Descriptions of 2018 SURP Positions available with Utica Faculty

Faculty: Chen-Fu Chiang

Program: Computer and Information Science

1. **Implementation of Quantum Walk on Reduced Uniform Complete K Partite Graph on IBM Q**

   Students will:

   a) Use systematic dimension reduction on certain high dimension graphs
   b) Use quantum walker (translating between continuous and discrete) on the reduced graph
   c) Implement on a IBM Q (5 qubit) machine via IBM QISKit

   Student Skills: matrix linear algebra, ability to pick up new programming languages fast (will be using a new language), graph theory and computer organization (circuit and gates)

Faculty: Leila Choobineh

Program: Mechanical Engineering

1. **High Power Electronics Cooling**

   Air cooling system and single phase liquid cooling system will be designed to remove the generated heat from power electronics system. CAD software will be used to design the heaters and liquid channels. ANSYS CFD will be used to perform the simulation and find the effective fluid mass flow rate. Then the experimental data will be measured by using LabVIEW software and compared with simulation results to find the most efficient cooling system. To show the efficiency of the designed cooling system, the temperature field before and after applying the cooling system will be compared.

   Student Skills: Fluid Mechanics, CAD and MATLAB programming and LabVIEW in order to start the project. Being hands on and interested in experimental measurements are crucial for this project.

2. **Microelectronics cooling by utilizing thermoelectric coolers combined with thermoelectric generators**

   Lower temperature in 3D ICs result in higher performance and it is necessary to remove the generated heat from the system. Electrical energy can be converted into thermal energy and vice versa in semiconductors . Thermoelectric coolers are solid state material, which operate based on Peltier effect; which applied voltage makes temperature difference while in thermoelectric generator a temperature difference generates electrical energy. The heat generated in chip can be removed by using TEC. Instead of using heat sink for dissipating heat to the surrounding area, a layer of TEG can

be used and the output heat of TEC can be used as the input source for TEG. The power generated in TEG may be used as the input power of TEC or for other parts. The experiment setup should be designed and the measurement will be done to calculate the coefficient of performance of the system. Performing a numerical simulation will give us better understanding of thermal performance of the system.

Student Skills: Fluid Mechanics, CAD and MATLAB programming and LabVIEW in order to start the project. Being hands on and interested in experimental measurements are crucial for this project.

Faculty: Roger Cavallo

Program: Computer and Information Sciences

1. **System Science and Data Science**

   This is an ongoing project to contextualize current fascination with "Data Science" into more established and comprehensive concerns of Science, Technology, and Systems Science. The overall goal is to provide system problem solving interpretation, which in turn provides data-analytic utility to recent mathematical and technical developments. Some progress has been made that needs to be focused. The project will use as motivation the development of specific response to funding possibilities, from both business and not-for-profit sources, to continue this development and provide further student support.

   Student Skills: The student will need to have (and develop) skill in literature search and application to one or more of a number of fairly well defined topics. Student should like and be able to 1)read 2)write 3)learn and "do" mathematics 4)compute.

2. **Graph, Hypergraph, and System Dynamics**

   One of the most important characterizations of systems is that of how they change: for example in a social network, what can be said about changes in the structure of the network that occur from the addition of new components or connections of these components. The project will primarily work out formalisms describing effects of some of these changes based on already existing characterizations of structure in terms of graph and hypergraph classes.

   Student Skills: Most specific skill(s) are interest in and basic knowledge of graph and hypergraph theoretic formalisms.

Descriptions of 2018 SURP Positions available with Utica Faculty

Faculty: Emilio Cobanera

Program: Mathematics and Physics

1. **Boundary control of topological band structures**

   Low-dimensional metals can emerge on low-dimensional arrays of atoms or on the surface of higher-dimensional topological insulators. The two types of metals are dramatically different, starting with the way they respond to disorder. Topological insulators are conceptually challenging; analytic solutions of non-trivial models are an invaluable research aid but remain scarce. I seek to employ one student over the summer to exploit a new diagonalization algorithm to search for analytically solvable models of topological quantum matter. The problem can be circumscribed to the diagonalization of certain structured matrices by a particular method that I will teach to the successful candidate in a self-contained manner.*

   * A. Alase, E. Cobanera, G. Ortiz, and L. Viola, Exact Solution of Quadratic Fermionic Hamiltonians for Arbitrary Boundary Conditions, PRL 117, 076804 (2016).
   E. Cobanera, A. Alase, G. Ortiz, and L. Viola, Exact solution of corner-modified banded block-Toeplitz eigensystems, J. Phys. A: Math. Theor. 50, 195204 (2017).
   A. Alase, E. Cobanera, G. Ortiz, and L. Viola, Generalization of Bloch's theorem for arbitrary boundary conditions: Theory Phys. Rev. B 96, 195133 (2017), featured in Physics, Editor's Suggestion.

   Student skills: Good working knowledge of linear algebra and a strong interest in pursuing creative research competitively. Familiarity with quantum mechanics and numerical methods for ODEs is preferred, but not mandatory.

Faculty: Andrea Dziubek

Program: Mathematics and Physics

1. **Structure Preserving Numerical Methods for Partial Differential Equations on Curved Surfaces**

   Advisor: Andrea Dziubek, Edmond Rusjan (http://people.sunyit.edu/~edmond/EyeDEC/)
   Exterior calculus, developed by Cartan several decades ago, has become the standard language of differential geometry and has gradually been gaining acceptance as the superior formulation of vector calculus in scientific and engineering community. Building on the foundation of modern differential geometry and in particular exterior calculus, geometric mechanics reformulates mechanics, in particular Lagrangian and Hamiltonian mechanics, in the language of geometry. Formulating the problems in the language of

geometrical mechanics has enabled researchers to develop new numerical methods, which preserve geometrical structures.

Students will work with faculty on one or more of the following:

a) Comparing Discrete Exterior Calculus and Finite Elements for some toy examples.
b) Understanding the discrete divergence operator and other operators of the basic equations of fluids, mechanics, and electromagnetism.
c) Implementing discrete exterior calculus routines for problems on curved surfaces.

Student Skills: Preference will be given to students who mastered multivariate calculus, differential equations, and a programming language, preferably Python.

Faculty: Lauren Endres

Program: Biology

1. **Oxidative stress regulation in cancer development and malignant progression**

   Several ongoing projects aim to understand how cells respond to oxidative stress, and how these mechanisms "go awry" in cancer. A primary focus of the research is to examine oxidative stress response pathways at the level of protein translation within the cancer cell. The cell models in use are derived from ovarian and bladder cancer, and research this summer will explore how deregulated protein translation contributes to the development of these types of cancer.

   Student Skills: The successful summer intern should have a strong foundation in biology, having completed freshman biology with at least a B+ average. Preferred (but not required) would also be a good knowledge of cell and molecular biology, particularly the flow of genetic information from DNA to RNA to protein. Also, some basic skills using Microsoft Excel and PowerPoint for data analysis and presentation in graph form (i.e., averages with error bars representing standard deviations) would ensure a successful experience.

Faculty: Amir Fariborz

Program: Mathematics and Physics

1. **Parallel and grid computations in low-energy QCD**

   My research is in theoretical elementary particle physics and is mainly focused on low-energy QCD (Quantum Chromodynamics). The theoretical frameworks in this area typically result in complicated mathematics and require development of various symbolic and numerical computations.

In this project, which is derived from one of my works in low-energy QCD (see for example, A. Fariborz and R. Jora, Physical Review D96, 096021 (2017) and references therein), a system of coupled and highly nonlinear implicit constraints derived from the underlying symmetries and their algebra, will be tackled using grid and parallel computational techniques. The outcome will contribute to our general understanding of gluonium spectra and low-energy hadron dynamics.

Student Skills: Students must be familiar with parallel and grid computation, have taken Multivariate Calculus (MAT 253), Differential Equations (MAT 260) and several upper division physics courses and completed a physics minor (20 credits of university level physics courses).

Faculty: Andrew Gallup

Program: Psychology

1. **Does acetaminophen disrupt emotion recognition?**

   Acetaminophen is a common over-the-counter drug designed to reduce pain and treat fever, but recent studies have shown that it can reduce feelings of social pain and empathy for pain experienced by others. Using a state-of-the-art eye tracking system, this project will extend this line of research to examine how acetaminophen alters how people look at the faces of others to detect emotions from their eyes.

   Student Skills: Students should be familiar with research practices involving human subjects, and have a willingness to learn some basic computing skills involved in designing experiments and analyzing data with an eye-tracker.

2. **Sperm competition in water striders**

   This project will examine behavioral adaptations for sperm competition in water striders (Aquarius remigis). These insects will be acquired from local streams and transported into a laboratory, where a series of experiments will be conducted to assess mating behaviors. Data will be acquired through video recordings and focal sampling methods.

   Student Skills: Ability to handle and work with insects in a must. Field biology and laboratory research experience preferred, but not necessary.

Faculty: Iulian Gherasoiu, *research will take place in Albany*

Program: Electrical Engineering Technology

Descriptions of 2018 SURP Positions available with Utica Faculty

1. **Resilient Water Splitting Cell for Hydrogen Generation**
   Most of the photoelectrochemical (PEC) cells have a surface that is easily oxidized and corroded affording a lifetime of only a few hours before the hydrogen generation stops. The project continues the development of a corrosion resistant and efficient PEC water splitting cell having the ability to spontaneously dissociate water under solar AM1.5 illumination.

   Student Skills: Knowledge of general physics for engineering students, including Electric charge and Electricity related topics. Knowledge of general chemistry.

2. **Resistive Switching Solid Electrolyte Memory Cell**
   Resistive switching memristors are promising to enable various applications as non-volatile memory devices that are extremely small, simple and do not require power to maintain information. This project aims to develop and optimize a metal-oxide/silicon dioxide device, compatible with silicon processes, and will analyze its reliability and operational lifetime.

   Student Skills: Knowledge of general physics for engineering students, including Electric charge and Electricity related topics. Knowledge of general chemistry.

Faculty: Ana Jofre

Program: Communications and Humanities

1. **What's in a face? An interactive visualization of faces appearing in Time magazine 1923-present.**
   We are developing a methodology for analyzing large cultural corpuses that contain images with a focus on Time magazine, and in particular on images of faces in Time. We have extracted all of the images of human faces from the archive, and our goal is to reveal relationships between these visual representations and their corresponding socio-political context. Specifically, we will use visual analytics to gain insight about how the form and context of representations of women and ethnic minorities have changed over time. The outcome of this project is a meaningfully accessible web-based platform through which both researchers and the general public can explore our findings to discover insights into our cultural history.

   Student Skills: Some knowledge of web-development, particularly JavaScript, and a desire to learn more coding. Strong design skills.

2. **Visualizations and digital narratives of historical archives**
   This work is in collaboration with a historian who has done extensive research on women religious congregation, particularly on the changes they underwent after the Second Vatican Council. Our goal is to make this research accessible to the public, through visualizations, concept maps, geographical maps (visualizing movements of the missions), and digital narratives. We have access to thousands of photographs (and other materials) from the archives, as well as other primary sources, such as interviews. The outcome of this project is a web-based platform through which both researchers and the general public can learn about this history through exploring primary sources as well by engaging with the historical theories that bring meaning to the sources.

   Student Skills: Some knowledge of web-development, particularly JavaScript, and a desire to learn more coding. Strong design skills. An interest in history and the humanities.

Faculty: Hisham Kholidy

Program: Network and Computer Security

1. **Building a Security Framework for University Campus Systems**
   Effectively assessing the cyber-security status of the University Campus Systems is a challenging task due to their large size and to their highly dynamic and heterogeneous nature. They are characterized by a large number of devices continuously entering and leaving the network and interacting with a more stable system constituted by servers and facilities belonging to every department. The overall goal of this project is to design and develop a Cybersecurity framework for the University Campus Systems. This framework will cover the entire life-cycle of vulnerability assessment by simulating the university campus systems using a small virtual network. Such project will include deployment of some open source security components, machine learning, and artificial intelligence.
   Student Skills: Requirements: Programming Skills (Java, PHP, Python), Basic Computer Network Experience, Virtual Machine setup and tools testing. Recommended: Penetration Testing, Knowledge of MySQL, Knowledge of distributed systems

2. **An Efficient Security Framework for Cloud Computing Systems**
   Security is a top concern which still solidly in first place in the field of cloud computing. Thus, we needed research on cloud computing security. Modern cloud service providers often provide security during unwanted traffic over cloud systems. The main goal of this project is to practically employ some machine learning techniques that students have studied to classify intrusions and to select the suitable responses against cloud network

attacks. Among the goals also is to build a small cloud testbed for research purpose and to deploy the security framework components in this testbed.

Student Skills: Required Programming Skills (Java, PHP, Python), Basic Computer Network Experience, Virtual Machine setup and tools testing. Recommended: Penetration Testing and Knowledge of MySQL.

3. **SCADA System Security**

   The SCADA cyber security is one of the key research areas. The proposed project specifically contributes toward the need of advanced tool to identify the abnormal behavior across the large SCADA systems such as the Cyber Physical Power Systems (CPPS) in a scalable way. Prospective students have wide scope to select a topic within this field. Some areas of current research activity include: intrusion detection (IDS) and situational awareness (combination of IDS and Threat Intelligence); simulation and machine learning techniques; cyber-physical system interaction and HMI vulnerability; and developing a new data reduction approach to select the important features from the SCADA input data.

   Student Skills: Requirements: Programming Skills (Java, Python), Basic Computer Network Experience. Recommended: Penetration Testing and Machine Learning Approaches

Faculty: Zhanjie Li

Program: Civil Engineering

1. **Computational modeling of cold-formed steel member under fire**

   During fire, elevated temperatures produce degradation of mechanical properties and thermal deformations on steel members, altering their expected performance at ambient conditions. The non-uniform temperature distribution through the cross-section of steel members changes over time of fire exposure, potentially impacting the interaction of buckling modes. This study will investigate complex instability phenomena of cold-formed steel members subjected to fire through computational modeling and using a modal identification approach based on the constrained finite strip method to identify the failure mechanism and their impact on the member's fire rating performance.

   Student Skills: Student should be familiar with structural analysis, MATLAB, and ABAQUS.

Faculty: Michael J. Reale

Program: Computer Science

Descriptions of 2018 SURP Positions available with Utica Faculty

1. **Deep Learning for Automatic Facial Expression Analysis on 2D and 3D Dynamic Data**
   Automatic machine understanding of facial expression behavior has many applications in a wide variety of fields, including education (e.g., automatic tutoring), industry (e.g., advertising, gaming), medicine (e.g., pain detection, human-computer interfaces), and military/law enforcement (e.g., airport security, lie detection). However, there are also many challenges to overcome, including unpredictable lighting conditions, non-frontal head pose, occlusion issues, and "micro-expression" behavior. In this project, we propose to utilize deep learning approaches on dynamic 2D and 3D face data to automatically analyze expressive behavior.

   Student Skills: Required: Python programming experience. Preferred: machine learning experience, computer vision experience, C++ programming experience

2. **Fundus image segmentation and analysis**
   The goals of the project are to perform image segmentation on the arteries and veins from fundus (back of the eye) images, build a 3D mesh of aforementioned vascular structures, and perform analysis as well as simulations from this information. We will explore deep learning approaches to accomplish some of these goals.

   Student Skills: Required: C++ and Python programming experience. Preferred: machine learning experience, computer vision experience.

Faculty: Carolyn Rodak & Brian Sanders

Program: Civil Engineering

1. **Combined Sewer Overflow and Runoff events in the Mohawk River (Year 3)**
   The goal of the work is to identify the critical storm intensity responsible for combine sewer overflow events and the resilience of the river to return to its baseline state after these disturbances. To do this, we will continue an intensive summer sampling campaign which started in the summer of 2016 focused on the presence of microbial indicators of fecal contamination. When not in the field, students will work to document combined sewer overflow (CSO) sources, either previously identified or presently unknown. Field assessment will characterize CSO sites with photo-documentation, GPS location, identification of linking water courses, and other descriptive data. In addition, participants may communicate with local or State officials to assess existing CSO site permitting, and to categorize present or planned CSO site remediation attempts.

Student Skills: Field work will include hiking / walking through wet and rough terrain. Previous experience with field work not required. Experience with GIS a plus.

2. **Probabilistic risk assessment (PRA) of hydraulic fracturing in unconventional reservoirs**
The overarching goal of this project is to quantify and communicate potential health risks from hydraulic fracturing activities through the development of a probabilistic risk assessment framework. This process will involve data collection and exploration into various PRA approaches such as Fault tree analysis and Bayesian belief networks. As data is collected and synthesized, students will have the option to either explore and compare PRA methods or GIS mapping of data synthesized from the literature depending on the student's interest and current skill level.

Student Skills: Basic knowledge of MATLAB required. Probability, risk assessment, and upper division math preferred but not required. Experience with GIS a plus.

Faculty: Edmond Rusjan

Program Mathematics and Physics

1. **Mathematical Modeling of Blood Flow in the Retina of the Eye**
The Mathematical Modelling Lab at SUNY Poly, Utica, specializes in the development, analysis and verification of mathematical models and the current focus is on modelling the blood flow in the retina of the eye. For example, our physically based modelling, based on first principles, coupled with the most advanced analytical and numerical solution techniques, has predicted that changes in the curvature of the retina of the eye lead to significant changes in the blood flow, which in turn may play a significant role in primary open- angle glaucoma. http://people.sunyit.edu/~edmond/EyeDEC/

The blood flow in the retina of the eye is modelled as a Darcy flow through a hierarchical porous medium and is described by the parameterized Darcy equation. This equation is similar to the traditional Darcy equation, which can be used for example to model the flow of water or oil through sand, but it is extended by an additional variable, which represents the various blood vessels: large arteries, small arteries, arterioles, capillaries, and the various size veins. In other words, the model describes not only the spatial flow, but also the hierarchical flow, from arteries, through capillaries, to veins.

Student Skills: The student will have the opportunity to participate and to contribute to all aspects of the project and to focus on one particular area of their choice, appropriate to their level. The prerequisites are a solid background in mathematics, minimally at the

level of calculus, and preferably including linear algebra, differential equations and multi-variable calculus, familiarity with a programming language, preferably Python, and an interest in applied mathematics, including mathematical modelling and scientific programming.

Faculty: Steven M. Schneider

Program: Comm&Hum / IDT-CID-IMGD

1. **Information Architecture: Building Xanalogical Structures**

   This project explores the process of architecting information spaces as xanalogical structures, and assesses the costs and benefits of architecting information spaces designed to facilitate teaching and learning as xanalogical structures.

   Xanalogical structures are a particular form of information architecture focused on symmetrical interconnection among data objects. In this project, we seek to architect existing open educational resources as xanalogical structures, and to develop a testbed to estimate the costs and benefits of xanalogical structure for writers, designers and readers engaged in building and using information spaces for teaching and learning.

   Researchers in this project will complete their work in the open source TiddlyWiki platform. TiddlyWiki is a single page and single file application constructed in JavaScript. Participants design using WikiText, a variant of MarkDown that is optimized to support representation of objects in xanalogical structures.

   Student Skills: Students should have familiarity either with writing HTML documents or writing programs in any language. Skills in JavaScript, database design, manipulating spreadsheets, CSS and text processing very helpful. Willingness to engage in open source community required.

Faculty: Xia Yang

Program: Civil Engineering

1. **Optimize the routing and spreading rate of salting operations in Utica, NY**

   This project will focus on the optimization of salting operations during snow and ice events in Utica, NY. To optimize the routing and salt spreading rate of trucks under different scenarios, knowledge of the fixed and variable costs, social benefits, road network and related parameters, vehicle depot locations, current quantity and operation of trucks and plowing, and crew assignments are required. We also need to investigate the current technology and equipment such as sensors for optimizing the salt spreading

rate. As the optimization matures, environmentally sensitive water bodies, drinking water protection zones, and overall environmental vulnerabilities will be incorporated into the optimization. The student will help with the collection and analysis of this data.

Student Skills: Good background in mathematics (linear and nonlinear optimization); Matlab/Python programming, GIS, and or experience with data analysis is a plus.

Faculty: Yu Zhou

Program: Mechanical Engineering

1. **Robotic Composite Layup Process**

   The ultimate goal of this research is to advance the fundamental understanding of the relationship among composite material properties, automated composite manufacturing processes and product mechanical properties. This summer project will focus on creating the robotic experimental system and carrying out robotic composite layup experiments. The assignments will include:

   - Designing, building and setting up the robotic composite layup system,
   - Performing robotic composite layup experiments,
   - Testing material properties,
   - Other reasonable duties as assigned.

   Student Skills: Machine design with CAD, machining skills, robot manipulator programming