Rose-Hulman Institute of Technology –26'th Undergraduate Mathematics Conference (2009)

Student Speaker Abstracts; Listed according to Presentation Times

Friday 3:30-3:50 p.m. G221, Crapo Hall

Jason Sauppe, RHIT

Title: *A Tabu Search Algorithm for the Bandwidth Multicoloring Problem*

Abstract: The bandwidth multicoloring problem is a generalization of the graph coloring problem where nodes receive multiple colors and the difference between colors assigned to adjacent nodes must be at least the weight of the edge joining them. The goal is to find a coloring that minimizes the difference between the smallest and largest colors used, or the color span. We present a tabu search algorithm for solving this problem that starts with a greedy initial coloring and iteratively searches for colorings with a smaller color span. Results from our approach are compared with the best solutions reported in the literature.

Friday 3:30-3:50 p.m. G222, Crapo Hall

Elizabeth Sweeney , IUPUI

Title: *Schroeder's Functional Equation for Linear Fractional Maps on the Ball*

Abstract:

Friday 4:00-4:20 p.m. G221, Crapo Hall

Sara Evans , Berea University

Title: *The Theta Complex of Graphs*

Abstract: This talk presents the information contained in an undergraduate research paper, which explores the homotopy equivalence of the Theta Complex of families of graphs. Given the definition of a graph and its Theta Complex (to be covered in the talk) the principal of the project was to establish and prove generalized formulas indicating the homotopy equivalence of said theta complexes. The ultimate goal was to search for patterns regarding the Theta Complex, so that we might discover rules or generalizations that hold for ALL graphs, not just those explored in the paper. The method used was overall very visual, and did not seek to find the exact mapping which would show that the graphs were homotopy equivalent. Initially the Theta Complexes were studied by literally drawing the graphs and attempting to visually derive the results. However, with complicated graphs and even with higher order simple graphs, the Theta Complexes were almost or

actually impossible to visualize. So we used the exact definitions of the graphs by listing the elements of the edge set and determining which simplices were critical (an indicator of the homotopy equivalence.). However, this soon became exceedingly difficult, as the edge sets became larger for graphs of a higher order. We were finally able to develop a method of determining critical simplices without listing all possible simplices belonging to the Theta Complex of a graph (which will be discussed during the talk). The results show formulas for the homotopy equivalence of six families of graphs, as well as insights into the complexity of those graphs relative to their theta complex. For example, graphs that were highly symmetric required much less intense calculation and the resulting formulas were simple in construction. However, graphs with minimal symmetry required intricate tables to fully explain the resulting formulas. Also, it noted that graphs whose theta complexes were contractible would cause another graph of any shape to be contractible whenever the two were "attached".

Friday 4:00-4:20 p.m. G222, Crapo Hall

Bonny Jain, IMSA

Title: *On the Embedding of Degree Sequences on the Projective Plane and Torus*

Abstract: The degree sequence of a graph is the list of its vertex degrees counted with multiplicity (usually given in nonincreasing order). A graphic realization of a sequence S is a graph with degree sequence S. An embedding of a graph is a drawing of its edges and vertices on a surface such that no edges cross. The problem of determining which degree sequences have the property that every graphic realization is planar was addressed by Prince and Wenger (2008). This raised the question of which degree sequences have every realization embed on other surfaces, namely the projective plane and the torus. In this talk we discuss joint work with Prince regarding the embedding of realizations of degree sequences on the projective plane and torus.

Friday 4:40-5:00 p.m. G221, Crapo Hall

Darrin Weber and Robert Arn, Millikin University

Title: *Can You Count?: A Look at Expected Scenarios by Way of a Quantitative Computer Simulation of the Ancient African Game Mancala*

Abstract: Mancala is a strategy game that has two rows of six cups, each filled with four stones with two empty pits on either side. By distributing the stones in a counter-clockwise manner the objective is to maximize the quantity of stones in a players' pit. By changing the number of initial stones and cups each player has, we hope to find an optimal strategy by analyzing the

expected number of moves, the winner in each outcome, score differential, and the number of different ways a game can be played by computer simulation.

Friday 4:40-5:00 p.m. G222, Crapo Hall

Sarah Jabon, RHIT

Title: *Content-Based versus Semantic-Based Image Retrieval: A LIDC Case Study*

Abstract: Content based image retrieval is an active area of medical imaging research. One use of content based image retrieval (CBIR) is presentation of known, reference images similar to an unknown case. These comparison images may reduce the radiologist's uncertainty in interpreting that case. It is, therefore, important to present radiologists with systems whose computed-similarity results correspond to human perceived-similarity. In our previous work, we developed an open-source CBIR system that inputs a computed tomography (CT) image of a lung nodule as a query and retrieves similar lung nodule images based on content-based image features. In this paper, we extend our previous work by studying the relationships between the two types of retrieval, content-based and semantic-based, with the final goal of integrating them into a system that will take advantage of both retrieval approaches. Our preliminary results on the Lung Image Database Consortium (LIDC) dataset using four types of image features, seven radiologists' rated semantic characteristics and two simple similarity measures show that a substantial number of nodules identified as similar based on image features are also identified as similar based on semantic characteristics. Furthermore, by integrating the two types of features, the similarity retrieval improves with respect to certain nodule characteristics.

Saturday 10:10-10:30 a.m. G221, Crapo Hall

Harley Eades III, Millikin University

Title: *From Graph Theory to Formal Language Theory*

Abstract: Abstract: It is known that any undirected graph can be converted into a digraph. I will use this fact to prove that the set of paths starting from a particular vertex of a digraph can be represented as language generated by a minimal regular grammar. I will conclude with a discussion of future research that investigates using this correspondence in commutative ring theory.

Saturday 10:10-10:30 a.m. G222, Crapo Hall

Sheng Ting Lin, IMSA

Title:	*Origami Axiom 6: Solving Cubic Equations and Trisecting Angles*
Abstract:	The Huzita-Hatori axioms are a set of rules of the mathematical principles of origami. They describe the operations on the Euclidean plane that can be made when folding a piece of paper. Each one of the seven axioms could be visualized mathematically and by folding paper. One of the axioms, Axiom 6, states that, given two points p_1 and $p_2 and two lines ℓ_1 and ℓ_2, there is a fold that places p_1 onto ℓ_1 and p_2 onto ℓ_2. This axiom is practical in solving cubic equation and thus angle trisection. In this talk, I will present the seven axioms and how origami can be used to trisect an angle.

Saturday 10:40-11:00 a.m. G221, Crapo Hall

Jordan Phegley, RHIT

Title:	*Enumerating Plane Partitions of Integers*
Abstract:	A partition of a positive integer n is a non-increasing sequence of positive integers such that their sum is n. The partition function is the function that returns the the number of partitions of its input integer. Al- though the partition function appears straight-forward, further study reveals some subtle properties. There are numerous identities and congruences, some of which have only recently been proven. Plane partitions are an extension of integer partitions to two dimensions. Although similar in appearance to integer partitions, plane partitions have a more complex structure that require different methods of enumeration. Likewise, the simple identities and congruences of integer partitions are not as forthcoming. I will be discussing methods of enumerating rectangular plane partitions and, beyond that, explaining different grid shapes and possible techniques for counting the partitions on them.

Saturday 10:40-11:00 a.m. G222, Crapo Hall

John Wang, IMSA

Title:	*The Educational Black-White Achievement Gap: Significant Factors in a Static State Intergenerational Model*
Abstract:	The black-white achievement gap is a robust empirical phenomenon in economics. Since the early 1960s, researchers have found that black students score consistently worse on tests than white students. This presentation explores the factors that cause such a gap and attempts to understand the determinants of lower test scores for blacks. We develop a model that exhibits a static state variation of Neal's (2005) intergenerational achievement gap model. Then, we proceed to analyze data from two cohorts of middle schoolers with multivariate regression analysis-one in Philadelphia and a randomized sample that comes from the Tennessee Star

Project. We find that a statistically significant portion of the residual gap persists and cannot be fully explained with the set of covariates available. We conclude that school effort and study skills are the primary determinants of worse academic performance, but that these may be linked to other exogenous variables, such as socioeconomic status or school quality.

Saturday 11:20-11:40 a.m. G221, Crapo Hall

Peter Nebres, IMSA

Title: *Lattice Geometry*

Abstract: Consider the two-dimensional integer lattice Z2, where the vertical and horizontal distance between consecutive lattice points is 1 unit. A lattice shape is a polygon that can be drawn so that its vertices are all on the lattice points. There are many polygons that are not lattice shapes. In this talk, I will show why certain shapes, such as equilateral triangles, are not lattice shapes.

Saturday 11:20-11:40 a.m. G222, Crapo Hall

Tim Olson, Valpariso University

Title: *Vertical transmission in epidemic models of sexually transmitted diseases with isolation from reproduction*

Abstract: We describe a population logistic model exposed to a mild life-long sexually transmitted disease, i.e. without significant increased mortality among infected individuals and providing no immunity/recovery. We then modify this model to include groups isolated from sexual contact and analyze their potential effect on the dynamics of the population. We are interested in how the isolated class may curb the growth of the infected group while keeping the healthy population at acceptable levels. In particular, we analyze the connection between vertical transmission and isolation from reproduction on the long term behavior of the disease.

Saturday 11:50-12:10 p.m. G221, Crapo Hall

Vladislav Kontsevoi, IMSA

Title: *PROBLEM SOLVING IN ELEMENTARY MATHEMATICS: The IMO and the Putman Competition*

Abstract: The International Mathematical Olympiad (IMO), open to six high school students from each country and held since 1959, and the William Lowell Putnam Mathematical Competition, held since 1927 are arguably the two most prestigious competitions in mathematics available to secondary school

	students and undergraduates, respectively. Each competition offers contestants the opportunity to solve problems by chiefly elementary methods (with the Putnam Competition requiring knowledge of analysis), but success in either competition requires ingenuity in creative problem solving. In this talk, I will present applications of fundamental mathematical ideas such as invariance, symmetry, and induction to problems from the IMO and from the Putnam Competition.

Saturday 11:50-12:10 p.m. G222, Crapo Hall

Igor Minevich, IUPUI

Title:	*Synthetic Proof of the Cevian Nest Theorem*
Abstract:	Projective geometry dates back to as early as the third century with Pappus of Alexandria. Much of the research in it was done in the 19th century, but theorems continue to be discovered even today with the advent of the computer and programs like the Geometer's Sketchpad. We present some of the fundamental ideas in projective geometry and part of a recently discovered synthetic proof of the cevian nest theorem.

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