THE UNIVERSITY OF BRITISH COLUMBIA

Department of Computer Science, Mathematics, Physics and Statistics
Okanagan Campus

CMPS Undergraduate Research Conference

Day 1:

- Date and Time: **Friday, April 12, 2024, 9:30 am – 3:30 pm**
- Discipline: Data, Math, Physics, & Stats
- Location: **SCI 337**
- Zoom Link: https://ubc.zoom.us/j/68541289559?pwd=dXFRMVMrbmZ0MFZnQ1JTeUxoZThFQT09
- Organizers: Alex Hill, Xiaoping Shi, and Paul Tsopméné
- Contact: Paul Tsopméné (paul.tsopmene@ubc.ca)
- Website: https://cmps.ok.ubc.ca/undergraduate/conference/

(A) Schedule

Welcome: 9:30 am – 10:00 am

Session 1: 10:00 am – 11:00 am, Phys

- 10:00 am – 10:20 am: **Takamitsu Koyano** (honours project) | *Analysis of Structures that Propagate Surface Waves* | Supervisor: Thomas Johnson
- 10:20 am – 10:40 am: **Dilyar Arkin** (directed studies) | *An experimental investigation of low-temperature metal-to-insulator transitions in doped silicon at microwave frequencies* | Supervisor: Jake Bobowski
- 10:40 am – 11:00 am: **Divyesh Dagia** | *Exploring interactions between Radio Frequency Transmission and Earth's Atmosphere* | Supervisor: Thomas Johnson

Break: 11:00 am – 11:15 am

Session 2: 11:15 am – 12:15 pm, Data/Stat

- 11:15 am – 11:35 am: **Jason Samuel Suwito** (Data, honours) | *Spatial Imputation Approach for Missing Raman Spectroscopy in Prostate Cancer Data* | Supervisor: Irene Vrbik
- 11:35 am – 11:55 am: **Daniel Krasnov** (Data, honours) | *GBR-NMF Initialization for Bayesian Positive Source Separation: A Novel Approach to Raman Spectroscopic Analysis* | Supervisor: Irene Vrbik
- 11:55 am – 12:15 pm: **Ryan DeWolf** (Stat/Data, research) | *Random Models for Fuzzy Clustering Similarity Measures* | Supervisor: Jeff Andrews

Lunch: 12:15 pm – 1:15 pm, we will offer the lunch (pizzas) in SCI 337

Session 3: 1:15 pm – 2:15 pm, Math

- 1:15 pm – 1:35 pm: **Tia Der** (directed studies) | *Change Point Regression with a Data Sharpening Approach* | Supervisor: John Thompson
- 1:35 pm – 1:55 pm: **Betty Zhang** (directed studies) | *A Survey of Derivative-Free Optimization Applications in Mathematical Finance and Stock Market Strategies* | Supervisor: Warren Hare
- 1:55 pm – 2:15 pm: **Ruoyan Hu** (directed studies) | *Perron-Frobenius Theory and Applications (Google PageRank)* | Supervisor: Paul Tsopméné

Break: 2:15 pm – 2:30 pm

Session 4: 2:30 pm – 3:10 pm, Phys

- 2:30 pm – 2:50 pm: **Erin Launer** (honours project) | *Testing Polarization Assumptions for the Radio Source PKS B1934-638* | Supervisors: Alex Hill & Jane Kaczmarek
- 2:50 pm – 3:10 pm: **Nasser Mohammed** (NSERC USRA) | *'The Tadpole in Space' - Faraday Tomography with CHIME* | Supervisor: Alex Hill

Closing: 3:10 pm – 3:30 pm, Prize Draw

(B) Zoom Link

We will also stream the presentations via Zoom. Here is the zoom link:

Meeting URL: https://ubc.zoom.us/j/68541289559?pwd=dXFRMVMrbmZ0MFZnQ1JTeUxoZThFQT09

Meeting ID: 685 4128 9559

Passcode: 092566

(C) Abstracts

Takamitsu Koyano

In 1899, A. Sommerfeld introduced the possibility of electromagnetic waves along finite radius wires, followed by J. Zenneck's work on surface waves along the conducting plane in 1907. Sommerfeld also

explored similar systems in 1909. Debye and Hondros analytically confirmed Sommerfeld's cylindrical wave in 1910, later validated experimentally in 1915 by Zahn, Ruter, and Schriever.
In the 1930s, Carson, Mead, and Shelkunoff expanded the theory, identifying TE, TM, and HE modes. G. Goubau resolved issues of radially diverging fields around conducting cylinders by introducing dielectric coatings, defining the resulting wave as the "Zenneck Wave" in cylindrical coordinates or "Sommerfeld Wave".
However, as the development of this area of studies, inconsistencies arose in terminology, prompting a need for classification and comparison of wave propagation systems especially after the addition of Surface Plasmon.
As once Shelkunoff himself mentioned in his paper, the terminology does not have consistency over different papers and claims misusage of terminology leads to confusion.
In this paper we aim to classify each of the wave types and compare with its propagating the system. Additionally, we attempt to show the generalization of Goubau System in Elliptic Cylindrical Coordinate, and verify the relationship of "Zenneck Wave", and "Sommerfeld Wave".

Dilyar Arkin

We have designed, built, and implemented an experiment to measure the microwave power absorption of single-crystal samples of silicon as a function of temperature. We worked with both p-doped and n-doped samples spanning a wide range of doping levels. Our measurements were made using a “loop-gap resonator” operating at 700 MHz which allowed us to measure as-grown crystals without requiring electrical contacts. We used a two-stage closed-cycle cryocooler and a thermal stage to vary the temperature of the sample from 20 to 80 K. The power absorption measurements and sample dimensions were used to extract the surface resistance of the samples. For samples with relatively low doping levels, a sharp decrease in the surface resistance was observed at low temperatures marking the onset of a metal-to-insulator transition. For each sample, a preliminary analysis of the surface resistance data has been used to extract the temperature dependence of the microwave conductivity.

Divyesh Dagia

This experiment is an exploration of Radio Frequency (RF) technology and the atmospheric properties in the local stratosphere. We will be using a helium balloon to attempt RF transmissions over large distances and interact with the higher atmosphere. We plan to send a payload provided to us by the Canadian Space Agency, containing a dipole antenna that transmits an RF signal down to our ground antenna, which is a Yagi-Uda antenna. The payload will also contain a telemetry system with an accelerometer, and a gyroscope. Our choice of antennas allows us to use polarization and changes in radiation pattern to measure the rotational characteristics of the balloon. By doing this, we intend to explore RF technology and effects the atmosphere could have on our RF transmission system. We also intend to observe how RF is attenuated through the stratospheric and tropospheric media. We hope to discover and quantify the relative trends and effects caused by electrical noise and atmospheric activity through this indirect method.

Jason Samuel Suwito

According to the 2023 Canadian Cancer Statistics, 1 in 4 Canadians will die from cancer. For males, prostate cancer accounts for 1 in 5 new diagnoses. One of the ways to reduce cancer mortality is through early diagnosis. Medical physicists have been developing different diagnostic methods for cancer

detection and radiation treatment analysis including using Raman spectroscopy. However, one of the main limitations of Raman Spectroscopy is that the data is very prone to saturation and cosmic rays making some of its spectra unusable. Hence, there is an opportunity to utilize machine learning for imputing the missing spectra. This study aims to compare the performance of known imputation methods for spectrometry-based data such as Random Forest, Quantile Regression Imputation of Left-Censored Data (QRILC), and K-Nearest Neighbour (KNN) with alternative imputation methods that involve weights that incorporate the spatial component of where on the tissue the spectra are measured. The results reveal that spatial imputation methods outperform the regular imputation method. This implies that there is a spatial relationship between spectra in a Raman spectroscopy matrix where spectra that are closer are more correlated than spectra that are further away.

Daniel Krasnov

Raman spectroscopy is an optical interrogation method capable of providing a unique “fingerprint” for both biological and non-biological compounds. However, due to the multiplexed nature of complex Raman spectra, machine learning techniques are required to identify which chemical signals are present. This thesis combines Group- and Basis-Restricted Non-Negative Matrix Factorization (GBR-NMF) with Bayesian Positive Source Separation (BPSS) to create a probabilistic non-negative matrix factorization technique. Our method not only allows for the incorporation of prior knowledge but also quantifies the uncertainty in the source separation process, an aspect missing from most standard NMF procedures.

Ryan DeWolfe

The Adjusted Rand Index (ARI) is a widely used method for comparing hard clusterings, but requires a choice of random model that is often left implicit. Several recent works have extended the Rand Index to fuzzy clusterings, but the assumptions of the most common random model are difficult to justify in fuzzy settings. We propose a single framework for computing the ARI with three random models that are intuitive and explainable for both hard and fuzzy clusterings, along with the benefit of lower computational complexity. The theory and assumptions of the proposed models are contrasted with the existing permutation model. Computations on synthetic and benchmark data show that each model has distinct behaviour, meaning that accurate model selection is important for the reliability of results.

Tia Der

In this talk, we discuss the challenges in estimating noisy regression functions with abrupt changes or ``change-points", where noise surrounding change-points causes errors and overweighting during estimation. We propose an iterative mean-shift clustering approach to improve function estimation around change-points by reweighting variables based on local distributional information. This is achieved through a data sharpening approach, which uses kernels to coalesce similar points to local modes and separate dissimilar points. We show that this method does not assume the shape of the underlying data-generating process or the location and number of change-points present. We explore the reweighting effects on change-point regression function estimator convergence, including the cost to rate of convergence away from change-points and boundaries. Through simulated non-linear data, we find improvements in estimating change-point shapes across many change-point regression estimation methods.

Betty Zhang

Derivative-free optimization has been gaining increasing attention in mathematical finance due to its unique ability to solve non-continuous and non-differentiable types of problems. As the name suggests, we minimize or maximize a function without any information about its first or second-order derivatives. This survey is based on ten papers about the applications of DFO in mathematical finance. Nearly all of the papers used the same approach using the Genetic Algorithm, which is considered to be a DFO algorithm. Thus, the aim of the survey is to answer one question: Why do we use genetic algorithms to solve problems in mathematical finance?

Ruoyan Hu

A matrix is nonnegative if all its entries are nonnegative. Nonnegative matrices frequently arise in many different fields of science and engineering as models of dynamical systems. Information about the eigenvalues and eigenvectors of these matrices is often essential to understanding the dynamical system. The Perron-Frobenius theorem provides a simple characterization of the eigenvectors and eigenvalues of certain types of nonnegative matrices. In this talk, we will go over the Perron-Frobenius theorem and discuss the applications in Web search engines (Google PageRank).

Erin Launer

PKS B1934-638 (hereafter 1934) is commonly used as a polarisation calibrator for radio telescopes in the southern hemisphere due to the assumption that the source has zero linear polarisation. This work aims to test this assumption by assessing the implied polarisation flux of 1934 after applying leakage calibration solutions determined by other well-known radio calibrators. I use a data-set collected by the Australia Telescope Compact Array and I show this assumption to hold true for frequencies ranging from 2.1GHz to 16.8GHz. The outcome of this work will improve confidence in all future projects that use 1934 as a polarization calibrator.

Nasser Mohammed

Faraday rotation influences the structures in the polarized sky at the radio wavelength. Within the Fan region—a portion of the radio sky that stands out in polarized intensity from ~100 MHz to 350 GHz—we find an elongated feature, G137+7. Using the first polarization maps of the Canadian Hydrogen Intensity Mapping Experiment (CHIME), we analyze this feature, dubbing it the ‘tadpole’ due to its ‘head’ and ‘tail’ morphology. Our 400-729 MHz bandwidth and 17' to 30' with CHIME allowed us to perform Faraday synthesis to perform an in-depth case study of the tadpole. The tail extends 10 degrees from the head which is ~2 degrees in diameter, the direction of which suggests the B2(e) star HD 20336 is a candidate for creating this feature through the ionization of the ambient interstellar medium. Investigations of HI and H-alpha find no connection to the tadpole. The head is a coherent feature in Faraday depth (~-8 rad/m^2), and Faraday synthesis identifies multiple Faraday components in both the head and tail. Our results show that our ~octavebandwidth Faraday rotation observations at ~ 600 MHz are sensitive to low-density ionized and partially-ionized gas; undetectable in other tracers.