VISHC Summer School 2023

Research Experiences for Undergraduates Program (VISHC-REU)

VinUniversity, Vinhomes Ocean Park, Gia Lam, Hanoi

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ID	Project Description	PIs
1	**Title**: "**Wastewater Epidemiological Surveillance in Vietnam**" **Description**: Antibiotic resistance (AR) threatens the progress of modern medicine not only on the treatment of bacterial infections but also on the treatment of non-communicable diseases such as cancers and chronic diseases, including diabetes. The following aims are proposed. Aim 1: We will use whole genome sequencing and a combination of CRISPR-Cas9 cleavage and next-generation sequencing (NSG) to determine ARG compositions and establish a new antibiogram. Aim 2: we will develop an app for residents that reminds them to take their medicine, including antibiotics. We will receive aggregated data from the app on the usage of antibiotics in the same communities where the sewage was collected and analyzed. This information will link the usage of antibiotics with resistance. Aim 3: we will develop both agent-based and population-based models, constrained by the collected data from hospitals, the mobile app, and the wastewater monitoring system, and augmented by Machine learning techniques, to understand patterns of uptake of antibiotics as well as to correlate these with social, dietary and demographical characteristics of the local population. We will also use the models to forecast the burden of disease on the general population and healthcare system and to identify potentially effective interventions to reduce that burden.	Helen Nguyen (UIUC) and Andrew Taylor-Robinson (VinUni)
2	**Title**: "**I-canManage: A Smart Mobile Application for Monitoring and Management of patient's symptoms after Cancer Treatment**" **Description**: In this project, we develop a smart app called i-CanManage that is able to collect and track health patients' conditions. The app will be used to investigate common symptoms experienced by Vietnamese women after cancer treatment. To this end, a Cancer Symptom Management protocol will be digitalized and integrated into the mobile app for women after cancer treatment and evaluate the improvement of symptom management practices among women after cancer treatment. This allows us to evaluate the effectiveness of the Cancer Symptom Management protocol in improving symptoms and quality of life; and evaluate the acceptability, usability, and transferability of the i-CanManage smart app.	Hieu Pham (VinUni) and Huyen Nguyen (VinUni)
3	**Title**: **"Envisioning Urban Environments Resilient to Vector-Borne Diseases: A One Health Approach to Dengue Management"** **Description**: Vector-borne diseases pose a public health threat across the globe. Dengue, Chikungunya, and Zika, which are all transmitted by Ae. aegypti, are increasingly prevalent in southeast Asia, and outbreaks of Dengue, Zika, and other arboviruses are becoming more common in the southern and southeastern U.S. Aim 1: we will develop a comprehensive modeling framework to predict the risk of Dengue infection in Vietnam. We envisage that this project will pioneer a new way of approaching smart health by developing preventive and predictive approaches for urban planning and learning continually using data from Vietnam's rapidly expanding urban development (VinHomes providing prime examples of this in locations across the country). The proposed framework for smart health will deploy computational approaches, including both process-based numerical simulation and ML/AI (Machine Learning/Artificial Intelligence), to develop long-term design strategies through adaptive learning from environmental surveillance and epidemiological data (available from VinMec and the Ministry of Health) for model validation. Aim 2: we will create digital twins of the urban environment, which receive sensor data for factors influencing Dengue transmissions, such as temperature, humidity, and CO2 concentration. Our model will predict infection risk levels in real-time and make corresponding public health recommendations for risk reduction. We believe this project will have an immediate and significant impact on the future planning of Vietnam's rapidly increasing urbanization in line with its fast rate of economic growth.	Praveen Kumar (UIUC), Helen Nguyen (UIUC) and Andrew Taylor-Robinson (VinUni)
4	**Title**: **"Pathogen bacteria biosensors based on novel materials"** **Description**: Biosensors are devices that can detect biological substances, including tiny molecules like DNA, protein, and cells. They have a wide range of applications, including clinical diagnostics, environmental monitoring, and food safety. Biosensors can be constructed to detect a variety of signals, but their principal function is to determine the concentration of a single species. The key elements to consider when constructing biosensors are sensitivity, selectivity, accuracy, low detection limit, preparation cost, and complexity. These goals can be met by optimizing the sensing materials. As a result, our team creates innovative biomaterials	Mai Tran (CECS, VinUni) and Nhung Nguyen (CHS, VinUni)

	and uses them to detect and measure the amounts of bio-analytes such glucose, pathogen bacteria DNA, and residual antibiotics. As a result, this initiative has two goals: **Goal 1:** Create a protocol, experimental procedures, and test the structural/optical/electrical properties of synthetic materials. **Goal 2:** Using biomaterials for biosensing applications using electrochemical and optical methods.	
5	**Title: "Smart Indoor Air Quality Control System for Healthier and Greener Buildings"** **Description**: The quality of the indoor environment has a critical impact on people's health because on average, we spend more than 90% of our time indoors. Providing a healthy and safe indoor environment can save lives, reduce diseases, and increase our quality of life. We propose a project funded by VinUni-Illinois Smart Health Center to deliver the necessary tool to achieve the target of making healthier buildings worldwide to protect human health. There are five proposed tasks: **Task 1**. Quantify environmental persistence and infectivity of respiratory viruses. The persistence and infectivity of coronavirus and influenza viruses will be measured under various indoor environment (e.g., temperature (T), relative humidity (RH), and lighting conditions). **Task 2.** Field research to quantify the concentration of air pollutants in indoor environments with and without intervention. We will deploy air samplers at different locations in hospital facilities (e.g., Vinmec Times City in Hanoi) and other buildings (e.g., VinUni and TechnoPark building in Hanoi) to collect bioaerosols and reactive volatile and particulate matter (PM) components. **Task 3**. Generate full-scale full-geometry predictive tools to understand airflow and aerosol transport in indoor environments. We will create a computational fluid dynamics (CFD) model that integrates the Navier-Stokes equations, heat transfer, and a scalar convection-diffusion equation to describe the airflow, temperature, and their efforts on aerosol transport. **Task 4**. Privacy-preserving analysis of air quality data and user profiling by federated learning. The indoor air quality data will be collected from various sensors and internet-of-things (IoT) devices. We will leverage Machine learning/Deep learning by Watson Studio to manage the HVAC system based on its operating parameters and the decision of building managers. **Task 5**. Design an AI management platform for controlling air quality. Our final task is to develop an AI-integrated privacy-preserving analytics platform that supports indoor air quality monitoring, detecting, and preventing anomalies. Specifically, the platform will offer interactive interfaces for infection control and facility managers to make informed and optimal intervention strategies as per different intended uses of the multi-used indoor environments. The project's outcome will be an accurate assessment of the health risks from indoor contaminants and real-time recommendations for intervention strategies to reduce these risks.	Vishal Verma (UIUC), Helen Nguyen (UIUC), and Jinhui Yan (UIUC), Le Duy Dung (VinUni), Kok-Seng Wong (VinUni), Andrew Taylor-Robinson (VinUni)
6	**Title**: **"Federated Backdoor Attacks in the Physical World"** **Description**: Machine learning, especially deep neural networks (DNN), rapidly advances and transforms our daily lives in various fields and applications. Such intelligence is becoming prevalent and pervasive, embedded ubiquitously from centralized servers to fully distributed Internet-of-Things (IoT). Unfortunately, since well-trained models are now viewed as high-value assets that demand extensive computer resources, annotated data, and machine learning expertise, they are becoming increasingly attractive targets for cyberattacks, including adversarial examples, poisoning attacks, backdoor attacks and privacy leakages. Among these, backdoor attacks expose the vulnerability in the model building supply chain that seeks to inject a stealthy backdoor into a model by poisoning the data or manipulating the training process. A backdoor attack in federated learning (FL) is when a malicious participant in an FL system tries injecting a backdoor into the trained model. Such an attack aims to manipulate the model's behavior to benefit the attacker. The backdoor attack typically involves two stages: poisoning and exploitation. In the poisoning stage, the attacker introduces a small number of poisoned samples into the training data of one or more participants in the FL system. These poisoned samples are specifically designed to trigger the backdoor behavior of the model. In the exploitation stage, the attacker waits for the model to be deployed and used in the real world. When the model encounters data that matches the poisoned samples, it triggers the backdoor behavior, allowing the attacker to carry out their intended attack. Existing works mainly focus on digital attacks that apply digitally generated patterns as triggers. However, it was shown recently, backdoor attacks using physical objects as triggers can achieve a high attack success rate. This project focuses on developing effective strategies and technologies to prevent or mitigate physical backdoor attacks. **We aim to (1) collect datasets for facial/object recognition, (2) conduct an empirical study on the existing attack strategies, and (3) assess the effectiveness of SOTA defenses against physical backdoor attacks.**	Kok-Seng Wong (CECS, VinUni) and Khoa Doan (CECS, VinUni)
7	**Title: "Emerging Properties of Recently Developed Deep Learning Models"** **Description**: In recent years, deep learning (DL) has experienced multiple novel developments in both network architectures, learning paradigms, and large-scale models, all of which have achieved incredible successes in several domains. For example, self-attention and transformer based architectures have transformed both language and vision applications. Built on large language models (LLMs), the generative and conversational functions of models such as ChatGPT or OPT have reached human level performance. Recently, the forward-forward algorithm has also been proposed to replace backpropagation, which is the de-facto standard of training neural networks. It is clear that, with their impressive performance and capabilities, these advanced and complex models and techniques will increasingly be used in more real-world applications. As a result, it is crucial to understand their robustness under both intentional and unintentional attacks. This project focuses on studying various robust features of these developments, with a focus on large-scale models and the new training technique forward-forward. We aim to (1) perform existing robustness studies on these models, (2) analyze and contrast the results compared to the existing models, and (3) summarize their emerging properties.	Kok-Seng Wong (CECS, VinUni) and Khoa Doan (CECS, VinUni)
8	**Title: "Simulating Human Musculoskeletal Dynamic for Medical Applications"** **Description**: This project focuses on developing computational model for analyzing human motion in orthopedic clinical applications. This is a multidisciplinary research which involves expertise in computer science, biomechanics and orthopedic. High-quality motion capture data and MRI images on real patients will be collected on real-patients at VinMec to reconstruct subject-specific 3D musculoskeletal system and motion simulation for a comprehensive analysis. In the first stage, this project will study a group of patients preparing to take hip and knee joint replacement surgery. The potential outcomes might provide a multi-purpose simulation software for doctors to design better surgery strategy, and post-surgery recovery rate estimation.	Minh Do (UIUC), Hieu Hoang (UIUC), Hieu Pham (VinUni), Ho Ngoc Minh (Vinmec)

9	**Title: "Point of Care Detection of Cancer miRNA using DNA Stabilized Silver Nanoclusters and Smartphone based fluorimeter"** **Description**: While a growing arsenal of drugs is available to treat specific molecular abnormalities across cancers, therapy effectiveness can now be predicted by detecting specific exosomal micro-RNA (miRNA) in plasma. While next-generation sequencing (NGS) can provide a comprehensive readout of genomic tumor variants that may provide biological and clinical efficacy insights, its cost, complexity, and sample-to-answer timeframe are not compatible with frequent, routine, point of care diagnostics. Thus, rapid, sensitive, inexpensive, and POCT capable surveillance and screening of cancer miRNA biomarkers will enable therapy selection to be performed at the earliest time while facilitating more frequent remission monitoring. In this project, we will first design, synthesize, and screen DNA probes that can nucleate the formation of silver nanoclusters and generate specific fluorescence signals upon the hybridization of a DNA probe and an miRNA target. We will then design and manufacture a smartphone based fluorimeter to read the release fluorescence signal of miRNA detection.	Brian Cunningham (UIUC), Xing Wang (UIUC), Do Danh Cuong (VinUni), Le Van Quynh (VinUni), Linh Le (VinUni), Tu Phan (VinUni)
10	**Title**: **"Active Learning for Low Data Supervised Learning"** **Description**: Supervised learning, especially with deep neural models, needs a lot of data. Sometimes, Large Language Models and other foundation models are adequate to get reasonable performance on tasks, for instance basic questions for a GP, but in more specialised areas further training may be required. For this, models may be tuned or built from scratch using whatever scarce data is available for the particular task. Active Learning is a specialised subfield that uses statistical methods to optimise the selection of unlabelled data to present to the human experts for labelling, and thus minimise the amount of additional training data required. Active Learning can reduce data needs by 10-30%. It only routes data to the human expert about which the training system lacks confidence and which are not similar to other data. We have developed a Bayesian theory of Active Learning and will demonstrate results on image and text classification, named entity recognition, and multi-labelled classification. In some cases, it is the only system performing substantially above random. We are currently testing it in a variety of medical contexts.	Wray Buntine (CECS, VinUni)
11	**Title**: **"Computational fluid dynamics (CFD) modeling of airflow and aerosol transport in indoor environments"** **Description**: The quality of the indoor environment has a critical impact on people's health because on average, we spend more than 90% of our time indoors. Providing a healthy and safe indoor environment can save lives, reduce diseases, and increase our quality of life. Elevated levels of indoor air pollutants such as black carbon and particulate matter in different buildings in urban areas of Vietnam are similar to or sometimes even higher than the level of those pollutants outdoors exceeding the WHO guidelines and thus posing an elevated risk for the occupants. Better management of indoor environmental quality and saving energy consumption at the same time is of critical national and international significance. In this project, we aims at building a platform that offer interactive interfaces for infection control and facility managers to make informed and optimal intervention strategies as per different intended uses of the multi-used indoor environments.	Le Duy Dung (VinUni) and Yan Jinhui (UIUC)
12	**Title**: **"LLM-powered Medical Chatbot"** **Description**: With advancements in natural language processing (NLP) technologies such as LangChain, Vector Search, and OpenAI GPT-3, chatbots can now interpret human language more accurately and effectively than ever before. In this project, we aim at building a medical Chatbot (English and Vietnamese) using these new technolgies to perform search-to-knowledge to prodivde "safe and helpful answers" to questions posed by healthcare professionals and regular users.	Le Duy Dung (CECS, VinUni), Wray Buntine (CECS, VinUni), Nguyen Quoc Dat (VinAI)
13	**Title**: **"Sleep-disordered breathing detection from electrocardiogram signal"** **Description**: This project aims to develop a machine learning algorithm that can accurately detect sleep-disordered breathing (SDB) from electrocardiogram (ECG) signals. SDB is a common sleep disorder characterized by abnormal breathing patterns during sleep and is associated with various health risks, including cardiovascular disease. Currently, the gold standard for SDB diagnosis is polysomnography, which is an expensive and time-consuming procedure that requires patients to spend a night in a sleep lab. The proposed algorithm would provide a less invasive and more convenient method for SDB detection, allowing for earlier diagnosis and treatment. The project would involve collecting ECG signals from individuals with and without SDB, preprocessing the signals to extract relevant features, and training a machine learning model to classify the signals as either normal or indicative of SDB. The project has the potential to improve the accuracy and efficiency of SDB diagnosis, leading to better patient outcomes and reduced healthcare costs.	Cuong Do (CECS, VinUni) and Hieu Pham (CECS, VinUni), Tien Thanh (Vinmec, CHS)
14	**Title: "Electromagnetics and Optics"** **Description**: This project is at the intersection between Physics, Electrical Engineering, Mechanical Engineering. The aim is to study the photonic structures supporting ultra-high quality factor for biosensing applications, particularly focusing on bound states in the continuum (BIC) photonics. The selected candidate will perform simulation and analyze the formation of BICs in photonic structures with in-house coding and commercial electromagnetism softwares. In parallel to the simulation tasks, the candidate will be trained in experimental work with Fourier spectroscopy and data analysis. Prerequisite: Students took Physics 2020 and 2030.	Quynh Le (VinUni) and Cuong Do (VinUni)
15	**Title: "Functionalization of quantum emitters with biomarkers"** **Description**: This is an interdisciplinary project (Physics, Chemistry, Biochemistry). It focuses on the functionalization of antibodies (IgG) and possible the easy detection biomarkers of colorectal cancer on colloidal plasmonic structures. The functionalization will be conducted at VinUniversity's laboratory where the team has fume hoods, equipment (Vortex mixer, centrifuge, shaker, thermal ovens, magnetic thermal hotplates...) and spaces for processing the materials. The aim is to study the fluorescence of the quantum emitters (semiconductor quantum dots) coupled with plasmonic particles with and without the biomarkers or IgG. After the functionalization, the photoluminescence of the system will be characterized by optical setups. Prerequisite: students took basic chemistry, physics 2020 and 2030, some experiment in wet lab and interested in biochemistry, chemical engineering.	Quynh Le (VinUni) and Cuong Do (VinUni)