

**2020 Forward Thinking Virtual Poster Session**  
**Table of Contents**

**Jump Start Award Entries**

---

**Ababei, Cristinel; Guan, Wenkai; Moghaddam, Milad Ghorbani**

Algorithm-Hardware Co-Design in Computing Systems: From Embedded Systems to the Cloud

In this project, we propose algorithm-hardware codesign methods for computing systems, from the embedded systems level to the datacenter level, to bridge the affordability compute-demand gap between software and hardware.

Keywords: Embedded Systems, Datacenter, Energy Consumption

**Ababei, Cristinel; Weng, Yuqin**

Balancing of Battery Cells Using Reconfigurable Switch Networks and Simulation in MATLAB

We are developing a simulation framework to co-simulate both the analog models of the battery-pack cells as well as the digital control algorithm for pack balancing and a Graphical User Interface (GUI) is developed to allow the user to investigate via simulations different models for the State of Charge (SoC), different battery-pack topologies.

Keywords: Battery Management System, State of Charge, Graphical User Interface (GUI)

**Ahamed, Sheikh Iqbal; Adibuzzaman, Mohammad; Adib, Riddhiman**

“Is Haloperidol effective in Delirium treatment?”: Answering Treatment and Policy Controversies in Healthcare through Prior Knowledge-driven Structural Causal Model Generation

Is Haloperidol effective in Delirium treatment? - A well-known controversy over the usage of anti-psychotic drug in treatment of delirium has kept physicians and policy makers divided in accepting a standardized treatment. Causal Inference aims to resolve this issue by extracting information from multiple sources and collaborate them structurally through graphical models. Our proposed research shines a light on the aforementioned controversy by generating structural causal model for delirium patients in the ICU from observational datasets, along with prior knowledge published as literature; and this will be built on the backbone of theories of causal inference.

Keywords: Causal Inference, Prior Knowledge, Structural Causal Model

**Ahamed, Sheikh Iqbal; George, Olawunmi; Dabas, Sarthak; Sikder, Abdur**

Motor Imagery Classification Using Convolutional Neural Networks (CNNs)

Motor imagery is the imagination of the performance of an activity. This work explores periodograms and convolutional neural networks for motor imagery classification on a publicly available dataset.

Keywords: Motor Imagery, EEG, CNN

**Ahamed, Sheikh Iqbal; Madiraju, Praveen; Jain, Niharika; Rubya, Sabirat; Franco, Zeno; Hooyer, Katinka; Flower, Mark; Hossain, Md Fitrat; Frydrychowicz, Wylie; Annapureddy, Priyanka**

Towards Developing a Mobile-based Alert System for Veterans

This project is about developing a mobile app based alert system for veterans in crisis. This will trigger appropriate alerts for peer mentors in the project when a mentee under his or her observation might progress to acute crisis from early warning signs which might eventually progress to long term crisis if overlooked.

Keywords: mHealth, PTSD, Peer-Mentorship

**Ahamed, Sheikh Iqbal; Pinto, Daniel; Tumpa, Jannat**

Preventing vision loss from Diabetes: Connecting AI with Behavioral Science to improve eye-health in a community

This is a collaborative contribution of Computer Science, Behavioral Science, and Ophthalmology to prevent vision loss of the diabetic population, especially in minority communities. We propose to build a standalone framework that can be used in community-settings to conduct an automated retinal screening with explainability and make action plans for diabetes management.

Keywords: Explainable CNN, Brief Action Planning, Diabetic Eye Disease

**Ahamed, Sheikh Iqbal; Povinelli, Richard J; Iqbal, Ani; Shuvo, Shafiul Alam; Ma, Jiachen; He, Lin**

Dynamics Reconstruction of Remote Photoplethysmography

Remote PPG is a method that uses a camera to collect a video of the region of the skin from a distance instead of using near-infrared light for PPG recording. The remote PPG signals provide similar health monitoring results to PPG signals. rPPG is a cost-efficient way of measuring essential signals such as heart rate, heart rate variability, and stress levels. Nonlinear signal analysis techniques such as phase space reconstruction could assist the analysis of the remote PPG signals dynamics to provide better results.

Keywords: PPG, Nonlinear Signal Analysis, Phase Space Reconstruction

**Ahamed, Sheikh Iqbal; Saxena, Piyush; Ma, Jiachen**

An Efficient Unsupervised Pattern Learning Framework with GANs

This project is focused on creating a robust feature detection framework on time series inputs. A pre-trained Generator learns to generate mixture of desired features based on desired conditional feature input. A Discriminator can then tell if the conditional input contains desired features.

Keywords: Feature Detection, Unsupervised Learning, Generative Adversarial Networks

**Blumenthal, Edward; Jhuti, Unmila P**

Hyperactive Innate immunity: a contributor of neurodegeneration in Drosophila drop-dead mutants

Innate immunity provides the first line of defense in any infection. The innate immune pathways have many beneficial roles in protecting healthy body functions; but hyperactivation of this pathway can also contribute to adult neurodegenerative diseases such as Alzheimer's, Parkinson's, Huntington's diseases. Drosophila, also commonly known as fruit flies, have a gene called drop-dead (drd) which shows adult neurodegeneration facilitated by hyperactivation of innate immunity. Understanding drd pathogenesis and hyperactivation of immune function will help us to understand some aspects of disease pathology of many human adult neurodegenerative disorders.

Keywords: Neurodegeneration, Hyperactive Innate Immunity, Drop-Dead Mutants

**Fitzgerald Jacklynn; Bennett, Meghan; Sheeran, Claire**

Timecourse of Heart Rate Variability (HRV), Cortisol, and Trait Anxiety in Adults

Prior research examines HRV and cortisol separately and at one point in time in their relation to anxiety. In contrast, we aim to examine the timecourse of HRV and cortisol over multiple measurements during a 1-day testing session to test the relationship between changes in HRV/cortisol and trait anxiety. More research is needed to understand how these metrics change together over time as HRV may be a viable treatment target for trait anxiety through biofeedback.

Keywords: HRV, Cortisol, Anxiety

**Gordon, Nakia S; Kangas, Keara; Wesley, Joia**

Combined Interpersonal Synchronization: Integrating Emotional, Physiological, & Neural Components

Social interactions are necessary for survival; emotion regulation and synchronization may serve as mechanisms to establish the strength of engagement. Integrating emotional, physiological & neurological measures will progress knowledge for social systems.

Keywords: Interpersonal Interactions, Synchronization, Emotion Regulation

**Gordon, Nakia S; Wesley, Joia; Kangas, Keara**

"I Feel You": Exploring Empathy and Physiological Linkage in Friend Dyads

Colloquially people say they "feel" other people's emotions when they are expressing empathy, this project explores whether people are in the same physiological state during empathetic moments. The current study will rely on self report as well as changes in the autonomic nervous system to evaluate how much partners are "feeling" one another during a distressing task.

Keywords: Interpersonal Physiology, Emotions, Physiological Synchrony

**Holly, Lindsay; Malkoff, Anne; Johnson, Madeline; Bohn, Maddie; Zendejas, Val**

Empowering Community Voices to Re-design Mental Health Services for Culturally Diverse Children and Families of Color

The purpose of this study is to improve youth mental health services offered by university-based psychology training clinics by increasing the accessibility and appropriateness of services for ethnically diverse families. The research team will collaborate with community stakeholders to 1) identify concerns related to youth mental health services among families of color, and 2) establish what is needed to re-design mental health care to ensure consistency between service delivery and the context, values, and needs of diverse families.

Keywords: Youth Mental Health Services, Mental Health Disparities, Community Engaged Research

**Hunter, Sandra K; Papanek, Paula E; Hoeger, Bement M; Bollaert, Rachel E; Uhrich, Toni; Piacentine, Linda B; Munson, Erik; Danduran, Michael; Haischer, Mike H; Zirgaitis, Gretchen Z; Beilfuss, Rachel; Turner, P; Weibye, Brianna; Opielinski, Lauren**

Lasting physical and psychological effects of COVID-19

This project aims to understand the lasting effects of COVID-19 infection on physical and psychological function, and how these effects are modified by factors such as age, sex, physical activity, and severity of the disease. These data will inform best practice for long-term physical and psychological rehabilitation of COVID-19 survivors.

Keywords: COVID-19, Physiology, Psychology

**Ko, Jen-Li; Lu, Ganhua**

An Analysis of COVID-19 Pandemic - A Case Study in Wisconsin

COVID-19 has global impact with approximately 40,914,651 confirmed cases (by Oct 19, 2020) (Data from <https://coronavirus.jhu.edu/>). This case study of COVID-19 in Wisconsin will provide a local lens to analyze the statistical data.

Keywords: COVID-19, Statistical Analysis, Wisconsin

**McNamara, Margaret L; Dalton, Sarah Grace; Fial, Alissa; Otto, Kate; Amoruso, Joe; Angelina, Emily; Del Conte, Danielle; Locascio, Amanda; McDermott, Molly; Savino, Patricia**

Transportation access after a stroke: Identifying barriers and facilitators

Stroke causes disability for millions of people in the U.S., which can lead to difficulty accessing the transportation system. Barriers range from physical (e.g., walking) to cognitive (e.g., reading signs, talking to a bus driver), and we are aiming to identify these barriers and create interventions. Transportation engineers and speech pathologists working in concert can create systems that will help reconnect stroke survivors to their communities, enriching life for millions.

Keywords: Transportation, Stroke, Participation

**Medeiros, Henry; Jiayu, Xie**

Searching methods for mobile manipulators

We have a robot which task is to move around and try to locate as many small objects (cylindrical markers) as possible. The position of these markers are known and they are fixed on the ground. To that end, we have developed a stochastic model to improve the search performance.

Keywords: Mobile Manipulators, Stochastic Searching Methods, Kalman Filter

**Medeiros, Henry; Mozhdehi, Reza Jalil**

Deep Convolutional Particle Filter for Visual Tracking

In visual tracking, we determine a specific target in the first frame and track the target in the next frames through challenging scenarios such as occlusion and deformation. We apply a particle filter to a CNN-Correlation framework to face with difficult frames.

Keywords: Particle Filter, Deep Learning, Visual Tracking

**Medeiros, Henry; Siddique, Abubakar**

Real-time Multi-camera Tracking System

We design a real-time multi-camera tracking system for surveillance applications. We process multi-camera video feeds in parallel using an online tracker and associate people in partially overlapped camera networks using our proposed MCTA algorithm. In terms of speed, MCTA can generate real-time output feeds using n-GPUs support for n-cameras.

Keywords: Tracking, Multi-camera, Surveillance

**Ong, LeeZa; Callender, Karisse; Othman, Enaya; Pawlowski, Julia; Witthuhn, Leah**

The Effect of Mindful Prayers on First-Generation Immigrant/Refugee Muslim Women's Wellness: A Qualitative Study

The purpose of this study is to explore impact of prayer on the wellness and mental health of first-generation, immigrant/refugee, Muslim women. Through a qualitative research design, the project examines participants' attitudes towards Salah and Jamaat (communal) prayers and the role of mindfulness in prayers.

Keywords: Muslim Women, Prayers, Mindfulness

**Ong, LeeZa; Othman, Enaya; Omar, Irfan; Bekhet, Abir; Reutter, Stefan**

Assessing Muslims' Mental Health and Related Stigma During Pandemic: A Mixed Methods Study

The purpose of the study is to explore the impact of pandemic on Muslims and its relations to their attitudes toward mental health in Muslim community by using a mixed methods study. This study will provide evidence to enhance antimental health stigma intervention based on culturally specific and responsive approach.

Keywords: Mental Health, Covid-19, Pandemic Response, Culturally Specific

**Povinelli, Richard J; Friedland, David R; Fasae, Taiwo D**

Benign Paroxysmal Positional Vertigo Predictive Diagnosis from Patient-facing Survey

BPPV is a leading cause of dizziness: a common complaint in emergency rooms and responsible for one-third of fall incidents. BPPV Diagnosis is, unfortunately, ridden with uncertainties and errors. In this project, we present machine learning models from medical information gathered from a patient-intake survey, and we demonstrate that BPPV diagnosis prediction is possible.

Keywords: Vertigo, Dizziness, Decision Trees

**Povinelli, Richard J; Quinn, Colin**

Natural Gas Forecasting on the State Level

State or multi-region natural gas forecasting is needed to optimize the use of national infrastructure and balance daily supply with demand. This project aims to develop and validate a set of integrated daily models to predict the aggregated natural gas demand for service regions across the United States.

Keywords: Natural Gas, Consumption Forecasting, Responsible Management

**Richie, James; Sultana, Yeasmin**

LSM and GLSM in inverse electromagnetic scattering

Learn about Inverse electromagnetic problem. Use LSM and GLSM to find object boundary. Use GLSM data to solve qualitative problem.

Keywords: Inverse Scattering, Linear Sampling Method, Generalized Linear Sampling Method

**Roy, Somesh; David, Chloe**

Computational Cost and Accuracy Comparison of Radiation Solvers

Radiation plays an important role in accurate combustion modeling. Various radiative transfer equation (RTE) solvers have been developed to solve for radiation. These solvers require side-by-side comparison to determine the relative computational cost and accuracy of each.

Keywords: Radiation, Combustion, Modeling/Simulations

**Roy, Somesh; Onwuzurike, Tito**

Atmospheric Dispersion Modeling of Hydrogen Sulfide in an Urban Environment

Investigating the impact of the Covid-19 lockdown on the atmospheric dispersion patterns of Hydrogen Sulfide.

Keywords: Atmospheric Dispersion Modeling, Covid-19, Hydrogen Sulfide

**Roy, Somesh; Tauer, Alec**

High Fidelity Modeling of Pollutant Dispersion in Urban Environments

We are using computational fluid dynamics to observe how aerial pollutants disperse through an urban environment. Currently, we are working to see which models can do this accurately and cost effectively.

Keywords: CFD, Pollution, Modeling

### **International Research Award Entries**

---

**Lodh, Nilanjan; Anang, Abraham; Choudry, Javeriya; Marchio, Mickey**

Interdisciplinary global health approach to understand the prevalence and pathology of a neglected tropical disease affecting millions

Schistosomiasis is the second deadliest parasitic disease in the world after malaria affecting approximately 290 million people and accounts for approximately 200,000 human deaths and is a major source of morbidity and mortality in sub-Saharan Africa. The disease is prevalent in Ghana and caused by two major co-occurring species, *Schistosoma mansoni* (intestinal infection) and *S. haematobium* (urinary infection) and is characterized by the presence of parasite eggs in stool or urine respectively. Risk factors to infection include age, sex, occupation, water contact practices, socioeconomic status, and distance to water sources. In Ghana, the area around Weiija Lake is being continuously utilized for human settlement but no study have been conducted on the prevalence of infection with schistosome among the residents in this resettlement areas. This collaborative interdisciplinary study will determine the public perception about schistosomiasis, infection prevalence and disease pathology.

Keywords: Schistosomiasis, Neglected Tropical Disease, Prevalence and Pathology

**Martins, Alexandre A; Franceschini, Juliana**

Community Participation in Public Health Decision-Making and Human Rights: Neoliberal Policies and Universal Health Care Coverage in Brazil

This project addresses the relationship between human rights, democracy, health care, health policies and community participation in Brazil. The Brazilian public health system was created after the 1988 Constitution stated the right to health. Recent political decisions and policies have favored the private health sector and the commodification of health. This project examines the impact of these policies on low-income families. Using participatory action research combined with insights from liberation theology, semi-structured interviews were performed to understand people's experiences with healthcare services in two communities in Sao Paulo. The material collected from these interviews will be analyzed during the fellowship at the Kellogg Institute. The aim is to measure from people's narratives whether or not the new health-related policies promote more access to healthcare services and participatory democracy. The findings will provide education for the communities and resources for public health strategies.

Keywords: Health Care, Human Rights, Community Participation

**Roy, Somesh; Goudeli, Erini; Mukut, Khaled Mosharraf**

Understanding Soot Formation in Combustion Devices

This work is a collaboration between Marquette University and the University of Melbourne. This work focuses on investigating soot formation and working towards a detailed soot model capable of retaining morphology information. The soot nucleation is the least understood phenomena in soot formation. The presented work contains some molecular dynamics results investigating soot nucleation and sintering in depth.

Keywords: Nucleation, Radiative Forcing, Stochastic Algorithm

**Tharp, Tim**

Measuring the Gravitational Force on Antimatter

Does antimatter fall up? For normal matter, whatever goes up must come down. But is this true for antimatter? The ALPHA collaboration has been working for years to build a new apparatus to measure the gravitational force on antihydrogen. Next summer, we will attempt the first measurement of this gravitational interaction, which will discern whether antimatter falls up or down.

Keywords: Physics, Antimatter, Gravity

**Vote!**

---

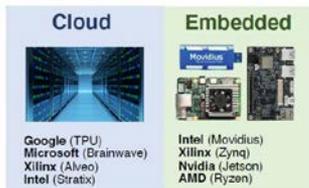
All MU faculty, staff and students are encouraged to view the slides and then [vote for their favorites](#). This voting will determine the finalists for the ORSP Jump Start Award Certificates and Presentations and will weigh into the review of the International Research Award.

Vote at the [Forward Thinking Poster Session](#) page.

# Algorithm-Hardware Co-Design in Computing Systems: From Embedded Systems to the Cloud

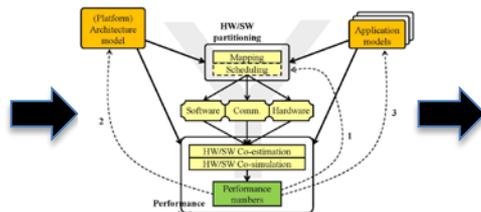
Wenkai Guan, Milad Ghorbani Moghaddam, Cristinel Ababei, Marquette University

## Motivation



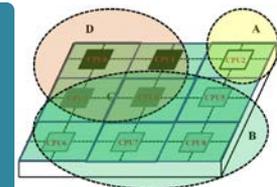
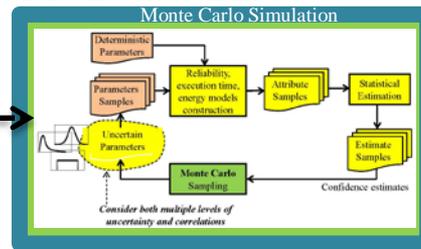
To bridge the affordability compute-demand gap between software and hardware.

## Problems

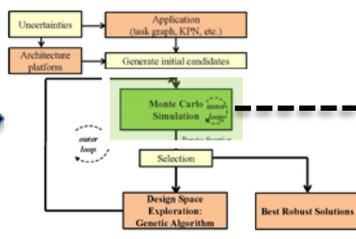


Necessities for considering uncertainty in design parameters

## Methods -- Embedded

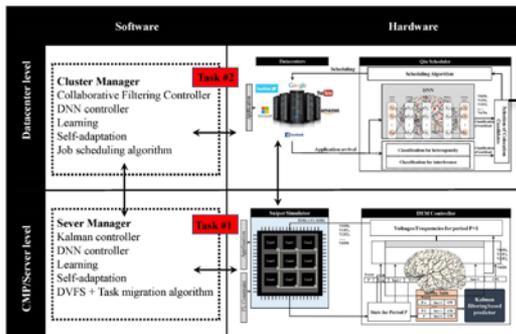


Uncertainty Correlation

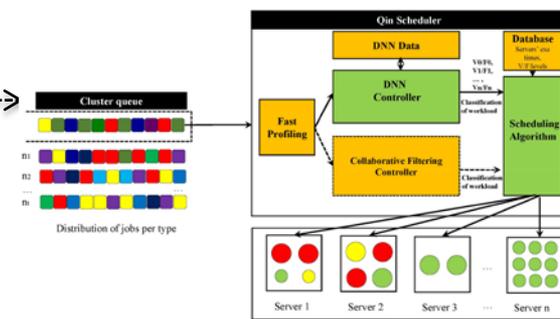


Proposed Method

## Methods -- Cloud



Algorithm-Hardware Co-Design



Deep Neural Network based Scheduler

## Current Results

**Embedded:**

4 EDA tools

DESUU, DESUU2  
DESUU-NOC,  
DESUU-InfoGap

**Cloud:**

2 Deep Learning tools

DEM, Qin

+ 4 publications

1 Journal  
3 Conferences

+ 4 publications

2 Journals  
2 Conferences

## Conclusion and Future Work

**Embedded:**

We propose HW/SW co-design methods in embedded systems under uncertainty.

**Cloud:**

We developed algorithm hardware co-design methods to reduce energy consumption.

**Future:** Energy reduction for deep learning jobs.

# Balancing of Battery Cells Using Reconfigurable Switch Networks and Simulation in MATLAB

Department of Electrical and Computer Engineering, Marquette University

Student: **Yujin Weng**

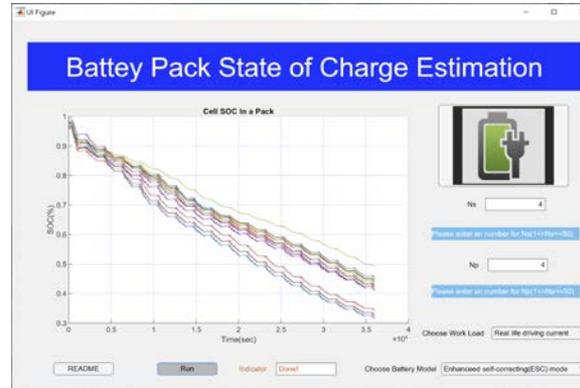
Faculty: **Dr. Cris Ababei**

## Abstract

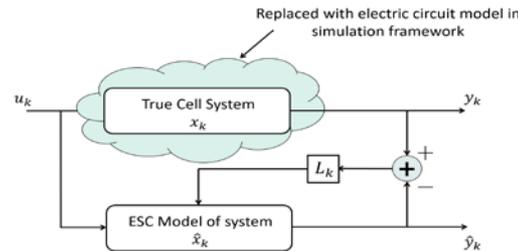
- We are developing a simulation framework to co-simulate both the analog models of the battery-pack cells as well as the digital control algorithm for pack balancing.
- Graphical User Interface (GUI) to allow the user to investigate via simulations different models for State of Charge (SoC), different battery-pack topologies, and different “what-if” scenarios for optimization of the charging/discharging process of the pack.

## Significance

- The framework is significant as it will enable simulations using state-of-the-art SoC models based on Kalman Filters theory.
- Specifically, Enhanced Self-Correcting (ESC) state space models will be the default SoC model used in simulations [1].
- The simulation engine, optimization algorithms, and the interface are developed in MATLAB.
- The source code will be shared with the research community.



Example of 4X4 battery pack state of charge simulation on GUI in MATLAB



ESC cell model runs in parallel with the true hardware cell

## Conclusion and Future Work

- A simulation framework to conduct investigations on: battery-pack size, type of mathematical SoC model, type of workloads, and different optimization algorithms for pack balancing is being implemented.
- Each of the cell's SoC in the battery pack is estimated by an extended Kalman filter.
- Detailed SoC analysis for different cells in the battery pack can be conducted.
- Tool execution time is optimized and reported.
- A switch network used for cell balancing with a new dynamic-programming optimization algorithm will be implemented next.

## References

- [1] G.L. Plett, “Extended Kalman filtering for battery management systems of LiPB-based HEV battery packs Part 3. State and parameter estimation,” *Journal of Power Sources*, vol. 134, pp. 277-292, 2004.

# "Is Haloperidol effective in Delirium treatment?": Answering Treatment and Policy Controversies in Healthcare through Prior Knowledge -driven Structural Causal Model Generation

Riddhiman Adib<sup>1</sup>, Mohammad Adibuzzaman<sup>2</sup>, Sheikh Iqbal Ahmed<sup>1</sup>  
<sup>1</sup>Department of Computer Science, Marquette University, USA  
<sup>2</sup>Regenstrief Center for Healthcare Engineering, Purdue University, USA

*Data doesn't lie. People do.*  
 - Lee Baker, *Truth, Lies & Statistics: How to Lie with Statistics*

*Data doesn't lie... but it doesn't tell the whole truth.*  
 - Bob Fisch, *ForbesBooks*

## Highlights of Research Idea

- **Structural Causal Model** is a standard representation of **underlying causal mechanism** of an experimental scenario.
  - Represents causal relationships through **graph structure**.
  - Highly sought after in healthcare, since it expands knowledge and enables **virtual intervention** (*do-intervention*)
- Causal Inference is the ideal framework to **collaborate information** from multiple data (information) sources, such as:
  - Published literature (i.e., *PubMed publications*)
  - Experts' experience (i.e., *experience of ICU physicians*)
  - Experimental data (i.e., *Randomized Controlled Trial data*)
  - Observational data (i.e., *MIMIC III database*) [Adibuzzaman et. al. 2016]
- Easier said than done, since no **state-of-the-art causal knowledge collaboration** method exists
  - due to large variability in knowledge representation and value from different sources
- **Data-driven analysis** is highly dependent on the questions asked and methodology involved, and highly prone to different types of **biases** (i.e., *selection bias, confounding bias, etc.*)
  - Causal Inference holds **structural definition** to eliminate these biases

## Significance & Innovation

- Delirium occurs in about **80% cases** in the Intensive Care Unit (ICU) and is commonly treated with **antipsychotic drugs (APD)** [Girard et. al. 2008]
- **Controversy** over usage of APDs in treating Delirium, since **RCTs do not agree in clear evidence of similar efficacy or safety**
- **Observational data** has potential to resolve this issue through generating **underlying causal model** using Causal Inference
  - **MIMIC III database**, an extensive EHR dataset with 53,423 distinct hospital admissions [Adibuzzaman et. al. 2016]
- The strength of the proposed methodology is **not limited to only Delirium**, rather any other policy or treatment controversies in healthcare

## Problem Statement

- We aim to build a standard and novel methodology to build a **Structural Causal Model**
  - for a **target experiment** (e.g., *delirium treatment*)
  - from causal information **extracted from published literature**
  - with help of **Structural Theory of Causation** [Pearl et al., 2016].
- The process involves **extraction of experiment type** (*RCT, pragmatic, etc.*), **confounding variables**, **selection variables**, **adjusted covariates**, **reported estimates of causal effects**, etc. from literature.

## Potential Directions

- Common methods of building causal relationships from existing knowledge (publications and datasets) include either **human-actions** (green boxes in Fig 1), **automated-process** (blue boxes in Fig 1), or a combination of them. Due to lack of true causal model, **no standard validation method is known/followed**.

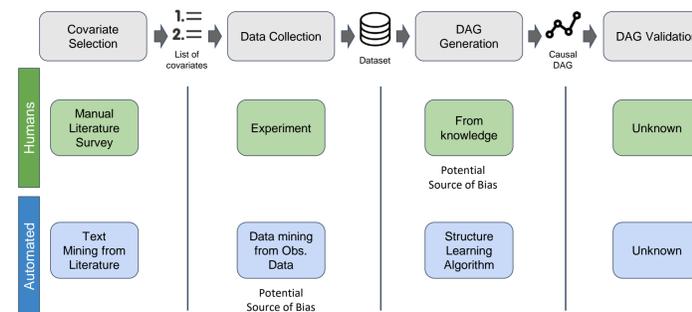


Figure 1: General process for building causal model as Directed Acyclic Graph from dataset, as done through human intervention versus automated

- Our proposed method (Fig 2) extracts causal information and incorporates them together in a structured way. The blue boxes represents **knowledge sources**, gray boxes represent specific **causal information**s at particular stage, and green circles represent segments of our **proposed algorithms**, driven by Causal Inference and defined by Structural Theory of Causation.

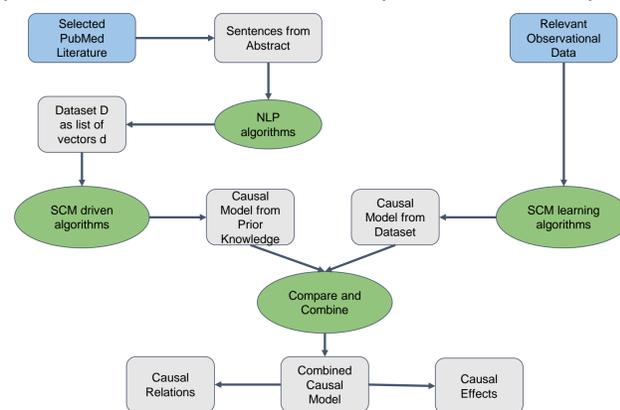


Figure 2: Proposed methodology for collaborating causal information, extracted from literature and publication, using Structural theory of causation

## Discussion & Conclusion

- Our ongoing work is focusing on extracting causal information from published PubMed papers, along with observational datasets. Fig 3 shows a **work-in-progress structural causal model** for delirium patients in the ICU.
- Although our current research focuses on Delirium, the methodology is built as sound and robust, so that it is **extendable to similar problem domains** as well.

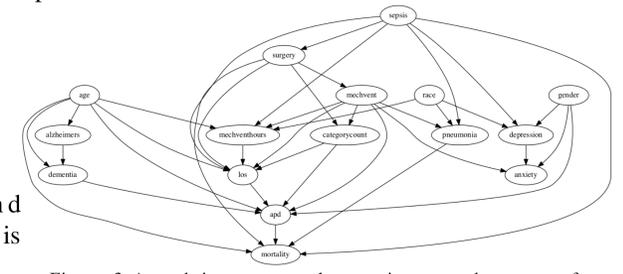


Figure 3: A work-in-progress showcasing causal structure for delirium patients in ICU

## Advancements

- The proposed research activities make notable contributions directly to the field of **Statistical Science**, **Machine Learning**, and **Epidemiology**.
- Our theoretical contribution is to **lower the gaps between experimental and observational studies** and to generate an **unbiased causal effect estimation** from dissimilar datasets with varying experimental settings.
- The study has **translational potential** for the treatment of delirium and the use of antipsychotic medications for delirium patients.
  - In addition to identifying the **effect of APD on outcomes such as mortality and length of stay (LOS)**, the methods can provide a more nuanced approach regarding the **administration of APDs**.
- The method and pipeline can provide the initial results for **larger studies** and a **complete framework** for the application of causal inference methods in other diseases and interventions.

## References

1. Pearl, Judea, Madelyn Glymour, and Nicholas P. Jewell. Causal inference in statistics: A primer. John Wiley & Sons, 2016.
2. Girard, Timothy D., Pratik P. Pandharipande, and E. Wesley Ely. "Delirium in the intensive care unit." *Critical Care* 12.S3 (2008): S3.
3. Adibuzzaman, Mohammad, et al. "Closing the data loop: An integrated open access analysis platform for the mimic database." 2016 Computing in Cardiology Conference (CinC). IEEE, 2016.
4. Girard, Timothy D., et al. "Haloperidol and ziprasidone for treatment of delirium in critical illness." *New England Journal of Medicine* 379.26 (2018): 2506-2516.

# Motor Imagery Classification Using Convolutional Neural Networks (CNNs)

**Olawunmi GEORGE<sup>1</sup>, Sarthak DABAS<sup>1</sup>, Abdur SIKDER<sup>1</sup>, Sheikh Iqbal AHAMED<sup>1</sup>**

1. Marquette University



## INTRODUCTION

- EEG-based Brain-Computer Interfaces (BCI) enhance communication between computers and humans [1].
- They can be used in gaming systems and vehicles.
- Imagined activities elicit similar neuronal mechanisms as actual action [2].
- Sensorimotor cortex is the well-known site responsible for actual & imagined movements.
- Existing publicly available datasets can aid motor imagery analyses.

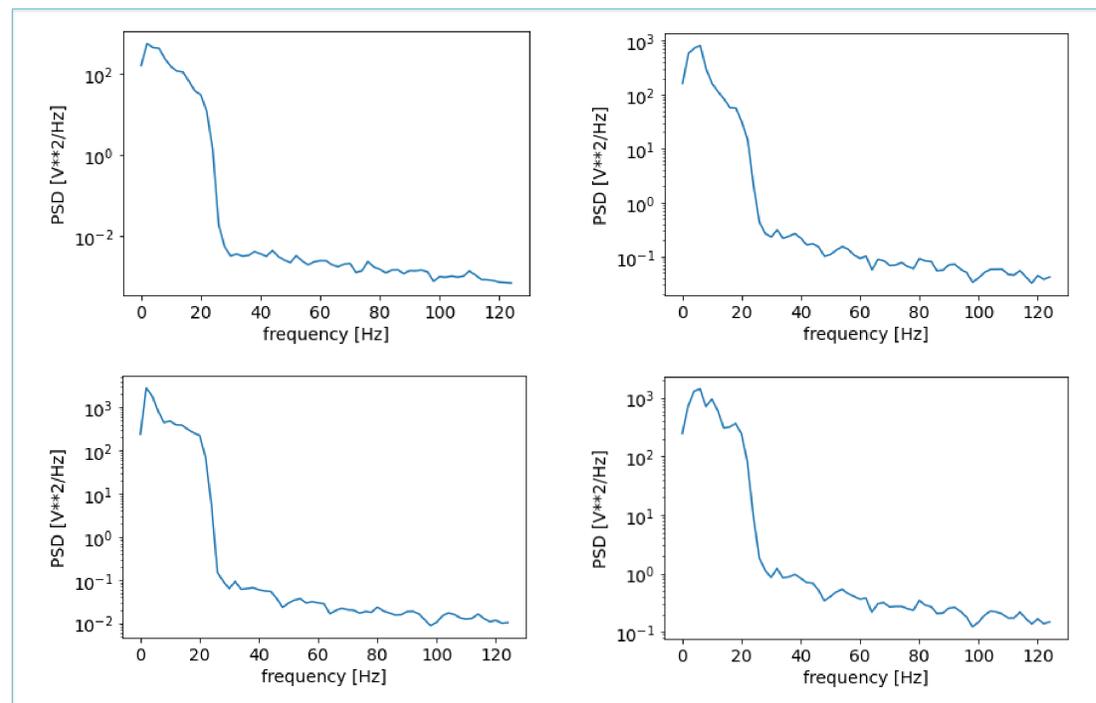
## OBJECTIVE

To classify the imagined movements of users, given two classes of imagined tasks - left & right hand imaginations.

## METHODOLOGY

- Data from 5 subjects were used from a publicly available dataset [3].
- Age range of all subjects: 18-33yrs.
- Trials lasted 7s, with 2s, 3s & 2s for the pre-cue time, imagination & intertrial rest period.
- Number of class trials between 100 & 120.
- 64-electrode 1010-based montage.
- 2s pre-cue period used for baseline correction.
- Segments of the data were rejected based on voltage amplitude & electromyographic (EMG) correlation.
- Subject-by-subject offline analyses was done.
- A convolutional neural network was used for the classification task.
- Periodograms of each trial were used as features in training the network.

## SAMPLE PERIODOGRAMS



## SUBJECT-SPECIFIC PREDICTION ACCURACIES

Subject	Accuracy (%)
II	51
V	51
VIII	57.50
XLIII	56
L	69
Average	57 ± 7.4

## FORWARD THINKING

To expand the subject population by selecting more subjects and exploring other machine learning techniques for the prediction.

## DISCUSSION

- Subject-specific accuracies varied, with highest accuracy achieved by the last subject.
- Lowest accuracy - 51%
- Highest accuracy - 69%
- Accuracies may depend on subjects' ability to generate the necessary signals.
- Only one CNN architecture was utilized.
- Results can be improved by using other feature extraction techniques.
- Comparison with approaches not utilizing feature extraction techniques.

## CONCLUSION

- Motor imagery activity can be classified using CNN architectures.
- Feature extraction techniques such as the periodogram and spectrograms extract frequency-specific information as features.
- Combinations of more than one technique should yield better results.

## ACKNOWLEDGEMENT

Thanks to the original authors of the dataset. Thanks to the Ubicomp Lab BCI team.

## CONTACT INFORMATION

Olawunmi GEORGE: [olawunmi.george@marquette.edu](mailto:olawunmi.george@marquette.edu)  
 Sarthak DABAS: [sarthak.dabas@marquette.edu](mailto:sarthak.dabas@marquette.edu)  
 Abdur SIKDER: [abdur.sikder@marquette.edu](mailto:abdur.sikder@marquette.edu)  
 Sheikh Iqbal AHAMED: [sheikh.ahamed@marquette.edu](mailto:sheikh.ahamed@marquette.edu)

## REFERENCES

- [1] Wolpaw *et al.*, 2002 Brain-computer interfaces for communication and control Clin. Neurophysiol. 113 767-91
- [2] Pfurtscheller, G., & Neuper, C. (2001). Motor imagery and direct brain-computer communication. Proceedings of the IEEE, 89(7), 1123-1134.
- [3] Cho, H., Ahn, M., Ahn, S., Kwon, M., & Jun, S. C. (2017). EEG datasets for motor imagery brain-computer interface. GigaScience, 6(7), gix034.



# Towards Developing a Mobile-based Alert System for Veterans

Md Fitrat Hossain<sup>1</sup>, Wylie Frydrychowicz<sup>1</sup>, Priyanka Annapureddy<sup>1</sup>

Dr. Praveen Madiraju<sup>1</sup>, Dr. Niharika Jain<sup>1</sup>, Dr. Sabirat Rubya<sup>1</sup>, Dr. Zeno Franco<sup>2</sup>, Dr. Katinka Hooyer<sup>2</sup>, Mark Flower<sup>3</sup>, & Dr. Sheikh Iqbal Ahamed<sup>1</sup>



<sup>1</sup> Marquette University, Milwaukee, Wisconsin, <sup>2</sup> Medical College of Wisconsin, Milwaukee, Wisconsin, <sup>3</sup> Mental Health America

## Introduction

- Currently 19.6 million veterans are living in the US [1].
- 14-19% of veterans are suffering from variety of mental health problems (such as PTSD) [2].
- Veterans with PTSD have higher chance of engaging in different types of risky behaviors.
- A mobile based community intervention was introduced by DryHootch.
- This contains a 12-week peer mentorship program.

## Aims

- Define long-term crisis based on PCL-5 score.
- Quantify acute crisis from the EMA survey data which predicts the long-term crisis with sufficiency.
- Develop a statistical model which will predict the progression to acute crisis from early warning signs.

## Data Collection Through App

### Participants

- 143 out of 305 surveyed veterans were diagnosed with PTSD (PCL-5 >33)

### Data

- Three equidistant time-points (Baseline, 6-week Midpoint and 12-Week Discharge).
- At these time points, different psychological scores like PCL-5.
- Ecological momentary assessment (EMA) approaches to collect data on sleep, health, feeling, engaging in risk, and stress.

## Previous Work

Previously with the help of an expert veteran, a psychologist and a medical anthropologist **Early warning signs, acute crisis and long-term crisis have been defined as follows:**  
**Early Warning Sign:** Any weekly survey missed.  
**Acute Crisis:** Any two symptoms getting worse between two consecutive week.  
**Long-term Crisis:** Miss the discharge survey.

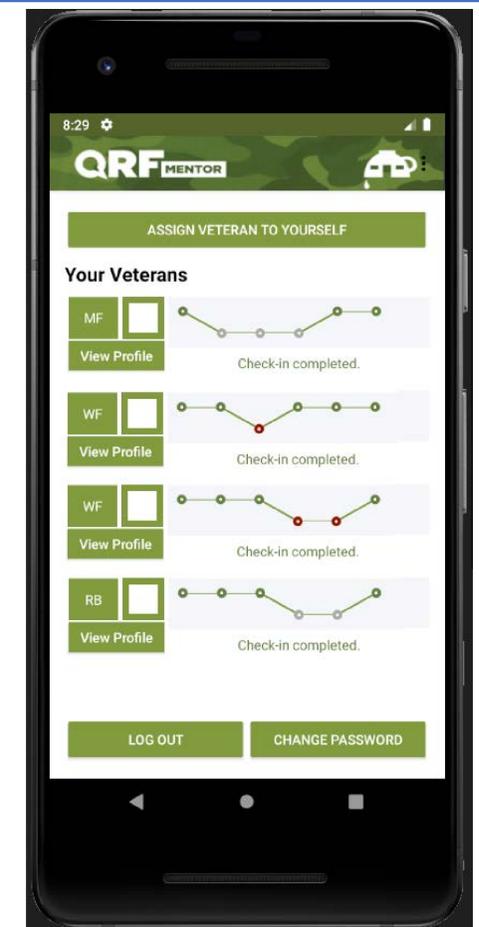
Three algorithms: Decision Tree, Logistic Regression and Naïve Bayes were compared as follows:

	Decision Tree	Logistic Regression	Naïve Bayes
Cross-Validation	0.294	0.295	0.294
False Posit	0.200	0.200	0.178
False NG	0.286	0.286	0.388
AUC	0.757	0.757	0.717

## Discussion and Future Work

- Long-term crisis will be defined based on the PCL-5 score on Baseline and Midpoint.
- A mixed method of focus groups and in-depth interview will be used to learn about peer mentors' decision-making process about intervention.
- This will be compared with ML approach.
- More personalized alert system will be created using machine learning algorithms.
- This system will be generalized to prevent other mental health crises in developing and under-developed countries.

## Mobile App



## Acknowledgement

This is an IRB approved project. We would like to thank DryHootch America for their support in collecting data from veterans. We would also like to thank Dr. Naveen Bansal for his guidance and support.

## References

- [1] US Census Bureau. 2014. Facts for Feature: Veterans Day 2014: Nov. 11. Retrieved September 25, 2015 from <http://www.census.gov/newsroom/facts-for-features/2014/cb14-ff24.html>
- [2] National Institutes of Health. 2015. Post Traumatic Stress Disorder: A Growing Epidemic / Neuroscience and PTSD Treatments. Retrieved September 25, 2015 from <https://www.nlm.nih.gov/medlineplus/magazine/issues/winter09/articles/winter09pg10-14.html>

# Preventing vision loss from Diabetes: Connecting AI with Behavioral Science to improve eye-health in a community

**Student:** Jannat Tumpa<sup>1</sup>, **Faculty:** Dr. Sheikh Iqbal Ahamed<sup>1</sup>, Dr. Daniel Pinto<sup>2</sup>

<sup>1</sup>Department of Computer Science, <sup>2</sup>Department of Physical Therapy, Marquette University

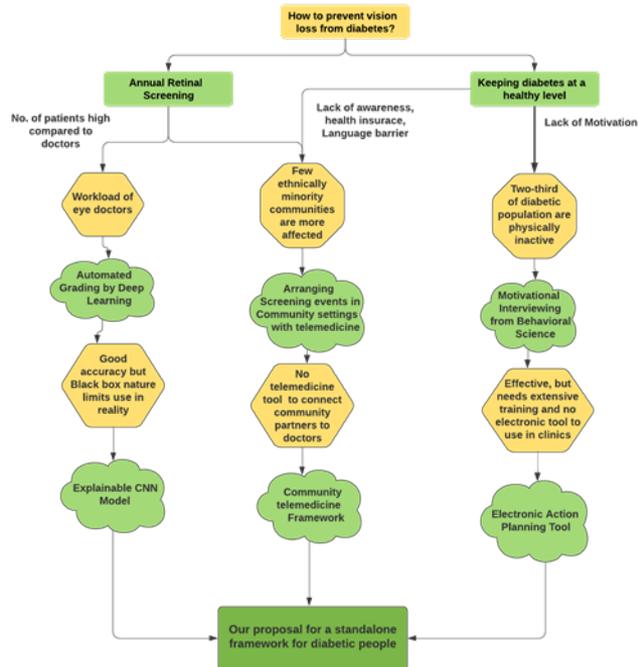
## Problem Domain

- 422 million people worldwide suffer from Diabetes.
- Prolonged diabetes causes vision loss.
- 90% of vision loss from diabetes can be prevented.
- Two main preventive measures are: Annual Retinal Screening and Diabetes Management.
- There are a number of barriers in facilitating these preventive measures.
- A collaborative contribution of Computer Science and Behavioral Science can make a difference.

## Innovation

- Developing an Explainable CNN model for Retinal assessment would be novel contribution in field of Computer Vision and Medical Imaging.
- Developing an action planning tool to make S.M.A.R.T plan following spirit of Motivational Interviewing would be innovative and first-of-its-kind work for clinical use.

## Proposed Approach



A summary of problems and proposed solution in preventing vision loss from Diabetes

## Initial Work

- We designed and developed a [community telemedicine framework](#) which is in use since June 2018 targeting Hispanic Community of Southern Wisconsin.
- We developed a beta version of an action planning tool named ["electronic Brief Action Planning" or \(e\)BAP](#).

## Forward Thinking

- We plan to work on developing the explainable CNN model in next 6 months.
- Once we have state-of-the-art accuracy including explainability feature, we plan to integrate the model in telemedicine framework.
- We will conduct an evaluation of the standalone framework in a controlled group to find efficacy in underprivileged community.

## Acknowledgment

This project is supported by a number of grants from Ubicomp lab, Department of Computer Science and BEHTA Lab, Department of Physical Therapy, Marquette University. We express sincere gratitude to Dr. Judy Kim and Velinka Medic of Medical College of Wisconsin for their guidance and knowledge.



# Dynamics Reconstruction of Remote Photoplethysmography

Lin He, Jiachen Ma, Shafiul Alam Shuvo, Dr. Anik Iqbal, Richard J. Povinelli, Sheikh Iqbal Ahamed  
Marquette University, Milwaukee, Wisconsin

## Introduction

- Photoplethysmography (PPG) based medical devices are widely used for cardiovascular health monitoring in clinical settings. PPG is a typical noninvasive method that measures subtle changes in the light reflection from human skin due to the blood volume variations through the cardiovascular pulse cycle[1].
- Remote PPG (rPPG), which uses a camera to collect a video of the region of the skin from a distance instead of using near-infrared light for PPG recording. The remote PPG signals provide similar health monitoring results to PPG signals. rPPG is a cost-efficient way of measuring the essential signals such as heart rate, heart rate variability and stress levels. [2]

## Method

- rPPG signals extraction
- Chaotic dynamics analysis on the rPPG signals using nonlinear signal processing methods such as phase space reconstruction (PSR). [3]
- Heart rate variability detection based on the rPPG signal properties in the reconstructed phase space

## Phase Space Reconstruction

- A uniformly sampled time series signal with a single variable  $X = (x_1, x_2, x_3 \dots x_n)$  can be reconstructed a phase space which has  $m$ -dimension. If the embedding method uses time lag  $\tau$ , the delayed reconstruction has coordinates as  $X_r = (x_j, x_{j+\tau}, \dots, x_{j+(m-1)\tau})$ . The time delay  $\tau$  can be estimated by finding the first minimum value of the average mutual information (AMI).
- Based on the 42-subject data in the UBFC-rPPG data set, we extract 4 signals for each subject and later used in PSR. The ground truth PPG signal is not uniformly sampled. To apply the approach, we interpolate the ground-truth signal to 240Hz by linear spline (PPG 240Hz). The rPPG signal is extracted from the video files at an original frequency of 30Hz (rPPG 30Hz). The rPPG signal is also interpolated to 240Hz (rPPG 240Hz) to match the PPG signal frequency. Then the signal is bandpass filtered by the continuous wavelet transformation (rPPG filtered).
- Certain properties in the reconstructed phase space such as Lyapunov exponent, approximate entropy and correlation dimensions could be used for signal classification and prediction on human physiological status.

## Reconstructed Trajectories

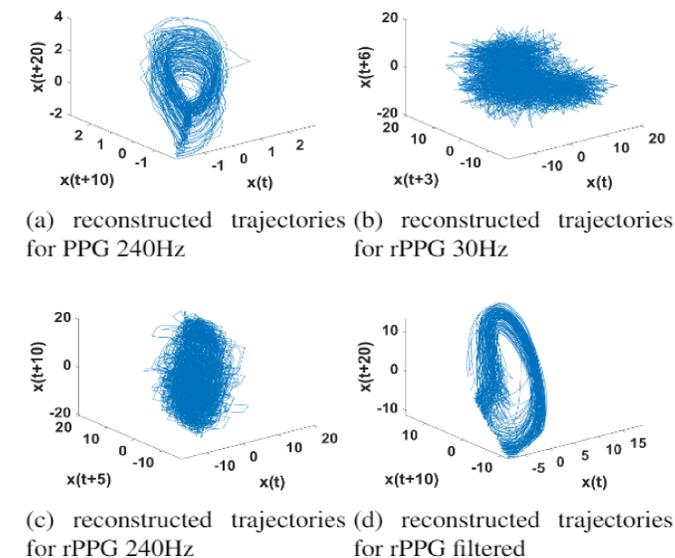


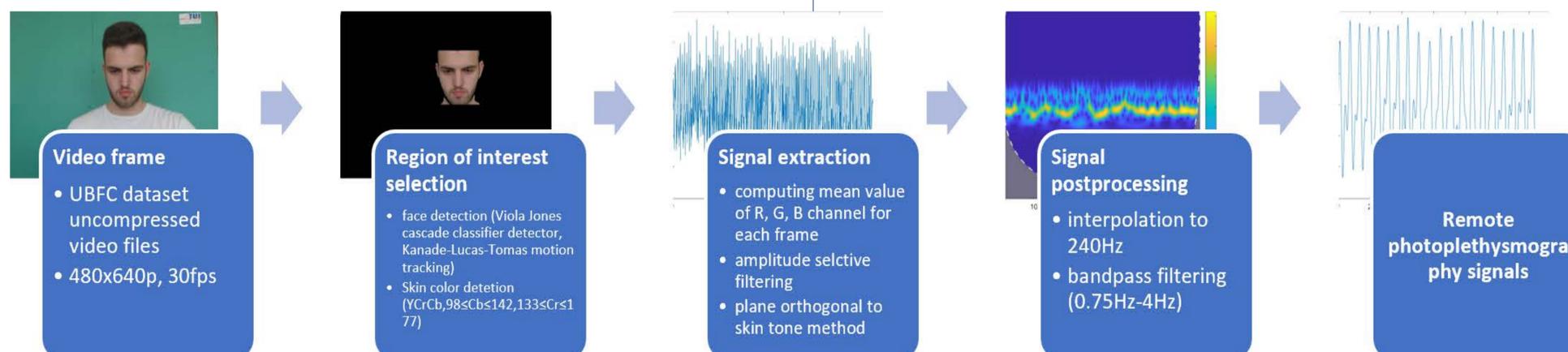
Figure 3: An example of reconstructed trajectories in  $m = 3$  for 4 signals

## Discussion and Future Work

- rPPG is considered as deterministic chaotic after interpolation and bandpass filtering. The best embedding dimension for the rPPG signal is between 3 to 4. The time delay is 10 for a 240Hz rPPG signal. Nonlinear approaches may evaluate the quality of different rPPG extraction algorithms and contribute to future studies of human mental and physiological health detection.

## References

- [1] Poh M-Z, McDuff DJ, Picard RW. Non-contact, automated cardiac pulse measurements using video imaging and blind source separation. *Opt Express*. 2010;18(10):1076274.
- [2] R.-Y. Huang and L.-R. Dung, Measurement of heart rate variability using off-the-shelf smart phones, *Biomedical Engineering Online*, vol. 15, no. 11, pp. 116, Jan. 2016.
- [3] Sviridova, N., Sakai, K. (2015). Human photoplethysmogram: new insight into chaotic characteristics. *Chaos, Solitons Fractals*, 77, 53-63

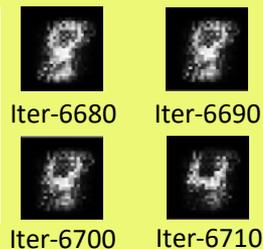
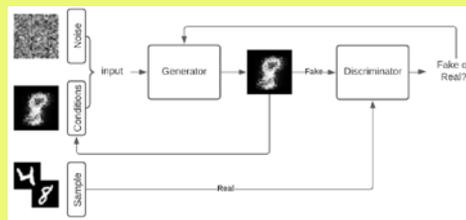


# An Efficient Unsupervised Pattern Learning Framework with GANs

Jiachen Ma (MSSC), Dr. Piyush Saxena (Direct Supply), Dr. Sheikh Iqbal Ahamed (COSC)

Unsupervised representation learning has been studied for years. Recently, generative adversarial networks (GANs) provides a new way of mapping from noise space directly to feature space. However GANs suffers from a series of training problems such as non-convergence or model collapse. Creating a robust framework is critically. In this research, we tried to use conditional input as a constraint to limit number of features which generator (G) learned during different stage of training. We hope to create generators which can capture mixture of patterns from time series inputs.

We trained a simple GANs network on MNIST dataset. To make our task easier, we manually selected two digits 4 and 8 from total 10 handwriting digits. The structure of our GANs network is shown as below. For each iteration, the Generator (G) uses its own output from previous iteration as a conditional input along with a vector of random noise. The G's loop make it become a recurrent network and has an ability converging to both  $P(\text{feature 1}|\text{feature 2})$  and  $P(\text{feature 2}|\text{feature 1})$  and same time.



Once trained, if a time series input may contain feature 1 and feature 2, we can simply plug in the input as our condition in to our GANs and let the Generator augmenting desired features we pre-trained and let the Discriminator tell us if boosted feature looks like a real one. If yes, then we successfully detect features.

The initial result shows the Generator can generate mixture images combined with both features. Therefore, the Discriminator is forced to recognized mixture of both features. To make network more robust, additional random image can be used as 'negative' conditional input to let the Generator correctly boosting features.

Future applications of this framework include detecting certain scenes in video clips or identify complex pattern in time series signals.

## Acknowledgements:

Gratefully thanks for the support from Direct Supply, Inc and Dr. Saxena's collaboration.

# Hyperactive Innate immunity: a contributor of neurodegeneration in *Drosophila drop-dead* mutants

Project team: Unmila P. Jhuti and Edward Blumenthal, Department of Biological Sciences, Marquette University, WI, USA.

## INTRODUCTION

- Innate immune system provides the first line of defense in any infection.
- Hyperactivation of innate immunity (HII) has been linked to diseases such as Alzheimer's, Parkinson's, Huntington's disease [1].
- *drop-dead (drd)* gene mutation in fruit flies show adult neurodegeneration like many human adult diseases. *drd* mutant flies also show HII. Since innate immunity is conserved between mammals and *Drosophila*, flies are an excellent tool to study HII mediated neurodegeneration [2].
- *drd* mutant flies also show altered glial structure in the brain. Although glial cells in flies regulate the brain immune function, the link between glial alteration and HII has not been studied in *drd* mutants.

## QUESTIONS

1. Does innate immunity get hyperactivated in *drd* specific neurodegeneration?
2. Does HII contribute to neurodegeneration and early lethality in *drd* mutant flies?
3. What is the chain of events by which HII contributes to neurodegeneration?

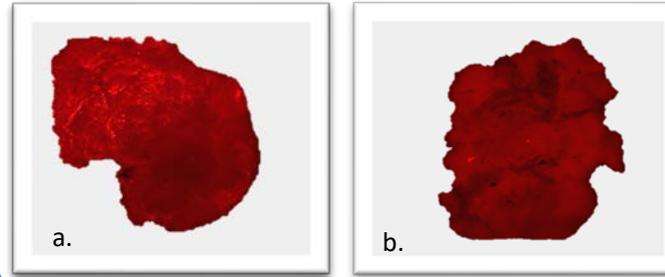
## SIGNIFICANCES

1. Understanding HII mediated neurodegeneration will help to understand the pathogenesis of adult neurodegenerative disease.
2. Understanding the relation between glia and HII in neurodegeneration will provide a new outlook to study neuronal degeneration.
3. Possible therapeutics can be developed against HII to control neurodegenerative disease progression.

## INNOVATION

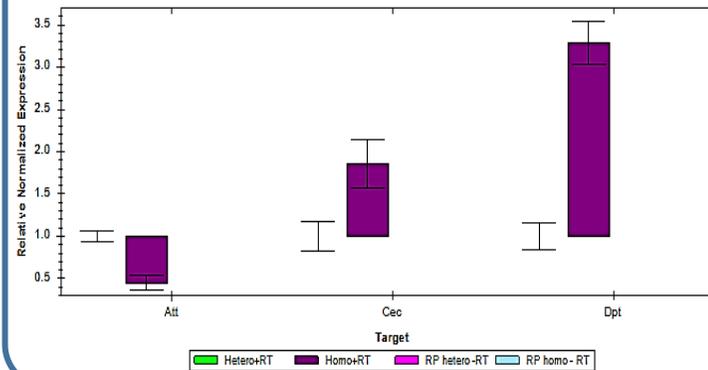
A novel fly model to understand HII and glial cell-linked neurodegeneration will be developed for the project. This study aims to understand neurodegeneration from the unique standpoint of glia and HII which will establish a new pathway of neurodegeneration.

## Increased expression of immune activation markers in *drd* mutant brains compared to wild type brains



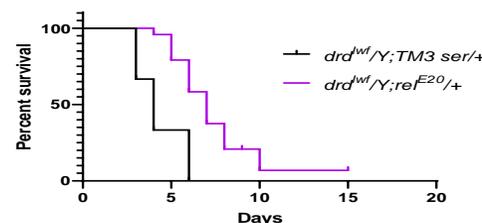
**Figure 1:** increased expression of antimicrobial peptides (AMPs) *Attacin*- an innate immune marker, in *drd* mutant brains (a) compared to wild type (b).

## Quantitative expression of immune activation markers is increased in *drd* mutant brains



**Figure 2:** qPCR shows upregulated expression of AMPs (innate immune activation markers- *Cecropin (Cec)* and *Diptericin (Dpt)* in *drd* mutant flies (purple bars) compared to controls (black bars).

## Deficient immune activity extends lifespan of *drd* flies, suggesting a potential role of HII in *drd* specific neurodegeneration.



**Figure 3:** increased rate of survival in *drd* mutant flies with decreased immune activity (*drd<sup>lwf</sup>/Y; Re<sup>E20</sup>*) when compared with *drd* flies without any decrease in immune activity (*drd<sup>lwf</sup>/Y; TM3 Ser/+*).

## CONCLUSIONS

1. *drd* mutant flies show hyperactivated innate immune markers expression in fly brains (Fig 1 and 2).
2. The immune deficient *drd* flies show increased rate of survival, suggesting an inhibition of neurodegeneration (Fig 3).

## FUTURE DIRECTIONS

1. Identify the pathways involved in HII mediated neurodegeneration.
2. Identify the brain cells that show HII in *drd* mutants and how HII facilitates in cell death.
3. Investigate different innate immune pathway to understand the mechanism of HII mediated neurodegeneration.
4. Investigate the role of glial cells in facilitating HII in *drd* mutants.

## ACKNOWLEDGEMENT

This research work is supported by Marquette University and the NMDSI Director's Endowment fund. I would like to thank all lab members from Blumenthal lab.

## REFERENCES

1. Labzin, L.I., Heneka, M.T. and Latz, E., 2018. Innate immunity and neurodegeneration. Annual Review of Medicine, 69, pp.437-449.
2. Shukla, A.K., Spurrier, J., Kuzina, I. and Giniger, E., 2019. Hyperactive innate immunity causes degeneration of dopamine neurons upon altering activity of Cdk5. Cell reports, 26(1), pp.131-144.

**Background:** HRV is a marker of adaptive emotion regulation that is easily measured in the lab setting. Salivary cortisol is a commonly used, noninvasive, measure of stress response. Prior research examines these variables separately and at one point in time in their relation to anxiety. In contrast, we aim to examine the timecourse of HRV and cortisol over multiple measurements during a 1-day testing session to test the relationship between changes in HRV/cortisol and trait anxiety. This study will utilize archival data from a large nationally-representative survey of adults in the US (MIDUS). Data was collected in 2012-2016.

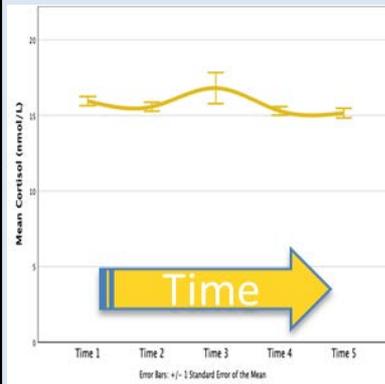
### Research Questions

1. Do HRV and cortisol responses to stressors differ among adults with high vs. low trait anxiety?
2. How do changes in HRV relate to changes in cortisol at several points in time over the course of 1 day?
3. Are the patterns of change in HRV or cortisol over time related to individual differences in trait anxiety?

### Innovation

- HRV and cortisol are not static measurements (see **Figures 1 and 2** from this sample). Studying the relationship between the changes over time for HRV and cortisol and their relationship with trait anxiety may illuminate a better understanding of the dynamic biological underpinnings of trait anxiety.
- Our research will utilize a large sample size and data-driven analysis (e.g., Latent Growth Mixture Modeling [LGMM]) to quantify change of HRV/cortisol over time.

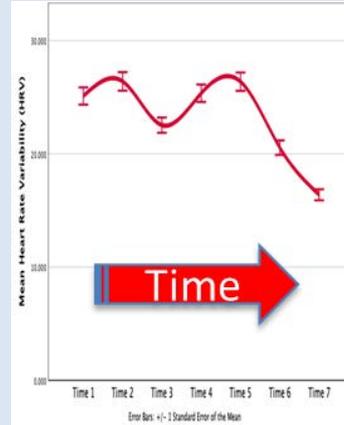
**Figure 1. Cortisol Response Over Time (N = 659)**



Cortisol is governed by the hypothalamic-pituitary-adrenal (HPA) axis as the main output of the stress response system. As individuals' differ in daily reactions to stress, cortisol levels fluctuate. Individuals' change in cortisol over time might be moderated by HRV and/or relate to trait anxiety.

**Figure 2. HRV Response Over Time (N = 659)**

HRV is associated with the autonomic nervous system (ANS) and used to measure the heart's flexible responding to stress (high HRV=high flexible responding). Individuals' HRV changes over time might be moderated by cortisol and/or relate to trait anxiety.



### Conclusions

Our preliminary findings (N=659):

- More trait anxiety is correlated with better HRV at most time points ( $r^2$ s=.09-.11;  $p$ 's < 0.013) (partial support for Question 1)
- Better HRV is correlated with less total cortisol output at most time points ( $r^2$ s=.08-.14,  $p$ 's < 0.046) (partial support for Question 2)
- Variability in this relationship over time suggests that the relationship between HRV and cortisol changes over time.
- Above results are reported for the entire sample and individuals may vary in strength of these relationships over time. We will test how cortisol and HRV's relationship over time using LGMM may correlate with trait anxiety.

### Significance

- More research is needed to understand how these metrics change together over time as HRV may be a viable treatment target for trait anxiety through biofeedback.

### Advancement

- To our knowledge, no study to date has examined the relationship between HRV and cortisol over time as it relates to trait anxiety.



# Combined Interpersonal Synchronization: Integrating Emotional, Physiological, & Neural Components

Keara Kangas M.S., Joia Wesley B.S., & Nakia S. Gordon Ph.D.,

## Specific Aims

Integrate emotional, physiological & neurological measures for an enhanced understanding of interpersonal engagement.

Determine how emotion regulation (ER) strategies impact synchronization & interpersonal interactions.

## Significance

Social interactions are necessary for survival; Synchronization may serve as a mechanism of establishing those bonds.

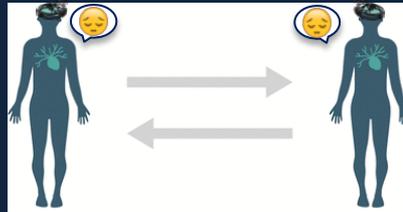
## Innovation

A small body of research has measured synchronization in dyads; None have integrated neural, physiological & emotional measures together.

## Interpersonal Relationships

Interpersonal interactions are complex. They rely on **bidirectional** signals that influence each partner.

Individuals regulate their interactions in at least 3 ways—emotional, physiological, & behavioral



Relationship success is dependent on the strength of partners' connection; this can be quantified through synchronization

Most interpersonal interactions are measured by single detection means

## Methods

- Questionnaires
- Dyads: Negative Story
- Behavioral Coding
- Physiological Measures:



EMOTIV: Mobile EEG Headset



BIOPAC: ECG & EDA

## Conclusions

Combining high quality data & analytic tools will enhance our understanding of interpersonal systems and could lead to improved relationships.

Combining different data sources to detect emotions makes it possible to overcome the limitations of single-detection method & increases validity and reliability.

## Advancing the Field

Combining research methods across the disciplines of neuroscience & psychology, deepens our research as a whole and progresses our knowledge for social systems; an essential area of study. This project will be conducted for a Ph.D. thesis



# “I Feel You”: Exploring Empathy and Physiological Linkage in Friend Dyads

Joia Wesley, Keara Kangas M.S., & Nakia S. Gordon, Ph.D.

## Research Idea & Question

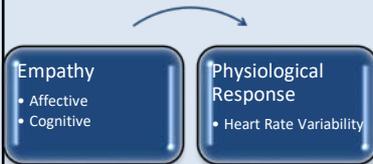
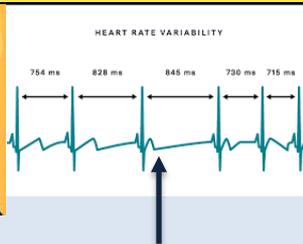
Colloquially people say they “feel” other people’s emotions when they are expressing empathy, this project explores whether people are in the same physiological state during empathetic moments.

**Question:** Does the extent to which friends exhibit physiological synchrony, during an emotionally evocative interaction, predict empathy.

## Innovation

Few studies have disentangled the contributions of cognitive empathy and affective empathy in interpersonal interactions. Fewer still, use multiple measures of these constructs.

The current study will rely on self report as well as changes in the autonomic nervous system to evaluate how much partners are *feeling* one another during a distressing task.



ECG recording of heart rate to analyze HRV as an index of physiological linkage

Same-sex friend dyads participating in a conversation task while simultaneously providing HR measures



## Significance

Successful interpersonal interactions require partners to both understand-- cognitive empathy-- and *feel*-- affective empathy-- what the other person is expressing especially in emotional contexts.

Empathy can be used to minimize otherness, induce prosocial behaviors, and promote interpersonal harmony.

This project can help elucidate the “feeling” of connection or disconnection during emotionally evocative moments.

## Advancing Research & The Discipline

This project advances the field of neuroscience by integrating physiological and psychological factors in the context of social interactions. It is also the basis for a Master’s Thesis.

# Empowering Community Voices to Re-design Mental Health Services for Culturally Diverse Children and Families of Color

Project Team: Madeline Johnson, B.S., Maddie Bohn, Val Zendejas, Anne Malkoff, M.S., Lindsay Holly, Ph.D.\*

**DEPARTMENT OF PSYCHOLOGY**

## Background and Significance<sup>†</sup>

- Nearly 22% of youth in the United States have a recognized mental health issue but less than 10% receive treatment from a mental health professional.
- Black and Latinx youth engage in significantly less outpatient mental health care than White youth.
- University-based psychology training clinics are well positioned to address this disparity.
  - Staffed by graduate student therapists receiving state-of-the-art training in culturally competent, evidence-based practices under close supervision
  - Offer low-to-no cost services
- However, service engagement among families of color is low in these clinics.
  - History of marginalization/mistreatment leading to mistrust
  - Mismatch between service system and needs/preferences/values

**Project Goal: Collaborate with communities to alleviate mental health care disparities experienced by diverse youth and families**

## Specific Aims

- 1) Better understand the unique experiences, perspectives, and priorities related to youth mental health care (including in university-based clinics) among communities of color
- 2) Guided by voices of community members, establish what is needed to re-design mental health care to ensure consistency between service delivery and youth and family context, values, and needs

## Method

- Mixed-methods assessment with key stakeholders from communities of color
  - Qualitative: 6 focus groups [youth, parents, community leaders (e.g., religious, health, school)]
  - Quantitative: self-report measure battery (e.g., demographics, service use history, stigma)

## Project Outcomes and Impacts

- Clear delineation of concerns and preferences related to youth mental health services among families of color
- Identification of the modifications needed in university-based training clinics to enhance treatment engagement and success with families of color
- Data driven re-design of services in Marquette's Center for Psychological Services

**Increased access to culturally appropriate mental health care services for youth and families of color living in urban Milwaukee!**



# Lasting physical and psychological effects of COVID-19

Haischer MH<sup>1</sup>, Zirgaitis GZ<sup>1</sup>, Beilfuss R<sup>1</sup>, Turner P<sup>1</sup>, Weibye B<sup>1</sup>, Opielinski L<sup>1</sup>, Danduran M<sup>1</sup>, Munson E<sup>2</sup>, Piacentine LB<sup>3</sup>, Uhrich T<sup>1</sup>, Bollaert RE<sup>1</sup>, Hoeger Bement M<sup>1</sup>, Papanek PE<sup>1</sup>, Hunter SK<sup>1</sup>

## RESEARCH QUESTIONS

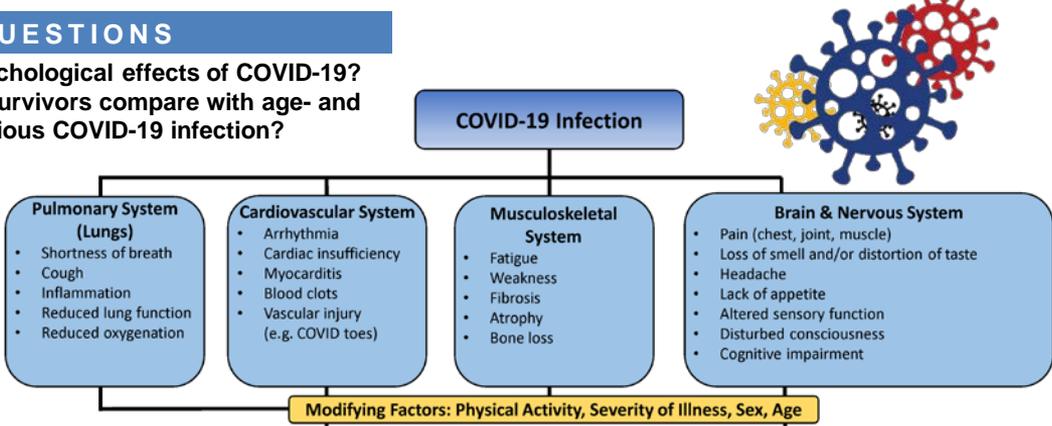
What are the lasting physical and psychological effects of COVID-19?  
 How does the functional capacity of survivors compare with age- and sex-matched individuals without previous COVID-19 infection?

## SIGNIFICANCE

- Over 8 Million Survivors and Counting!**
- Over 8.3 million cases and 220,000 deaths from Coronavirus Disease 2019 (COVID-19) in the United States
- Surviving = Full Recovery?**
- Some survivors experience debilitating symptoms for months

## INNOVATION

- A "Cura Personalis" Approach**
- Understanding a wide range of outcomes and modifying factors (e.g. age and sex differences; effect of physical activity) will facilitate giving **person-centered care for the entire COVID survivor**
  - Multidisciplinary research team from physical therapy<sup>1</sup>, clinical lab science<sup>2</sup>, and nursing<sup>3</sup>
  - No other studies have addressed the functional capacity of COVID-19 "long-haulers"



- Physical Assessments**
- Heart Rate, Blood Pressure, Height, & Weight
  - Body Composition and Bone Scan
  - Handgrip Strength Test
  - Balance Test
  - 30-s Sit to Stand Chair Test
  - Lung Function Test(Spirometry)
  - Aerobic Capacity Test (submaximal prediction)
  - EKG (Rest and Exercise)
  - Leg Strength and Fatigue Tests
  - Pain Assessments
  - Leisure Time Exercise and Fatigue Survey

- Psychological Assessments**
- Smell and Taste Test
  - Various surveys will address the following:
    - Depression
    - Anxiety
    - Stress
    - Resilience
    - Self-Efficacy
    - Sleep Quality



## CONCLUSIONS

- We anticipate lasting physical and psychological effects of COVID-19 infection.
- Increased age and greater severity of disease will be associated with greater physical and psychological dysfunction.

## ADVANCING THE DISCIPLINE

These data will inform best practice for long-term physical and psychological rehabilitation of COVID-19 survivors.

### Foundation for Future Studies:

- Effects of COVID-19 pre- and post-infection
- Protective effects of exercise before infection and with rehabilitation

# COVID-19 Pandemic - A Case Study in Wisconsin

Project Team: Ganhuan Lu and Jen-Li Ko

**Research Idea:** This case study of COVID-19 in Wisconsin provides a local lens to analyze the statistical data.

**Questions:** What is the trend in confirmed cases in Wisconsin? Have Wisconsin flattened the curve?

**Significance:** We have developed an interactive visualization to show the data of COVID-19 in Wisconsin, including the current status, the trend, and the scope in Wisconsin.

**Conclusions:** The number of confirmed cases in Wisconsin has increased since March to October. The curve shows the large number of increase in September and October.

**Dashboard:** [https://ganhualu.shinyapps.io/COVID\\_WI\\_0418/](https://ganhualu.shinyapps.io/COVID_WI_0418/)

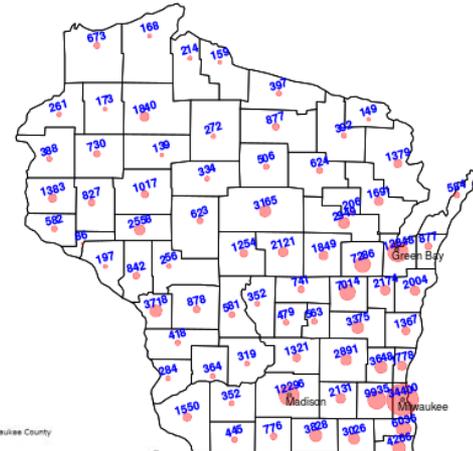
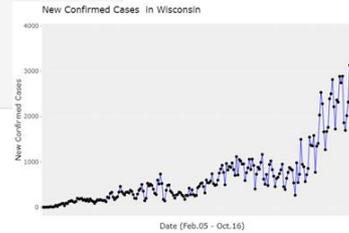
## COVID-19 in Wisconsin

Choose a category to display

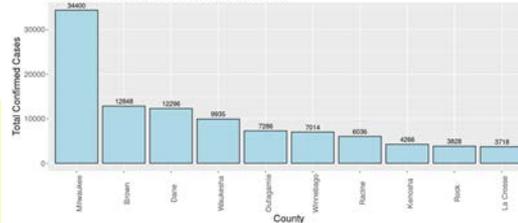
Total Confirmed Cases

Map Time Series WI Counties Data Explorer Notes U.S.

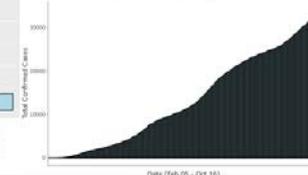
### Total Confirmed Cases in Wisconsin by County



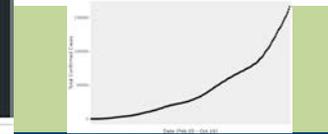
Total Confirmed Cases in Counties on Oct.16



Total Confirmed Cases in Milwaukee County



Total Confirmed Cases in Wisconsin



# Transportation access after a stroke: Identifying barriers and facilitators

Dr. Margaret L. McNamara<sup>1</sup>, Dr. Sarah Grace Dalton<sup>2</sup>, Alissa Fial<sup>3</sup>, Kate Otto<sup>3</sup>, Joe Amoruso<sup>1</sup>, Emily Angelina<sup>2</sup>, Danielle Del Conte<sup>1</sup>, Amanda Locascio<sup>1</sup>, Molly McDermott<sup>2</sup>, & Patricia Savino<sup>2</sup>

<sup>1</sup>Marquette University Opus College of Engineering, <sup>2</sup>Marquette University College of Health Sciences, <sup>3</sup>Marquette University Raynor Memorial Libraries

- Stroke causes disability for millions of adults living in the U.S.
  - Including difficulty talking, reading and writing, thinking, seeing, and walking.
  - Causes problems participating in life activities.

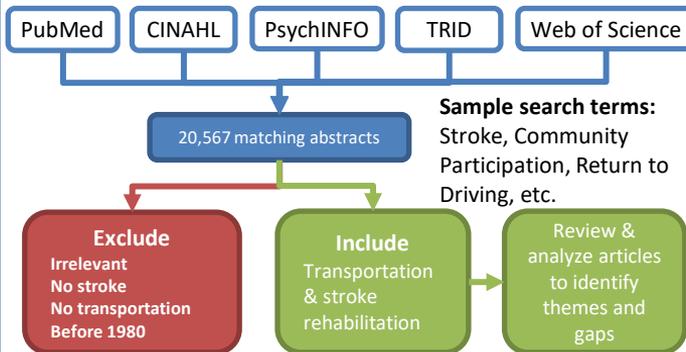


- Bridging gaps in transportation access due to cognition and language deficits will lead to better participation and quality of life.
- We can identify and address systems (including structures, attitudes, and behaviors) that limit transportation access.
  - E.g., format of bus schedules, app interfaces, talking to transportation workers, signage.

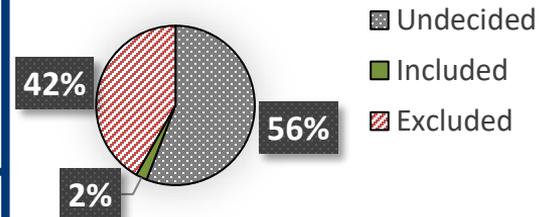
**Transportation engineers and speech pathologists working in concert can create systems that will help reconnect stroke survivors to their communities, enriching life for millions.**

*What do we already know about the intersection of these fields?*

## Step 1: Conduct a systematic article search



## Step 2: Review articles for inclusion



- Most studies focus on EMS transport to the hospital during a stroke.
- Few studies investigate living well with stroke difficulties in the years or decades of life remaining.

## Looking Forward:

- Engage community members to discuss barriers and potential solutions.
- Design interventions at the intersection of transportation engineering, cognition, and language to improve access.

# Searching methods for mobile manipulators

Student: Xie Jiayu

Advisor: Dr. Henry Medeiros

Acknowledgment: NIST award 70NANB16H259

## Autonomous mobile robots:

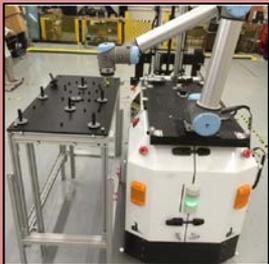
Minimal reconfiguration;  
Saving time.

## Potential areas of impact:

Space exploration;  
Manufacturing industries.

## Challenge:

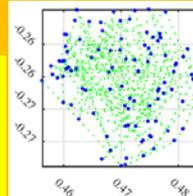
Accuracy in robots with:  
fixed bases  
vs.  
mobile bases



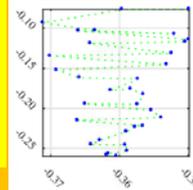
## Task of our mobile manipulator: locate a group of markers

### Kalman Filter method:

1. Predict next base position
2. Move to that position
3. If didn't find the object, **stochastically sample a set of points**
4. Update the position



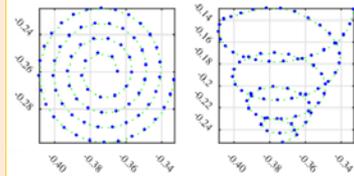
Sample points  
for Kalman Filter



### Spiral method:

1. Move ahead
2. Try to find the marker using a spiral sample points

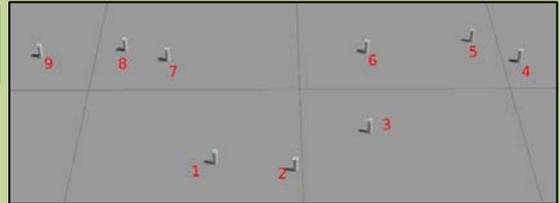
Sample points for Spiral Search



1

### Current progress:

Robust model that works under **different base speeds** and **different arrangements** of the markers (cases 1 and 2)



Performance	Kalman Filter	Spiral Search
Interception	73.33%	96%
Search Time	3.155[s]	1.19[s]



Performance	Kalman Filter	Spiral Search
Interception	89.82%	88.89%
Search Time	1.107[s]	0.949[s]

2

### Future research:

- (a) Improve current stochastic method;
- (b) Tests on an industrial mobile manipulator.

# Deep Convolutional Particle Filter for Visual Tracking

Student: Reza Jalil Mozhdehi (PhD candidate)

Faculty: Dr. Henry Medeiros (Electrical and Computer Eng. Dep.)

## Visual Tracking

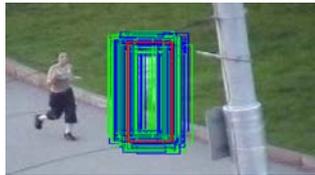
Determine a specific target in the first frame and track the target in the next frames through challenging scenarios such as occlusion and deformation.

## Significance

Security and surveillance, video communication, traffic control, and medical imaging.

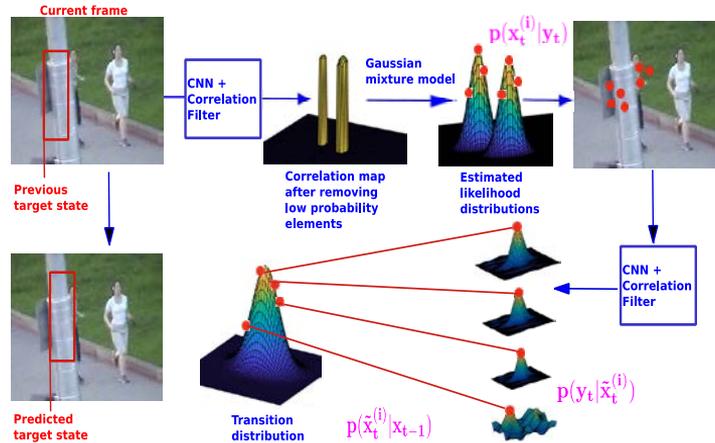
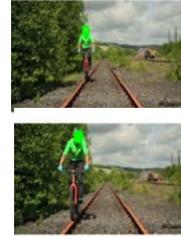
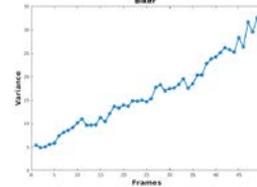
## Innovation

Apply a particle filter to a CNN-Correlation framework [1,2,3]:



## Forward Thinking

Find target sizes based on the variance of the likelihood distribution estimated from the below Framework:

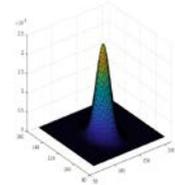


## Conclusion

Improving the accuracy of the sampling distribution is useful in visual tracking [4].

## Future work

Work on improving target models to generate sharper Correlation maps:



## References

- [1] R. J. Mozhdehi & et al, "Deep convolutional particle filter for visual tracking," *ICIP*, 2017.
- [2] R. J. Mozhdehi & et al, "Deep convolutional particle filter with adaptive correlation maps for visual tracking," *ICIP*, 2018.
- [3] R. J. Mozhdehi & et al, "Convolutional Adaptive Particle Filter with Multiple Models for Visual Tracking," *ISVC*, 2018.
- [4] R. J. Mozhdehi & et al, "Deep Convolutional Likelihood Particle Filter for Visual Tracking," *IPCV*, 2020.

# Real-time Multi-camera Tracking System

Abubakar Siddique and Henry Medeiros, Marquette University, {abubakar.siddique, henry.medeiros}@marquette.edu

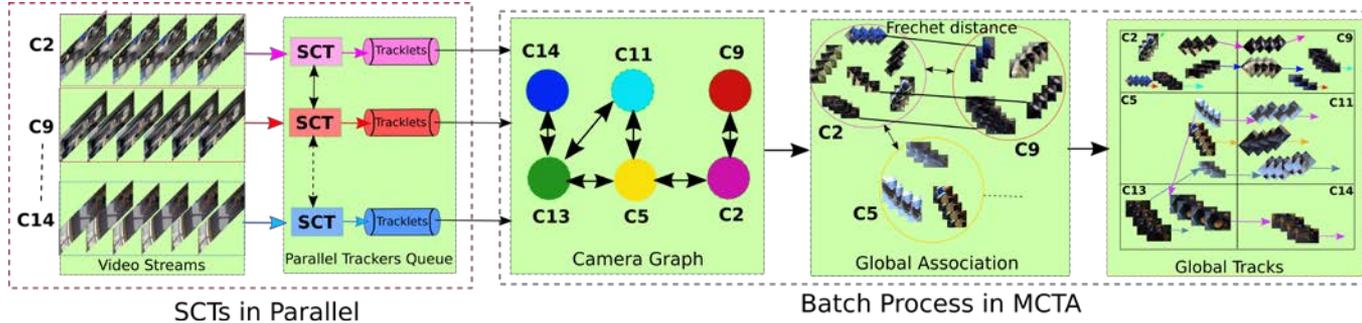
## Objective

We design a real-time multi-camera tracking system for surveillance applications. We process multi-camera video feeds in parallel using an online tracker [1] and associate people in partially overlapped camera networks using our proposed MCTA algorithm. In terms of speed, MCTA can generate real-time output feeds using n-GPUs support for n-cameras.

## Parallel SCTs and MCTA

We finetune the tracktor [1] model using mock checkpoint datasets to get the tracklets and store in n-parallel queues. The corresponding camera nodes use homography in MCTA to do the association by minimizing the multi-camera cost.

## Proposed Multi-camera Tracking Algorithm



## Association Cost:

$$c_{mc}(\tau_a, \tau_p) = \begin{cases} d(\tilde{\tau}_p, \tilde{\tau}_a) & \text{if } \tilde{\tau}_a \neq \emptyset, \tilde{\tau}_p \neq \emptyset, \\ & d(\tilde{\tau}_p, \tilde{\tau}_a) < d_{max} \\ \infty & \text{otherwise,} \end{cases}$$

$$d_f(\tilde{\tau}_p, \tilde{\tau}_a) = \inf_{\alpha, \beta} \max_{t \in [0,1]} \{d(\tilde{\tau}_p(\alpha_t), \tilde{\tau}_a(\beta_t))\}$$

## Conclusion

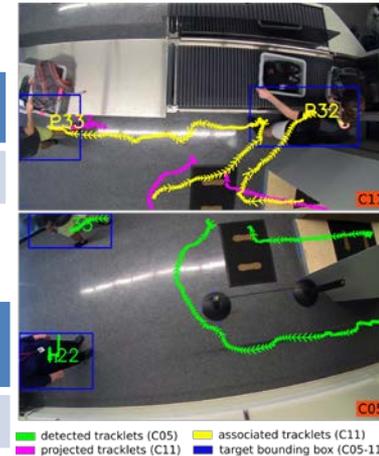
The proposed MCTA algorithm is applicable for fully/partially overlapped camera networks. This algorithm can be extended for disjoint views by using both motion appearance models.

## Tracking Metrics

IDF1	Prcn	RcII	MOTA
66.5	73.6	90.1	47.35

## Throughput Metrics

#Cam	#GPU	Batch Size	Output Time
6	6	4 s	4 s



[1] Philipp Bergmann, Tim Meinhardt, and Laura Leal-Taix'e, "Tracking without bells and whistles," in ICCV, 2019

# The Effect of Mindful Prayers on First-Generation Immigrant/Refugee Muslim Women's Wellness: A Qualitative Study

Julia Pawlowski, Leah Witthuhn, Dr. Lee Za Ong, Dr. Karisse Callender, & Dr. Enaya Othman

## Research Idea & Questions

- What are the role of mindfulness in prayers in participants' well-being?
- What are the Muslim women's attitude towards Salah prayers and Jamaat (communal) prayers in helping them coping with their circumstances including those related to immigration and refugee process?

## Significance

- We explore the use of Muslims mindfulness prayers as their coping strategies to immigration distress and social discrimination.
- Offer a comprehensive investigation on the effect of mindful Salah prayers on first generation immigrant and refugee Muslim women's mental wellness, as they encounter higher rates of acculturation stress and are most vulnerable to social discrimination, depression and anxiety

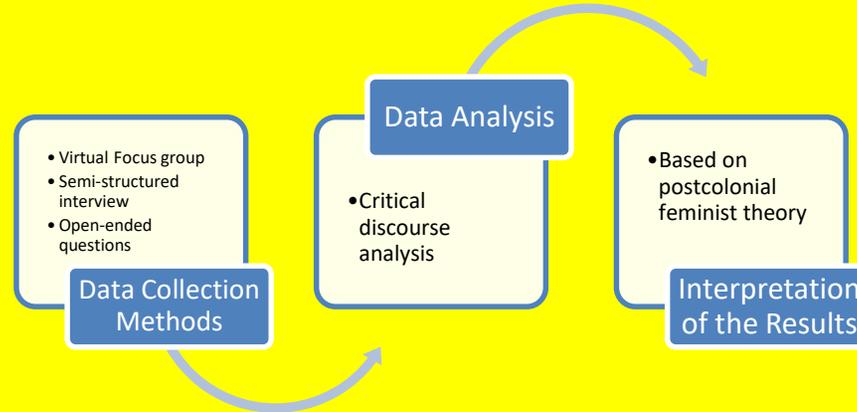
## Participants

- Muslim women who are first generation female immigrants or refugees to generate deeper insights of the experience of women who are underrepresented and underserved regarding mental health and wellbeing.

## Introduction

Research has shown that religious practices have a positive impact on mental health and wellness (Bonelli, Raphael, & Harold, 2013). The purpose of this study is to explore the use of prayer on wellness and mental health of first-generation Muslim women immigrants and refugees in the Milwaukee area, as this population experiences high rates of stress and discrimination.

## Methods



## Innovation

- The interdisciplinary scope of this research brings together clinical mental health counseling, cultural humility, women and gender studies, religious studies, and immigration.
- the project incorporates psychological inquiry and cultural and social analyses.

## Implication for Interdisciplinary Research and Professionals

- Promote community, cultural, or religious based mindfulness activities such as Muslims' prayer rituals.
- Contribute to the health equity of Muslims women by advocating for community based mental health care and promotion by linking mindfulness and prayers.
- Reveal Muslim women in relations to their gender role, claim private time, space, and group membership through Salah and Jamaat prayers
- Promote cultural humility in mental health counseling by fostering Muslims' psychological health and mindfulness

# Assessing Muslims' Mental Health and Related Stigma During Pandemic: A Mixed Methods Study

Stefan Reutter, Lee Za Ong, PhD, Enaya Othman, PhD, Irfan Omar, PhD. Abir Bekhet, PhD.

## Research Questions

1. Do different demographic characteristics report a significantly different impact of pandemic and attitude toward mental health?
2. What are the relationships between impact of pandemic and their attitudes toward mental health?
3. What are the impacts of pandemic on Muslims particularly their personal wellbeing, family relationship, spirituality, religiousness, and social identity, and justice?

## Significance

- Gained knowledge in intersectional stigma in the context of Muslim mental health that have been shaped by structural and interpersonal discrimination after September 11 attacks.
- Understanding the complex multi layers of cultural/religious rituals, social isolation, and gendered aspects of community life

## Innovation

- Interdisciplinary research to provide comprehensive evidence
- Mixed methods to elicit multidimensional impact of pandemic and its relation to other factors

## Introduction

There are several unique mental health and psychosocial consequence of COVID 19 pandemic in Muslims community:

- Lamenting the loss of the communal aspects of Ramadan
- Losing the access to their places of worship and community gatherings with mosques closure
- Distressing about the closing of Masjid al-Haram for pilgrimage.
- Being traumatized again due to Black Lives Matter and Islamophobia
- Experiencing double stigma in mental health and intersectionality

## Purpose of Study

**To explore the impact of pandemic on Muslims and its relations to their attitudes toward mental health in Muslim community by using a mixed methods study.**

## Methods

Quantitative data to compare within group differences and to examine the association between impact of pandemic and stigma of mental health.

Qualitative data to generating rich detailed accounts of Muslims' unique experiences during pandemic on their wellbeing, family dynamic, spirituality, religiousness, and social justice issues

### Instruments:

\*Demographic questionnaire Quantitative - Pandemic  
\*Emotional Impact Scale (PEIS) & Muslim Perceptions and Attitudes towards Mental Health Scale (M-PAMH).  
\*Semi-structured open ended Interview Questions

### Data Analysis Methods

\*RQ1: MANOVA or ANOVA for each DV  
\*RQ2 Correlation analysis (PEIS & M-PAMH) \*RQ3 Thematic Analysis

## Implication for Interdisciplinary Research and Professionals

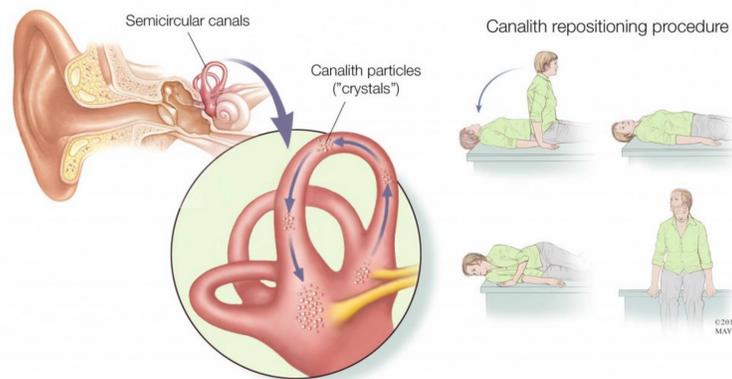
- Interdisciplinary research in transcultural mental health, cross-cultural psychology, and cultural anthropology provide different explanatory models for and conceptualizations of mental illness to ensure health equity
- Provide evidence to enhance anti-mental health stigma intervention based on culturally specific and responsive approach
- Highlight community strengths and resiliency
- Promote community-based health promotion



## Background

- BPPV is a spinning sensation triggered by head positions, caused by debris in some ear structures.
- Treatment can be complex, lengthy and resource-intensive.

Vertigo (benign paroxysmal positional vertigo)



## Objective

- Use patient pre-encounter survey to predict BPPV diagnosis and expedite treatment process.

## Data

- 41-question survey on 10" android tablet.
- Questions cover 5 major areas
  - Nature of Dizziness
  - Duration of attacks
  - Temporal pattern of dizziness
  - Triggers: lying down, tunnels, aisles
  - Migraine History
- Population
  - 397 patients (186 +ve, 211 -ve)
  - Mainly those referred for vestibular examination.

Accuracy	Sensitivity/Recall	Specificity
69%	67%	70%

## Conclusions

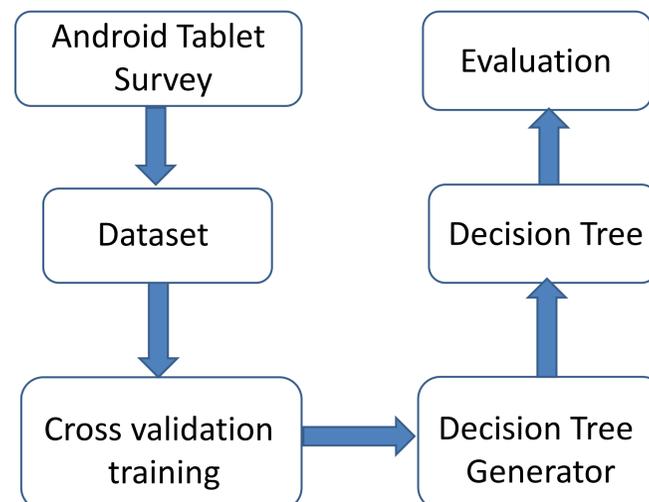
- Patient-intake survey is good for Predictive BPPV Diagnosis

## Value of research

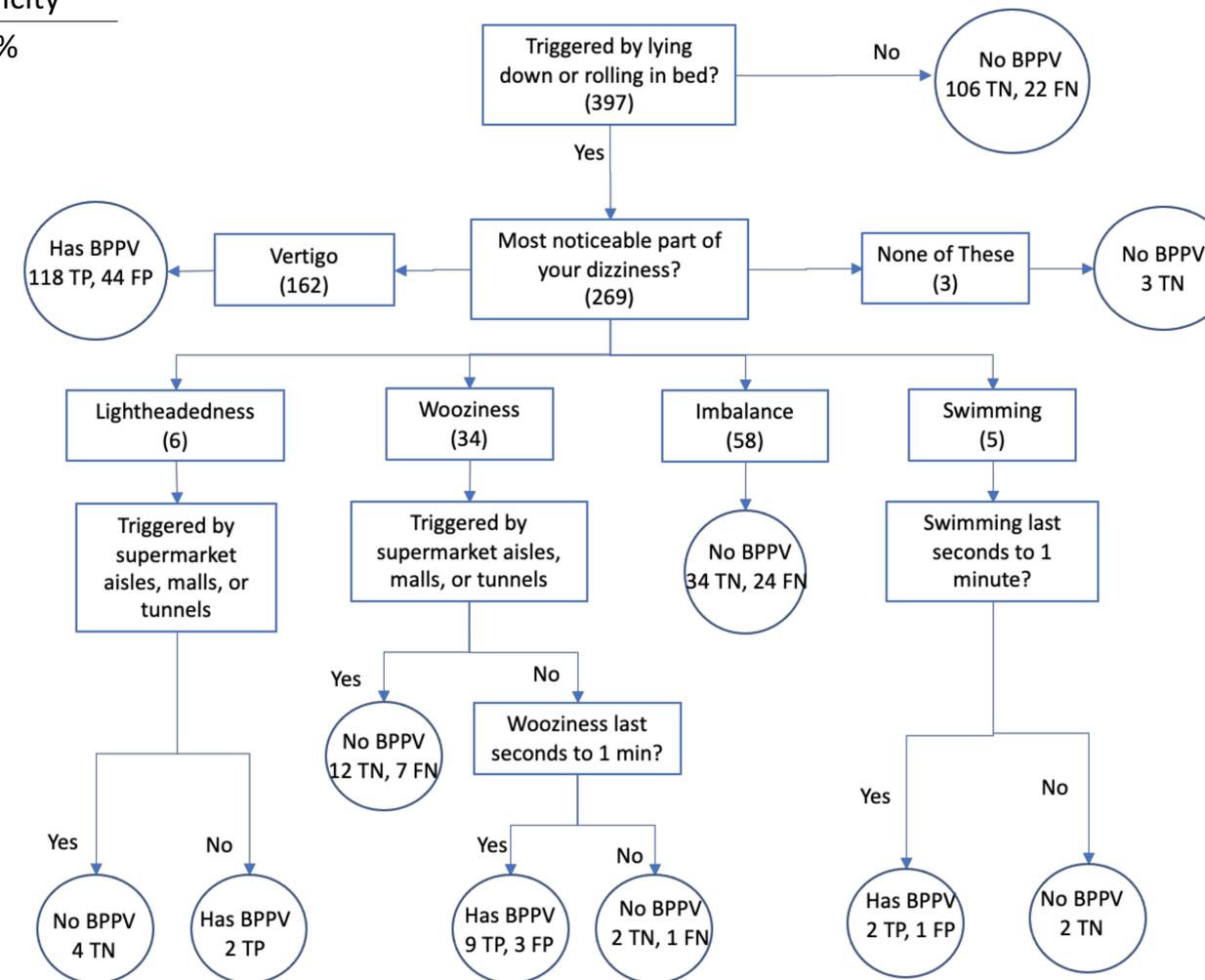
- Improve vestibular clinical efficiency: appointment scheduling, time to intervention and appropriate staffing.
- Extend solution to many other vestibular disorders.

## Method

- Decision Trees Classifier**
- Why Decision Trees?
  - Interpretability (readable by clinicians)



## Results



## Forward Thinking

- Reconduct survey with improved experience.
- Natural Language Processing for symptoms description

## References

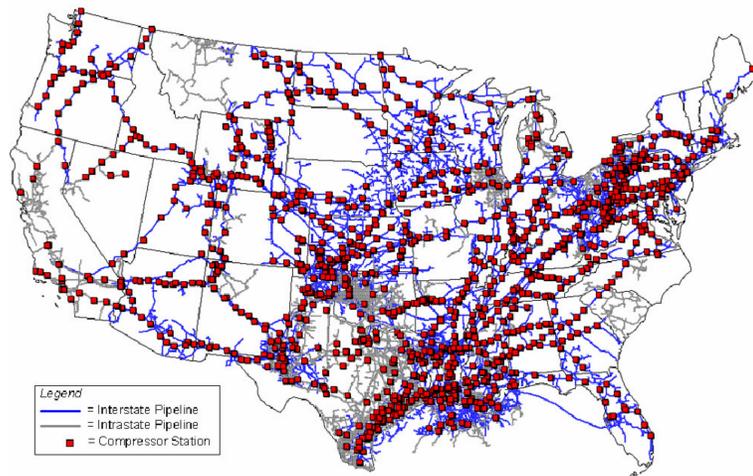
Friedland, D. R., Tarima S., Erbe C., Miles A. Development of a Statistical Model for the Prediction of Common Vestibular Diagnoses (2016). *JAMA Otolaryngol Head Neck Surg*, 142(4), 351-356.

Richburg, H. A., Povinelli, R. J., Friedland, D. R. Direct-to-Patient Survey for Diagnosis of Benign Paroxysmal Positional Vertigo (2018). *IEEE International Conference on Machine Learning and Applications ICMLA.2018.00056*, pp 332-337.



## Problem Statement

- State or multi-region natural gas (NG) forecasting is needed to optimize the use of infrastructure and balance daily supply with demand
- The challenge of accurately forecasting NG load is rooted in the availability, relevancy, and accuracy of information on which we are basing the forecasts
- Forecasting NG consumption has

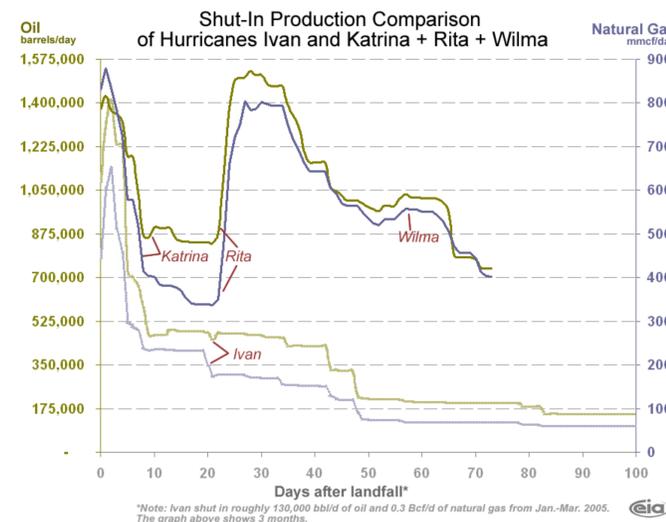


traditionally been done on a small-scale for a particular geographical area

- Large amounts of NG is transported through an extensive U.S. pipeline infrastructure to make small-scale forecasting possible
- The infrastructure supporting this is bulky and complex; optimization is needed to better distribute this non-renewable resource

## Relevance

- NG traders base the buying and selling of gas commodity contracts off what they believe the future demand will look like
- NG marketers want to know future projections as they facilitate their own transportation, storage, or transaction of natural gas
- LDCs use demand forecasts to help assure the delivery of gas to the customers they serve



## Value of Research

- The forecasts generated from this project can be used by those buying and selling natural gas commodities, natural gas marketers, and Local Distribution Companies (LDCs) to make early and effective business decisions.
- Provides diagnostic feedback to pipeline operators so they are able to maintain a safe and efficient production process

Brown, R. H. (2009). *GasDay USA, National Daily Natural Gas Demand Model*.

Herbert, J. H. (1995). Trading volume, maturity and natural gas futures price volatility. *Energy Economics*, 17(4), 293–299. [https://doi.org/10.1016/0140-9883\(95\)00033-Q](https://doi.org/10.1016/0140-9883(95)00033-Q)

Vitullo, S. R., Corliss, G. F., Adya, M., Nourzad, F., & Brown, R. H. (2013). An algorithm for disaggregating temporal natural gas consumption. *Canadian Applied Mathematics Quarterly*, 21(3), 391–410.

U.S. Energy Information Administration. (2011). *The Geology of Natural Gas Resources*.

<http://www.eia.gov/todayinenergy/detail.php?id=110>

## Objective

- Develop and validate a set of integrated daily models to predict the aggregated natural gas demand for service regions across the United States
- Optimize use of infrastructure to balance daily supply with demand
- Simulate peak day/design day conditions
- Disaster & maintenance planning and response (hurricanes, accidents, terrorism)



## Forward Thinking

- Helps ensure responsible production of a natural, non-renewable resource
- The state-by-state or multi-region forecasts can help provide valuable insights to both governmental and private sector production, transportation, and storage
- Provides safer working environments for human operators

# LSM AND GLSM IN INVERSE ELECTROMAGNETIC SCATTERING

Yeasmin Sultana

Advisor: James Richie

## Objectives:

- Learn about Inverse electromagnetic problem
- Use LSM and GLSM to find object boundary
- Use GLSM data to solve qualitative problem

## Introduction:

- Inverse Scattering: Find extent and composition of unknown object
- LSM: Linear Sampling Method. Commonly used to find extent
- Quantitative Solution: Includes estimate of composition of object

## Inverse Scattering:

- Information is gained for unknown target from scattered field using known incident field
- Problem is ill-posed & non-linear
- Used in medical, military and industrial applications
- The general inverse scattering equation is

$$E_s(\vec{r}_m, \phi_n^i) = \int_D G(\vec{r}_m, \vec{r}') k_b^2 \chi(\vec{r}') E_t(\vec{r}') dr'$$

$$G(\vec{r}_m, \vec{r}') = \frac{-j}{4} H_0^{(2)}(k_b |\vec{r}_m - \vec{r}'|)$$

where  $H_0^{(2)}$  is the cylindrical Hankel function of the second kind of order 0.

- The total field can be written as

$$E_t(\vec{r}', \phi_n^i) = E_i(\vec{r}', \phi_n^i) + E_s(\vec{r}', \phi_n^i)$$

## LSM in Inverse scattering:

- Linear sampling method (LSM)
- $\xi_n$  is the Herglotz kernel for sample point n

$$\sum_{n=1}^N \xi_n(\vec{r}_p) E_s(\vec{r}_m, \phi_n^i) = \frac{-j}{4} H_l^{(2)}(k_b |\vec{r}_m - \vec{r}_p|)$$

- Regularization method TSVD used to eliminate the ill-posedness.
- Generalized LSM (GLSM): getting more information about the scatterer and fields by using higher order for Hankel function

- Virtual Experiments from scattering equation

$$\psi_s(\vec{r}_s, \vec{r}) = \int_D G(\vec{r}, \vec{r}') [\psi_i(\vec{r}_s, \vec{r}') + \psi_s(\vec{r}_s, \vec{r}')] k_b^2 \chi(\vec{r}') dr'$$

where  $\psi$  represents a transformation of the field using  $\xi$ .  $\psi_s$  within the scatterer should be approximately a point source in the presence of the object.

## Results:

### LSM (l=0):

- Object length  $a=0.5\lambda$  and width  $b=0.25\lambda$ ; relative permittivity  $\epsilon_R=3.0$ ; antenna distance  $2\lambda$ . According to the object size the yellow colored one (fig1&2) is the object boundary
- Elliptical boundary of the object is more precise as more incident and observation points are used

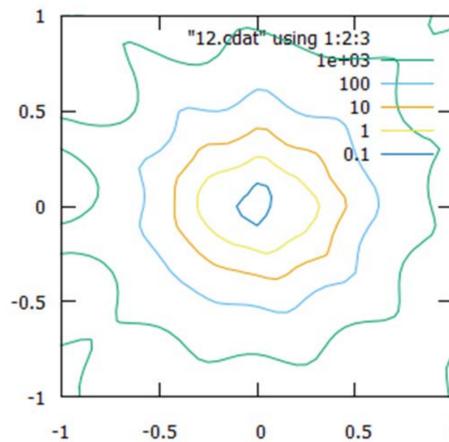


Figure 1. LSM results with 12 observation and incident points

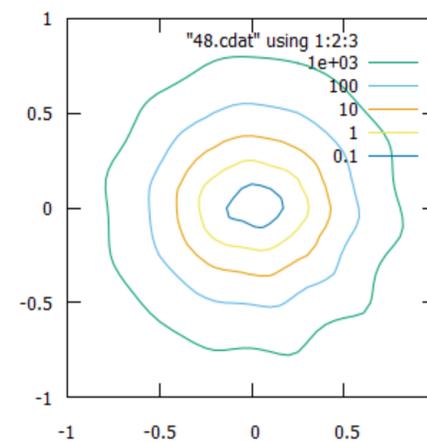


Figure 2. LSM results with 48 observation and incident points

- The incident field is known and the total field can be simulated. The scattered field (fig 5) can be found by subtracting the incident field (fig 4) from the total field (fig 3) showing a uniform scattered field

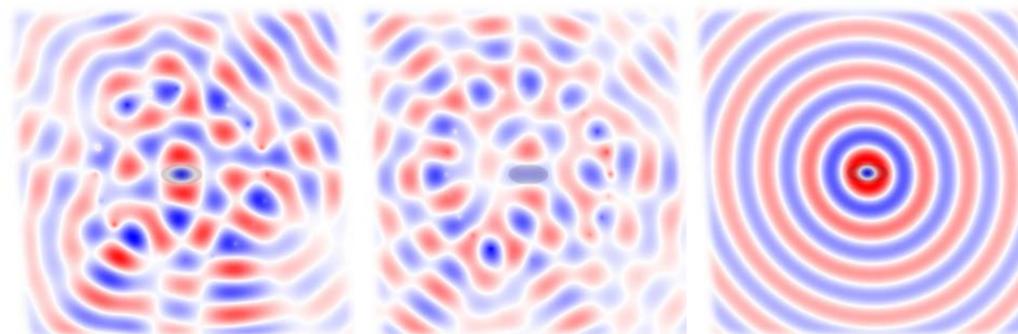


Figure 3. Total field

Figure 4. Incident field

Figure 5. Scattered field

## GLSM(l≠0):

- As the value of l changes the  $||\xi||$  changes but the change is not noticeable for lower orders. For the higher orders of l i.e.  $||l|>2$  the change of  $||\xi||$  is high (fig 6)

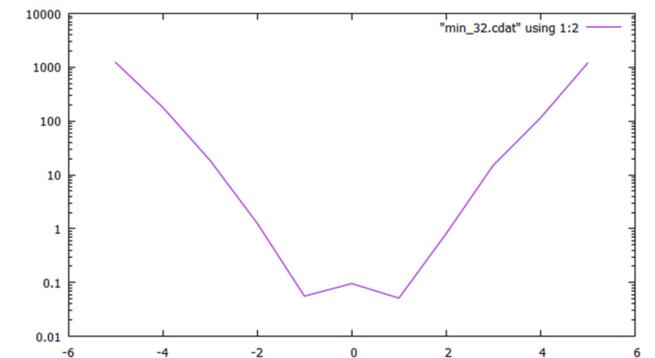


Figure 6. Change of  $||\xi||$  with value changing of l (l=-6 to +6)

- As the  $||\xi||$  changes abruptly for  $||l|>2$ , it is not feasible to identify the boundary with higher value of l (fig 7)

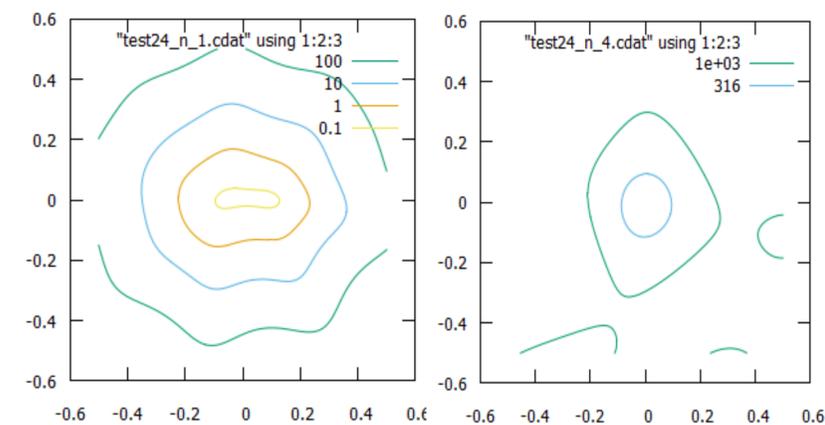


Figure 7. Change of elliptical boundary with changing value of l. (a) l=1; (b) l=4

## Conclusion:

- LSM is used for the inverse scattering problem and estimating the shape of the object
- GLSM is used to gain more information of the object and the scattered field
- Future work will aim at improving the method by using the scattered field bandwidth to bandlimit the data

# Computational Cost and Accuracy Comparison of Radiation Solvers

Chloe David, Dr. Somesh Roy

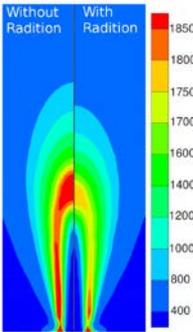
## Why is radiation important?

Figure 1: Comparison of results with and without radiation factored in [1].

Radiation plays a large role in accurate combustion modeling. As seen in Figure 1, negligence of radiation can lead to large inaccuracies in results. However, the radiative transfer equation (RTE) is extremely complex (see below).

In other words, radiation is **HARD** to solve for.

Radiation is found by using an RTE solver to compute radiative intensity ( $I_\eta$ ). Intensity is then plugged into the energy conservation equation to find the radiative source term.



$$\frac{1}{c} \frac{\partial I_\eta}{\partial t} + \frac{\partial I_\eta}{\partial r} = j_\eta - \kappa_\eta I_\eta - \sigma_\eta I_\eta + \frac{\sigma_\eta}{4\pi} \int_{4\pi} I_\eta(\hat{s}_i) \Phi_\eta(\hat{s}_i, \hat{s}) d\Omega_i$$

Spectral properties can be found using a spectral model.

The RTE is a complex, integro-differential equation that depends on position, direction, wavenumber, temperature, and time.

## Research Question:

**What is the relative accuracy and computational cost of various RTE solvers?**

Table 1: Types of RTE solvers with comparative accuracy and computational cost

RTE Solver	Accuracy	Computational Cost
Photon Monte Carlo (PMC)	Exact	High
Quasi-Monte Carlo (QMC)	High	Medium
Spherical Harmonics ( $P_N$ )	Arbitrary	Varied
Discrete Ordinates (DOM)	Arbitrary	Varied

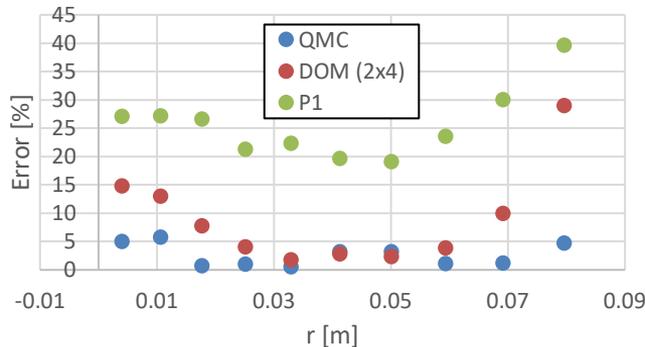


Figure 2: Sample plot of percent error in radiative source term along  $z=1.0$  m of Sandia Dx4 flame (see right) where PMC results are used as benchmark.

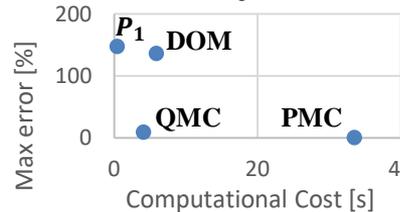


Figure 3: Sample plot of maximum percent error vs. computational cost for each RTE solver. PMC was used as the benchmark, so it has a percent error of zero.

## Combustion Configuration:

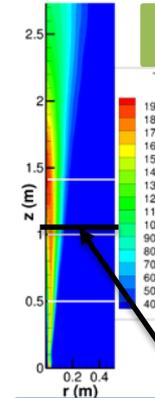


Figure 4: Temperature distribution of Sandia Flame D.

For this comparison, a snapshot of the Sandia Flame D was used. The radiative source term was computed along the line  $z=1.0$  m using each of the RTE solvers referenced in Table 1. The PMC results were used as a benchmark. The percent error for each RTE solver was plotted (see Figure 2).

Line at  $z=1.0$  m.

## Conclusions:

QMC has the highest accuracy compared to the PMC benchmark results and low computational cost. Both DOM and P1 have lower accuracy than QMC but comparable computational cost. However, the PN and DOM methods can be used to an arbitrary order of accuracy. A small order was chosen here, but in general, **as the accuracy of an RTE increases, so does the computational cost.**

## What's Next?

- This comparison will be expanded to other combustion configurations, spectral models, and RTE solvers.
- Potential improvements to the computational efficiency of all RTE solvers will be investigated.

## Acknowledgements:

Dr. Wenjun Ge, ORNL. National Science Foundation.

## References:

[1] Roy, S. Personal communication.



# Atmospheric Dispersion Modeling of Hydrogen Sulfide in an Urban Environment

Tito Onwuzurike ,Dr. Somesh Roy

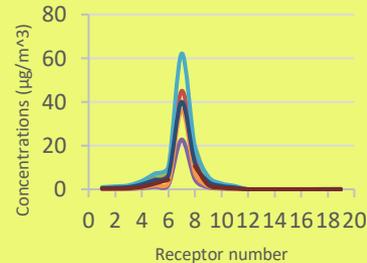
## Did the Covid-19 Lockdown influence the atmospheric dispersion patterns of H<sub>2</sub>S?

If we can adequately characterize the sources of a pollutant, we can use atmospheric dispersion models to simulate the spread of that pollutant in the atmosphere. The pollutant of interest in this study is Hydrogen Sulfide (H<sub>2</sub>S), a toxic, malodorous chemical compound.

H<sub>2</sub>S is produced by bacterial breakdown of organic matter. This makes wastewater treatment plants (WWTP's) a significant source of H<sub>2</sub>S emissions.

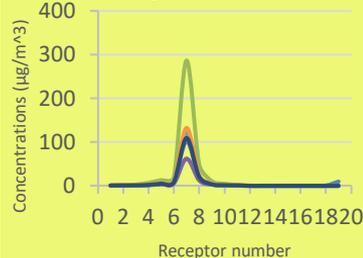
H<sub>2</sub>S dispersion models from the covid-19 lockdown period were compared with those from the post-lockdown period in order to observe differences between trends in the two categories.

## General trends in atmospheric H<sub>2</sub>S concentration in between April and July 2020



Despite the differences in concentration magnitudes (which likely can be attributed to seasonal transitions), figures 1 & 2 have similar shapes.

**Fig 1: Model predictions of H<sub>2</sub>S concentrations during Covid 19 lockdown**



**Fig 2: Model predictions of H<sub>2</sub>S concentrations after Covid 19 lockdown**

Results from a data collection campaign conducted at the same time also show no obvious changes in trends of H<sub>2</sub>S concentrations during the transition from the lockdown period.



**Fig 3: Map of emission source and receptors. The source is represented by the red marker**

## Conclusions:

There are no significant differences in trends that can be observed in the two data categories ( i.e. lockdown data and post lockdown data). This suggests that pollution from traffic and transportation related sources do not have a significant effect on the atmospheric dispersion patterns of H<sub>2</sub>S.

## Further Work:

The H<sub>2</sub>S source in these scenarios was modeled after a local WWTP as pictured in Figure 3. Further work to be done on this topic includes further characterizing the source by gathering more data on source parameters, for a more accurate model.

# High Fidelity Modeling of Pollutant Dispersion in Urban Environments

Alec Tauer, Dr. Somesh Roy  
Department of Mechanical Engineering

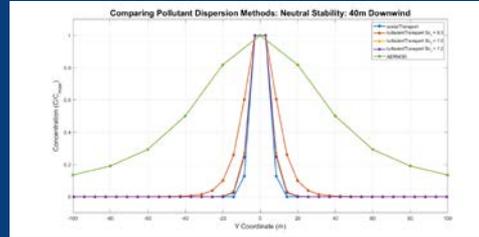
## Introduction

- Over 50% of the world's population lives in an urban and is expected to continue to increase<sup>1</sup>.
- An estimated 4.2 million deaths are linked to poor air quality<sup>2</sup>.
- Better dispersion models can assist with urban planning and public health to mitigate the risks pollution related illness.

## Objective

- Computational Fluid Dynamic can model the air flow and dispersion of pollutants but can be very computationally expensive.
- Gaussian Plume Models have been validated and are used for regulatory purposes but cannot provide extensive detail about the dispersion.
- Refined CFD models can provide key insight into how the urban environment affects dispersion in addition to how the pollutants evolve over time.
- AERMOD, a Gaussian Plume Model, can be used to validate results from CFD models.

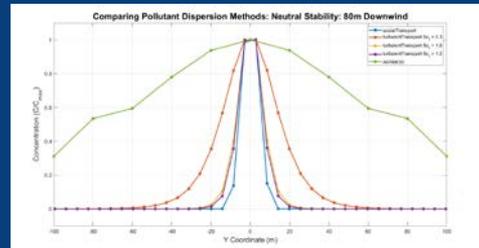
## Current Results and Discussion



Results show concentrations along a line downwind of a pollutant source.

4 CFD trials are compared to AERMOD to determine the validity of the models.

Turbulent dispersion models perform slightly better than the laminar counterpart.



The CFD models struggle to capture the lateral dispersion of pollution when compared to AERMOD.

The lack of lateral dispersion is likely due to the averaging of wind direction.

## Next Steps

- A new method to incorporate changing wind direction is being developed to account for the lateral dispersion seen in regulatory models
- The new method is based off methods used in Quinn et al.<sup>3</sup> and hope to be less computationally expensive
- The new method along with currently used methods will be compared against filed measurements of H<sub>2</sub>S emissions from a local Water Reclamation Facility.

## References

- <sup>1</sup>ONU. World population prospects 2019. Number 141. 2019.
- <sup>2</sup>"Ambient Air Pollution: Health Impacts." *World Health Organization*.
- <sup>3</sup>A. D. Quinn, M. Wilson, A. M. Reynolds, S. B. Couling, and R. P. Hoxey. Modelling the dispersion of aerial pollutants from agricultural buildings - An evaluation of computational fluid dynamics (CFD). *Computers and Electronics in Agriculture*, 30(1-3):219(235, feb 2001.

# International Research Award Entries



# Interdisciplinary global health approach to understand the prevalence and pathology of a neglected tropical disease affecting millions

Javeriya Choudry<sup>1\*</sup>, Mickey Marchio<sup>1\*</sup>, Abraham K. Anang<sup>2</sup> and Nilanjan Lodh<sup>1</sup>

<sup>1</sup>Department of Clinical Laboratory Science, College of Health Sciences, Marquette University, Milwaukee, Wisconsin; \* = Undergraduate students;

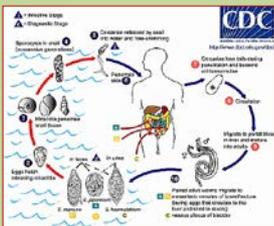
<sup>2</sup>Parasitology Department, Noguchi Memorial Institute for Medical Research (NMIMR), University of Ghana, Legon, Accra, Ghana

## Research Questions

- Determine the perception, prevalence and intensity of **Schistosomiasis** in **Weija Lake area of Ghana**.
- Questionnaire approach to explore the **knowledge, attitudes and practices in Schistosomiasis control** among the study population.
- Evaluate the presence of *Schistosoma mansoni* and *S. haematobium* from **three different types of field collected samples** (from same individual) across age groups to establish a better understanding of the disease prevalence

## Significance

- **Schistosomiasis** is the second deadliest parasitic disease in the world after malaria.
- Affecting around **290 million** people, with 90% of infected people are from sub-Saharan Africa.<sup>1,2</sup>
- Two human parasites: *Schistosoma mansoni* and *S. haematobium* often present in the same habitat.<sup>1</sup>
- In endemic areas, **children** are more susceptible to become infected and show symptoms more than their teen and adult counterparts.<sup>3</sup>
- Schistosomes are **easily transmitted and multiply considerably** in an intermediate host, so public understanding and accurate diagnosis plays a key role in prevention, control and surveillance of the disease.<sup>4</sup>



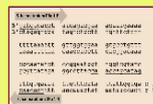
Disease life cycle

## Innovation

- Collaborative global health research project involving **University of Ghana and Marquette University**.
- Combining **public perception and socio-economic condition** with molecular, and genomics approach to understand diseases pathology and dynamics.
- **Diagnostic procedure** is entirely novel and there is no need to collect and process stool, whole urine or whole blood in order to scrutinize them for eggs.



S. mansoni DNA repeat fragment



S. haematobium DNA repeat fragment

- Innovative **RNA-sequencing approach** for field collected samples to understand the diseases pathology.
- **MU campus** is diversifying including faculty and students and there is a huge appetite for global health related research work and for service-learning experience.

## International component

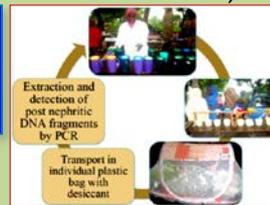


## Project location

- **Study location: Weija Lake area, Ghana**.
- Weija Lake is the **drainage site** for multiple rivers known for **schistosome infection**.
- This is a vast **open settlement area** for people around the area.
- **No central source of potable water**.
- **Only communal latrines** are present.
- People acquire **Schistosomiasis** infection during routine agricultural, domestic, occupational and recreational activities, where they encounter infested fresh water.

## Workflow (from Ghana to USA)

Sample collection, packaging, shipping, reception and procession of samples.



Diagnostic workflow at Marquette University

## Conclusion and future goal

- **Development** of novel program and impact assessment tools and indices using innovative techniques.
- **Fulfilment** of Marquette students' interest and desire for global health research and aligning with University's strategic goal of Beyond Boundaries.
- Increased global health **research activity and funding** at Marquette.
- Initiated application for **global health research and training grant** (through NIH) along with other MU faculty and will be more in future.



# Community Participation in Public Health Decision-Making and Human Rights: Neoliberal Policies and Universal Health Care Coverage in Brazil

Alexandre A. Martins (Marquette) and Juliana Franceschini (UNIFESP – São Paulo)



Participatory Action Research about the relationship between human rights, health-related policies and community participation in Brazil.

**Aim:** understand the impact of the last four years of health-related neoliberal policies on the public health services that low-income people received from the Unified Health System (SUS), the Brazilian public health system.

**Perspective:** from the narratives of the users of the the system in a liberating theology approach of social activism.

Apparently, there is a conflict between the Brazilian public health system (SUS) – created after the 1988 Constitution that stated the right to health – and recent health-related policies favoring the private health sector.



Three phases - project:

1. Analysis of health-related policies.
2. Engaging with local communities in Brazil through PAR/LTM in order to understand the real impact of these policies in the lives of low-income families.
3. Qualitative analysis of the collected material from semi-structured interviews and community gathering observations.

**Results:** understanding how community members have handled this process of commodification of health, centralization of decisions in higher gov. bodies, and their access to healthcare services, measuring whether neoliberal policies improved or worsen the services they received and their participation of decision-making processes.

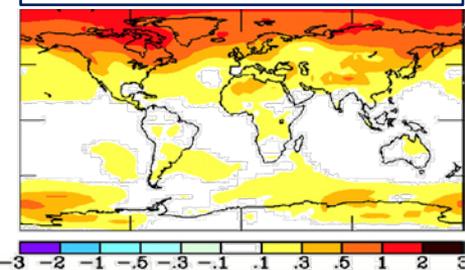
**Research Impact:** understanding of the consequences of neoliberal policies on population health; practical implications in the life of communities; community education on the roots of their own challenges to access health care and strategies to acting to strengthen the system.

# Understanding Soot Formation in Combustion Devices

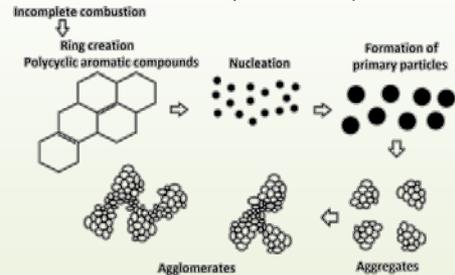
Khaled Mosharraf Mukut, Dr. Somesh Roy, Dr. Erini Goudeli\* (University of Melbourne)

## Research Goal

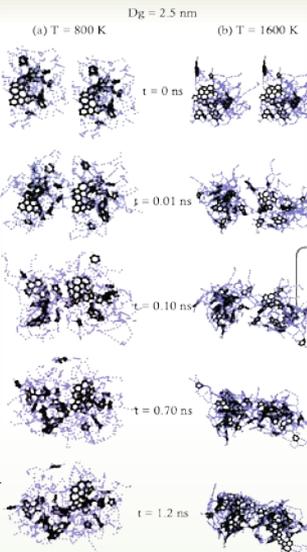
Our goal is to model soot formation keeping the size and morphology information consistent with the actual formation process.



Change of temperature due to soot accumulation in arctic ice (1880 to 2002)

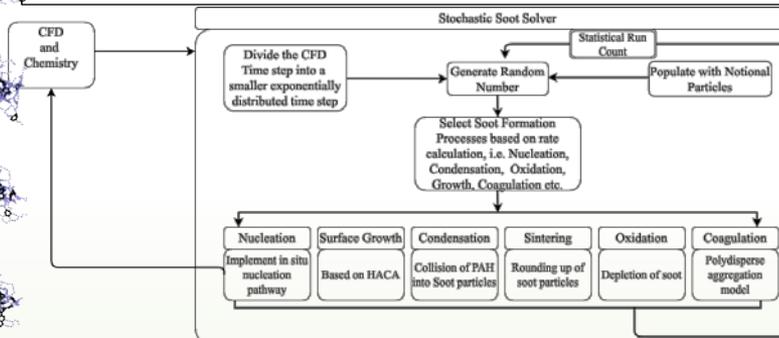


The morphology and aging of soot particle impacts the amount of radiative forcing which impacts global temperature.



## Methodology

- Reactive molecular dynamics simulations to extract the nature of complicated micro-scale phenomena like nucleation and sintering.
- Calculate rate of nucleation, sintering etc. to model the macro-scale soot mode.
- Map the molecular scale morphology to macro-scale using the following stochastic algorithm.



Primary structures												
Radius of gyration [nm]	8.3442	13.2448	13.5678	13.7136	13.5506	14.2946	14.135	14.2594	13.1215	13.1891	13.856	13.3464
Fractal dimension	2.1247	2.0091	2.4718	2.4643	2.6449	2.6342	2.7318	2.6188	2.5581	2.7106	2.7614	2.8043
C/H Ratio	2.4230	2.7654867	2.559896	2.795811518	2.596107	2.373077	2.375	2.364486	2.745981	2.522026	2.358182	2.338115
AR/AL	0.2233	0.2421	0.4123	0.8382	1.2799	1.2683	1.3179	1.4563	1.3722	1.7995	1.7773	1.72315
5 membered rings	2	6	19	28	31	47	38	41	31	44	48	42
6 membered rings	1	8	29	53	81	76	76	85	60	88	103	87
7 membered rings	2	12	12	23	22	32	41	40	21	33	34	30
	AR/AL: Ratio of aromatic to aliphatic hydrocarbons											
Time	0.25 ns	0.50 ns	0.75 ns	1.0 ns	1.25 ns	1.50 ns	1.75 ns	2.0 ns	2.25 ns	2.50 ns	2.75 ns	3.0 ns

## Findings/Conclusion

- Soot nucleation events are mostly **aromatic formation in the beginning**.
- Aliphatic chains in the flame brings the aromatic molecules together and forms larger cluster.
- **Fractal dimension** of the primary remains **consistent at around 2.7**.
- Sintering becomes relevant for **medium sized particles at lower temperatures**.
- Sintering process is completely governed by aliphatic chains in soot clusters.

## Future Works

- Extract the relevant rate terms from the molecular dynamics study and create the macro-scale stochastic model.
- Study the soot's morphological impact on radiative forcing.

**\*This work is a collaboration between Marquette University and University of Melbourne.**

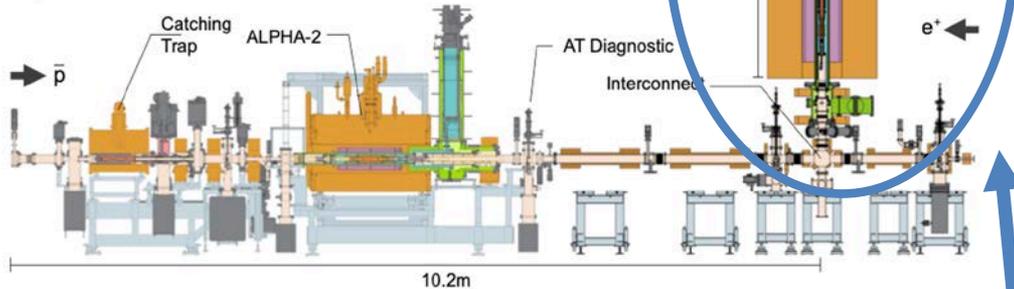
# Measuring the Gravitational Force on Antimatter

Tim Tharp, Department of Physics

## Does antimatter fall *up*?

For normal matter, whatever goes up must come down. But is this true for antimatter?

The gravitational force on antimatter has never been measured, and this has huge implications for Cosmology, General Relativity, and our understanding of the history of the universe.



Significant elements of this experiment were designed and built at Marquette University.

The ALPHA collaboration has been working for years to build a **new apparatus**, ALPHA-g, to measure the **gravitational force** on **antihydrogen**. Construction is finally complete, and next summer the CERN beams are anticipated to come back online.

Standing near the top of ALPHA-g during construction



Next summer, we will attempt the first measurement of this gravitational interaction, which will discern whether antimatter falls up or down!

This is an excellent opportunity to participate in **international**,\* high-impact research! Depending on funding, Dr. Tharp and an undergraduate student will travel to Switzerland to run these experiments.

\*Please consider this project for the International Research Award. This work can only be performed at CERN, the world's only facility capable of creating antihydrogen.

# Vote!

All MU faculty, staff and students are encouraged [to vote for their favorite slides](#). This voting will determine the finalists for the ORSP Jump Start Award Certificates and Presentations and will weigh into the review of the International Research Award.

Vote at the [Forward Thinking Poster Session](#) page.

