAY CUT is the MAX SNP-Hard problem of finding a multiway cut of minimum cost. Previously, a very simple combinatorial algorithm due to Dahlhaus, Johnson, Papadimitriou, Seymour, and Yannakakis gave a performance guarantee of $2(1-{}^{1}/_{k})$.

In this talk, we present a new linear programming relaxation for MULTIWAY cut and an approximation algorithm based on it. The algorithm breaks the threshold of 2 for approximating MULTIWAY CUT, achieving a performance ratio of at most 1.6. We believe that a somewhat more complicated algorithm achieves a ratio of at most 1.5. This is joint work with **Howard Karloff** and **Yuval Rabani**.

December 4

Mathematics Colloquium

Peter Alfeld, University of Utah
``Multivariate Splines and the Bernstein-Bezier Form''
4:30 pm at Skiles 269

ABSTRACT: Multivariate splines are smooth piecewise polynomial functions defined on a tessellation of an underlying domain. They are used for interpolation and approximation of functions and data, the design of surfaces, and for the numerical solution of differential equations. Their basic properties are very simple in the univariate case (of one independent variable) and very complicated in the multivariate case. The Bernstein-Bezier form of a polynomial is a way of representing a polynomial that allows to approach algebraic problems (like how to ensure a differentiable transition from one polynomial piece to another) in geometric terms. This talk is focussed on bivariate splines defined on triangulations of a two-dimensional domain. It will summarize the history of bivariate splines, introduce the Bernstein-Bezier form, illustrate its use, and state some unsolved and apparently very difficult problems.

December 5

ACO Colloquium / Combinatorics Seminar

Peter Alfeld, University of Utah
``Multivariate Splines and the Four Color Map Problem''
11:00 am at Skiles 269

ABSTRACT: This talk describes an approach to solving a particular multivariate spline problem using the same techniques that were used to solve the four color map problem. Thus we construct an unavoidable set of sub-triangulations using a discharging technique. The ideas are illustrated by proving a simpler result by the four color map techniques. That result, however, can also be obtained

by simpler means. The work described here is very tentative but it does illustrate a perhaps unexpected connection between multivariate splines and the four color map problem. Understanding the talk requires familiarity with the Bernstein-Bezier form of a bivariate polynomial which is introduced in the preceding colloquium. The slides for this talk may be previewed on http://www.math.utah.edu/~alfeld/talks/S13/4CMP.html.
