Women in Mathematics and its Applications Research Day at AIMS

Hosted by the African Institute for Mathematical Sciences (AIMS) - South Africa

Organizers

Karin-Therese Howell, Associate Professor, Stellenbosch University
Nancy Ann Neudauer, Professor, Pacific University, and Associate Secretary of the Mathematical Associate of America

Panels and Discussions

Out of Africa: Study, Research, and Collaboration opportunities
Student Networking: Breakout Groups by Research Topic
Belonging and Community: Building the Network
Building Community . . . What next?

Research Talks

Discrete Energy behavior of a damped Timoshenkosystem

Sabrine Chebbi (Tunisia)
AIMS Research Centre

The Timoshenko system describes the transverse vibrations of a beam at a first approximation, these movements can be modeled by a set of two coupled wave equations. In this talk, we consider a one-dimensional Timoshenko system subjected to different types of dissipation (undamped, linear damping and nonlinear damping) and we design a discretization scheme, based on a combination between the finite element method and the finite difference one. This scheme presents the discrete energy formula showing the positivity, the energy conservation property and the types of the decay rates in the case of a damped system. We numerically reproduce the analytical results established on the decay rate of the energy associated with each type of dissipation.

Neural Machine Translation for Low-Resource Languages

Everlyn Asiko Chimoto (Kenya)
AIMS Research Centre

In recent years, neural networks have achieved remarkable performance in language translation for numerous languages. However, African languages have not seen adequate benefits from this progress, despite being spoken by large populations. Insufficient digitized language data is a key barrier to developing effective translation models, leading to most African languages being considered low-resource. This talk aims to explore the techniques used to create neural machine translation models for low-resource African languages. The techniques include transfer learning, active learning, and data pruning, all of which can assist in developing effective machine translation models for low-resource languages.

Inductive tools for graphs

Carolyn Chun (USA)
United States Naval Academy and University of Maryland

In this talk, we consider inductive tools for graphs (and matroids) that preserve a kind of robustness, called connectivity. In 1966, Tutte proved that every 3-connected graph (or matroid) other than a wheel (or whirl) has a single-edge deletion or contraction that is 3-connected. Seymour extended this result in 1980 to show that, in addition to preserving 3-connectivity, we can preserve a given substructure, namely a 3-connected minor. We present the long-running project joint with James Oxley and Dillon Mayhew to obtain such results for graphs (and matroids) that are internally 4-connected.

Emmy Noether, the Large Hadron Collider, DUNE and . . . you

Claire David (Canada)
York University and Fermi National Accelerator Laboratory

Experimental particle physics is based on a gauge theory called the Standard Model. It describes the building blocks of matter, aka elementary particles, and their interactions through three (of the four) fundamental forces of nature. The Standard Model has proven incredibly successful with many of its predictions verified experimentally with mind-boggling accuracy. At its foundation lies a theorem about symmetries and conservation that was discovered by the German mathematician Emmy Noether. This presentation introduces Emmy Noether briefly and then will showcase the two particle physics experiments I work on. The first is ATLAS, a multi-purpose detector at the Large Hadron Collider at CERN, the European Organization for Nuclear Research. The second is the Deep Underground Neutrino Experiment, DUNE, a future multi-detector complex aiming at understanding the neutrinos. Finally, I will talk about you, the audience, and tell you what are the possibilities for mathematicians interested in exploring the subatomic world and how to trust yourself to catch your dreams.

The Mathematics of Facial Recognition

Maya Gibson (USA)
Pacific University

Facial recognition is the process of receiving an input image and identifying the individual. The computer must reduce a large amount of data from an image so that the most important information is retained while removing unnecessary information. We investigate the mathematics of two methods: Principal Component Analysis and Linear Discriminant Analysis. Principal Component Analysis reduces the dimensionality of data by finding principal components that describe the variance of data. Linear Discriminant Analysis identifies an individual among several classes of faces by finding a projection vector that maximizes the difference between classes and minimizes the variance within a class. We compare these methods.

What is a zero-knowledge protocol?

Martha Kamkuemah (Namibia)
AIMS Research Centre

A zero-knowledge protocol is our name for a distributed algorithm that enables a sender to inform a receiver of some secret without having to communicate the secret itself. For example, in online banking, a customer can access his/her account without revealing his/her password. In identity authentication, a user can prove his/her identity without disclosing personal information. Topically, public-key cryptography has recently used a zero-knowledge protocol to identify its users.

Although the term "zero knowledge" may seem paradoxical due to the fact that at least one bit of information is revealed about the truth of a statement, we borrow the term from its original use in the context of a distributed prover and verifier. The goal of this talk is to use a modal operator of knowledge ("who knows what") to capture the concept of zero knowledge. Once we have established this notion, we will demonstrate how it is implemented in a zero-knowledge authentication protocol. To achieve this, we will epistemic logic to analyse and reason about the behaviour of Lamport's One-Time Password-Authentication Scheme.

You Can't Make Diamonds! Reconfiguring Independent Dominating Sets in Graphs

Kieka Mynhardt (Canada and South Africa)
University of Victoria

An independent dominating set D in a graph G is a set of vertices, no two of which are adjacent, such that every vertex not in D is adjacent to a vertex in D. Such a set of smallest cardinality is called an i-set. Using all the i-sets of G, we make a new graph H, called the i-graph of G, whose vertices are the i-sets of G, and where two vertices (i-sets) are adjacent if their symmetric difference consists of two adjacent vertices. Which graphs can be made in this way? We show that not all graphs can. This leads to the open problem of determining exactly which graphs are realizable as i-graphs.

Motivated Agents

Shreya Pandit (USA)
Massachusetts Institute of Technology (MIT)

Motivation is a powerful force that drives human action and behavior. It drives us to pursue our goals and aspirations and can significantly impact our decision-making processes. In the field of artificial intelligence, the most common method for modeling human action and decision-making is through reinforcement learning, which relies on external reward-based learning mechanisms to influence the agent's behavior. While rewards are a primary incentive for learning both in the brain and in machines, recent studies have shown that reward signals in the brain influence motivated behavior in a way that is distinct from learning. In this paper, we design a motivated agent that makes decisions based on individual motivation, rather than learning. To do this, we set out to demonstrate that a motivated agent can outperform a learning agent in a sparse reward environment. We also propose a framework for a goal sustaining mechanism based on dopamine firing, and demonstrate how this component immediately impacts the agent's behavior in a grid environment without relying on learning. In summary, our work aims to contribute to the understanding of motivation and its role in decision-making, both in humans and in artificial intelligence. By designing a motivated agent that can make decisions based on individual motivation, we hope to shed light on how this fundamental aspect of human psychology can be modeled and utilized in artificial intelligence.

A knapsack problem combined with a difference equation model to optimise resource allocation during an epidemic

Linke Potgieter (South Africa)
Stellenbosch University

The tumultuous inception of an epidemic is usually accompanied by difficulty in determining how to respond best. In developing nations, this can be compounded by logistical challenges, such as vaccine shortages and poor road infrastructure. To provide guidance towards improved epidemic response in terms of team and vaccine allocation, a knapsack problem in combination with a network-based SEIRVD epidemic model was formulated and will be presented in this talk. For the sake of generality, results are presented for a range of network structures, representing different types of interconnected populations in rural and urban settings. The approach followed, when compared with a range of alternative resource allocation strategies typically used in real world scenarios, were found to reduce both the number of cases per epidemic, and the number of resources required.

Wallman basis and S-metrizability of Frames

Cerene Rathilal (South Africa)
University of Johannesburg

García–Maynéz made use of a Wallman basis as a tool to characterise S-metrizable spaces (ie. spaces whose topology can be induced by a Property S metric). Utilizing the results of Garcia–Maynez, in this talk, we shall provide an intrinsic pointfree characterisation of S-metrizability, in terms of the Wallman basis of a frame. Utilizing results of Steiner, we first show that every compact metric frame is a Wallman compactification of each of its dense sublocales. In addition, we discuss how S-metrizability of a locally connected frame ensures the existence of a countable locally connected and uniformly connected Wallman basis.

Critical aspects of domination in graphs

Riana Roux
Stellenbosch University

The domination number of a graph is the cardinality of the smallest set of vertices of a graph such that every vertex not in the set is adjacent to a vertex in the set. In this talk we will consider how the domination number changes if certain properties of the graph changes. First, I will give an overview of the literature on how vertex- and edge removal, and the subdivision of edges influence the domination number. Then we will look at some open problems and the way forward.

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