Student Research Presentations
Présentations de recherche des étudiants
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LAURA BROLEY, Concordia University
Computer programming in "doing mathematics": Mathematical research vs. undergraduate mathematics education

Many mathematicians today construct computer programs in order to accomplish important research tasks, be it calculation, visualisation, experimentation, simulation, or even proof. And yet, undergraduate mathematics students are only rarely invited to conceptualize and write their own programs. Why? The experiences and perspectives of 14 Canadian mathematicians provide possible explanations and may serve as the foundation for bridging the gap, should that be deemed the favourable direction to take.

MELANIE FOERSTER, University of Calgary
The Contact Number Problem in the Plane

Given a packing of n unit disks, we want to maximize the number of touching pairs (the number of contacts) in the packing. In other words, given a set, P, of n points in the plane, with pairwise distance at least one, we want to determine the maximum number of times that two points are of distance one apart in P. In this talk we give a proof of Harborth's Theorem on the maximum contact number in the plane. Additionally, we examine the totally separable version of Harborth's Theorem.

SARAH MATHIEU-SOUCY, Concordia
What do calculus' students think about mathematical theory?

This talk will report on 56 students' perceptions of mathematical theory and what it is useful for. The students were individually exposed to one of four different approaches to teaching a Calculus topic and then engaged in a task-based interview. Based on the data and with the goal of characterizing students' views of mathematical theory and how they (don't) use it for problem solving, 5 categories came up. I will present them with examples of students' statements. The analysis strongly suggests that students view theory only as explanatory and (therefore) unnecessary for problem solving. Furthermore, they don't recognize the role of theory or generalized examples in developing problem solving techniques. We reflect on the (negative) implications of students' perceptions of theory and propose to discuss possible remedial strategies.

KAVEH MOUSAVAND, Université du Québec à Montréal
Exceptional Modules over Hereditary Algebras

This talk starts by a short reference to the fact that over an algebraically closed field K, every basic, connected, finite dimensional hereditary algebra A is isomorphic to a path algebra KQ, where Q is a finite, connected and acyclic quiver. This may suffice to believe that studying the path algebra of these simple quivers leads to interesting results in some other areas. Hence, each finite dimensional module over A could be considered as a structure on the associated quiver Q, called a representation of Q, which will be introduced via examples, and the notion of dimension vector becomes clear.

As a bit more technical aim, I will talk about the idea of canonical decomposition of a given dimension vector. In particular, we will look at some of the motivations for this problem, addressed by V. Kac, A. Schofield and some others. Namely, a generic behaviour (in the sense of algebraic geometry) that occurs in the affine variety $Rep(Q, \alpha)$, where points are representations of the quiver Q, all of the same dimension vector α. This is important if we recall that by the well-known Krull-Schmidt theorem every finite dimensional module M over A uniquely decomposes into indecomposable summands.

Although the problem could be stated in a more general setting, in this talk we assume Q is finite, connected and acyclic. If time permits, a class of modules with strong homological properties, known as Exceptional, will be introduced and their prominent role in the canonical decomposition will be highlighted.

YULIYA NESTEROVA, Queen's University
Exploring the Beta Invariant over Toric Varieties

When faced with a line bundle L on a projective algebraic variety X over $\mathbb{C}$, it is useful to be armed with some invariants to understand what we are dealing with. To this end, we consider the blowup at a point whose exceptional divisor is E. Visually, once presented with a shape to each point of which a direction has been assigned, we are inserting a copy of $\mathbb{C}^n$ at a problem point in order to more closely examine the point. These tools suffice to give us a new invariant to assign to our line bundle.

In this talk we follow up on the paper by McKinnon and Roth, exploring the invariant $\beta(x) = \int_0^\infty \frac{Vol(\pi^\star L - \gamma E)}{Vol(L)} d\gamma$; we present an alternative closed form for this invariant for a line bundle L on a toric variety, exploring the asymptotic ability of global sections of a line bundle to approximate it. We briefly discuss the convenience of toric varieties as testing grounds for invariants in algebraic geometry, using this invariant $\beta(x)$ as a launch pad for our exploration. In particular, the visually striking cases of $\mathbb{P}^1 \times \mathbb{P}^1$ and $\mathbb{P}^n$ for a general n will be showcased.

We then make the explicit connection of the ingredients of $\beta(x)$ to volumes of Okounkov bodies of the corresponding line bundle and variety (following earlier work of Okounkov and Khovanskii).

YING JIE QIAN, McGill University
The Extremal Function of Unions of Triangles

A graph H is a minor of a graph G if H can be obtained from G by deleting vertices and edges and contracting edges. A deep theory of graph minors has been developed by Robertson, Seymour and others. We discuss extremal properties of graphs not containing a particular fixed graph as a minor.

For a graph H, let the extremal function of H be the supremum of $|E(G)|/|V(G)|$ taken over all simple graphs G not containing H as a minor, denoted by $c(H)$. My conjecture that if H be a disjoint union of graphs H_1 and H_2 then $c(H) \leq c(H_1) + c(H_2) + 1$, if true provides a general way to determine $c(H)$ for many disconnected graphs H. This conjecture has been recently "almost settled" by Csoka, Lo, Norin, Wu and Yepremyan, which allowed them to verify a conjecture of Reed and Wood about the value of $c(H)$ when H is the disjoint union of cycles, as a special case.

Further, we discuss the value of $c(H)$ when H is a union of (not necessarily) disjoint triangles, determining the exact value in many cases.

MORGAN ROOSENMAALLEN, University of British Columbia Okanagan
Nucleic Acid Conformation Space as an Optimization Problem on Simultaneous Group Equations

Conformational changes in the phosphate backbones of individual nucleotides is a primary driver of large scale, polynucleotide conformational changes. As much of the functionality of RNA is derived from its conformation, thorough knowledge of the conformational limits of its constituent components is therefore of great importance. By viewing the phosphate backbone as a kinematic chain and sampling the chain's solution space in a regular manner, I demonstrate that the conformation space of a nucleotide backbone can be approximated by viewing the sample space as a graph edge cover problem with unusual conditions. By defining a group on the set of perfect matchings of bipartite graphs, the cover problem is reduced to finding a minimum solution to a system of group equations.

HAOTIAN SONG, University of Calgary
The 2 Disjoint Shortest Paths Problem with Distance Constraints

An electric power supplier needs to build a transmission line between 2 jurisdictions. Ideally, the design of the new electric power line would be such that it maximizes some user-defined utility function, for example, minimizes the construction cost or the environmental impact. Due to reliability considerations, the power line developer has to install not just one, but two transmission lines, separated by a certain distance from one-another, so that even if one of the lines fails, the end user will still

receive electricity along the second line. We discuss how such a problem can be modeled and prove the exact problem to be NP-hard. In addition, we demonstrate an approximate setting that allows us to solve this problem in polynomial time.

DON YU, York University

Temperature-driven model for the abundance of Culex mosquitoes

Vector-borne diseases account for more than 17% of all infectious diseases worldwide and cause more than 1 million deaths annually. Understanding the relationship between environmental factors and their influence on vector biology is imperative in the fight against vector-borne diseases such as dengue, malaria, and West Nile virus. We develop a temperature-driven abundance model for West Nile vector species, Culex pipiens and Culex restuans. Temperature dependent response functions for mosquito development, mortality, and diapause were formulated based on results from published field and laboratory studies. Preliminary results of model simulations compared to observed mosquito traps counts from 2004-2014 demonstrate the capacity of our model to predict the observed variability of the mosquito population in the Peel Region of southern Ontario over a single season. The proposed model has potential to be used as a real-time mosquito abundance forecasting tool and would have direct application in mosquito control programs. This is work is supported by CIHR, PHAC, and NSERC, under the supervision of Professors Neal Madras and Huaiping Zhu.