Abstracts

Opening Address

10:00–11:00
Mathematical modeling, analysis and simulation of biological and bio-inspired systems Room 205
Dr. Padmanabhan Seshaiyer, George Mason University

In the last decade, there have been dramatic advances in mathematical modeling, analysis and simulation techniques to understand fundamental mechanisms underlying biological and bio-inspired systems. This work will present examples of undergraduate research projects that evolved from multidisciplinary applications modeled via coupled differential equations. Some of these examples include using mathematics to understand why aneurysms rupture; understand how zika spreads; studying social dynamics and; employing mathematics to stop poaching of elephants in Africa. Mathematical analysis and computation for some benchmark model applications will also be presented. Finally, we will also discuss how such projects can provide opportunities for students at all levels to employ transformative research in multidisciplinary areas.

Student Presentations (Morning)

11:05–11:20
Artificial Intelligence Applied to Genetic Vaccine Design Room 121
Michael Krause, American University

The American Cancer Society estimates that 155,870 people die from lung cancer annually, accounting for one out of four cancer deaths in the U.S. Common treatments - radiation and chemo therapies - carry dangerous side effects. One promising solution is vaccine therapy, in which the patients own immune system is modified to recognize and destroy tumors while leaving healthy cells unharmed. The major hurdle for this method is that the proteins used to trigger a tumor-specific immune response are extraordinarily complex, and vary from patient to patient, making the development process costly and slow. To accelerate vaccine therapy research, we present a computational package that semi-automates the production of patient-specific protein vaccines. By providing a ready-made in-silico experimental environment and automating certain elements of the discovery, design, and optimization processes, we facilitate future research into making vaccine therapy a viable lung cancer treatment.

11:05–11:20
Crime Data Analysis Room 122
Stephen Brock, Bryan Lee Ateo-an, Clay Duncan, Samual Evans, Rachel Gorenstein, Liam Walsh, Towson University

Our research seeks to understand patterns in crime occurrence within the city of Baltimore through the use of the point processes. In particular we analyze the Poisson Point Process and its applicability to analyzing crime patterns in comparison to other point processes. Our ultimate goal is to determine if the occurrence of a primary crime at any location affects the probability of the occurrences of other crimes within close proximity in space and time to the primary crime.

11:30-11:45
A Mathematical Analysis of Language Room 121
Gerald Roman-Gonzalez, Stevenson University

Using concepts from information theory such as entropy, we analyze the complexity of several natural and fictional languages. The entropy of a written language, as defined by Claude C. Shannon in his landmark 1948 paper, A Mathematical Theory of Communication, measures how much information is produced on average for each letter of text in the language. Shannon's work led to the foundation of information theory which has shaped the ways in which we communicate today. In a subsequent paper, Prediction and Entropy of Printed English, Shannon estimated the entropy of written English by doing experiments to approximate word and letter frequencies. Since Shannon's work, a multitude of attempts have been made to estimate the entropy of different written languages such as English, Spanish, and Russian. We will analyze and compare the entropy and other similar quantities of constructed languages such as Dothraki (Game of Thrones), Tengwar (Lord of the Rings), Navi (Avatar), Klingon (Star Trek), Esperanto, and Lojban as well as natural languages such as English, French, and Spanish.

2:00–2:15

Boom-and-Bust Dynamics in Financial Systems Room 121

Zhusong Mei, George Mason University

Geometric Brownian motion is often used to simulate assets price paths but this model does not represent the 'boom-and-bust' nature of actual financial markets. I shall describe two closely-related, previously developed, agent-based models. Each of them is based upon a realistic and different source of non-rationality or efficiency, but only one of them has an analytically tractable solution.

It is therefore of interest to try and quantify any statistical differences between the price outputs of the two models. The problem of choosing comparable pairs of parameters will be explained and our results suggest that the statistical similarities between the models may be good enough for many applications (e.g., Monte Carlo simulations).

2:25–2:40

Enhanced Data Exploration and Visualization Tool for Large Spatio-Temporal Climate Data Room 121

Benjamin Smith, Towson University

This project builds on the research from past REU projects by creating CMIViz, a graphical user interface (GUI) for data exploration and visualization of spatio-temporal climate data from the Missouri River Basin (MRB). Teams from 2014 and 2015 REUs built GUIs using the R software to facilitate the statistical downscaling process for precipitation and maximum/minimum temperatures using historical simulated data from the Global Climate Models (GCM) MIROC5 and HadCM3. Modeling attempts for temperature were largely accurate while precipitation proved more difficult to predict due to the semi-continuous nature of rainfall. Therefore, our project seeks to complement modeling efforts with visualization to reveal spatio-temporal patterns such as underlying correlations and other trends in the data. In this project we will enhance several aspects of the GUI by using the R package, Shiny, which allows greater control of the GUI design and thus will enable us to give more data visualization and exploration options. Specially, we will enable an easy inter-comparison of the MIROC5, HadCM3, and NCAR-CCSM4 GCMs in terms of prediction accuracy using bias, root mean-squared error (RMSE), and other metrics of interest for daily precipitation. We also seek to determine temporal trends and autocorrelation through the use of time series plots and sample autocorrelation function plots. In order to detect spatial correlation and patterns, we will use contour plots, surface plots, and semivariograms. We will also provide calculation of canonical correlation analysis (CCA) to help find similarities between the models.

2:00–2:40

United States Natural Gas Consumption Room 122

Kelly Coffey, Rachel Gorenstein, Matthew Rhoades, Liam Walsh, Marissa Whitby, Towson University

Accurate forecasting of the United States natural gas consumption is of crucial importance to energy providers for decision making regarding natural gas purchasing and energy pricing to increase profits and efficiency. How do we best model and predict consumption of natural gas while considering possible economic, industrial, and environmental factors that could impact our results? Through analysis of big data sets, pertaining to consumption and temperature, we can find trends, examine seasonality, and identify possible clustering of different states. We employ clustering analysis to group each state into a category based on similar consumption patterns. Our approach drives us to use multiple model inferencing with a base model for each cluster involving a general linear, an ARIMA, and a neural network model. Our approach provides us more insight regarding to energy consumption modeling. In this research, we aimed to better forecast natural gas consumption by accounting for economic, industrial, and environmental factors given two data sets, Power Plant (millions of cubic feet per day) and Residential and Commercial (billions of cubic feet per day). The approach to this problem was to analyze big data sets pertaining to natural gas consumption to find trends, examine seasonality, and identify possible clustering of different states. After the initial analysis, we employed clustering analysis where states were grouped into category based on similar consumption patterns, not necessarily by geographic regions. From this, we worked to create an effective model for a short and long forecasting periods that allow us to develop models for each state. We plan to utilize non-linear models, explore neural networks, incorporate multiple model inferencing, and determine an optimal model. Our research is important because the knowledge gained and models created will help Constellation Energy to increase profits for natural gas purchasing or selling and energy pricing. This of economic and business importance so that Constellation can make effective and efficient beneficial business decisions. This problem and methodology is applicable in the energy consumption industry because it allows businesses to better forecast demand of natural gas or energy to increase profits and better serve the public. Our approach is innovative because we introduce a new method of clustering analysis of big dependent data to calculate the similarity between two time series as well as introduce new models for consumption of natural gas. We used statistical analysis in this research to find benchmark models for each individual state with significant results. These models capture general seasonality of data for state consumption and forecast well.

2:50–3:05

Geometric Deformations of Diamond Frameworks Room 121

Yuliya Mikhnevich, Rider University

We investigate auxetic deformations of periodic frameworks modeled on the diamond structure. In materials science, auxetic behavior refers to the property of lateral widening upon stretching. We identify frameworks which allow auxetic deformations.

2:50–3:05

Planning the Future of Akua Island Room 122

Zachary Hill, Towson University

Our goal is to develop an optimal zoning solution for Akua Island. There are twenty zones available for the following land-uses: conservation, recreation, private housing, fishing, and agriculture. We want to meet the desires of both environmentalists and industry stakeholders. Our team used the data available to us to make the best decision for each zone while keeping all parties involved in mind.

Closing Address

3:45–4:45 Room 205

Challenges and Opportunities in Real-World Simulations on Modern Parallel Computing Platforms

Dr. Matthias Gobbert, University of Maryland, Baltimore County

Processors in consumer devices are dual- or quad-core CPUs today. State-of-the-art distributed-memory computer clusters contain multi-core CPUs with 8 to 16 cores. Most recently, a second-generation of the Intel Xeon Phi many-core processor has more than 60 cores. I will show results on hardware such as these in the context of an application problem of modeling calcium waves in a heart cell that is modeled mathematically by a system of partial differential equations with point sources. These results shown were produced by participants in the REU Site: Interdisciplinary Program in High Performance Computing (hpcreu.umbc.edu) at UMBC in Summer 2016.