NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Graduate College

Joint Projects

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Graduate College

1. Visual Language Models to Generate Medical Report and Explanations

Date Posted	24 March 2024	
Home University	Nanyang Technological University	
Partner University	Technical University of Munich	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	To generate accurate medical reports and providing clear explanations of diagnostic findings are critical tasks in healthcare. Visual Language Models (VLMs) can integrate visual data from medical imaging data (eg. X-ray, Ultrasound, and CT) with textual clinical information (eg. patient history, symptoms, and lab test). This project will develop a VLM-based system that not only generates medical reports but also offers detailed, understandable explanations of the diagnosis, enhancing clinical decision-making and patient communication. The goal is to design a system that analyzes radiological data, identifies important features or abnormalities, and cross-references this visual information with relevant textual data to generate structured medical reports. These reports will describe the findings, suggest potential diagnoses, and offer treatment recommendations. In addition to generating these reports, the system will also provide clear explanations of the visual detection in the context of the patient clinical details, to help healthcare professionals easily understand and act on the data. The project will improves the ability of the model to integrate and understand multiple modality data, to facilitate the accuracy and relevance of generated reports, and to develop explainable AI that allow clinicians to understand the rationale of the AI suggestions. The project will improve workflow efficiency, reduce errors, and enhance communication between medical professionals and patients, ultimately leading to better patient outcomes.	
Program/Center Website(s)	https://medvisailab.github.io/research/ https://aim-lab.io/author/daniel-ruckert/	
Additional Information (e.g., files with project details)	NA	

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2. Enhancing Privacy and Security in Medical Imaging Using Federated Learning

Date Posted	24 March 2024	
Home University	Nanyang Technological University	
Partner University	Technical University of Munich	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	The privacy and security of medical imaging data are important concerns in the healthcare sector, especially as medical imaging (e.g. CTs and X-rays) are increasingly used for diagnostic purposes and shared across systems for analysis and collaboration. The student will work to enhance the privacy and security of medical imaging data through the use of federated learning and advanced data encryption techniques, ensuring that sensitive patient information are protected while enabling the development of AI models for data analysis. Federated learning allows multiple healthcare centres and medical data repositories to collaboratively train machine learning models. This approach ensures that medical data remains on the local servers, maintaining data confidentiality and compliance with regulations eg. HIPAA. Each participating centre trains a local model on its medical data, and only model updates, not raw data, are shared and aggregated in a central server. Furthermore, encryption techniques, such as homomorphic encryption, may be used on the data during the training process. This allows computations to be performed on encrypted data, ensuring that the imaging data are not exposed, even during model training or inference. The student will integrate the privacy-preserving methods into medical imaging workflows while facilitating computational efficiency for secure protocols for cross-centre collaboration. This will facilitate collaboration between medical centres and improve compliance with stringent privacy regulations.	
Program/Center Website(s)	https://medvisailab.github.io/research/ https://aim-lab.io/author/daniel-ruckert/	

Additional Information (e.g., files with project details)	NA

3. Homomorphic Encryption for Privacy-Preserving Analytics and Learning

Date Posted	5 July 2024	
Home University	Nanyang Technological University	
Partner University	Technical University of Munich	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	In an era where data privacy concerns coincide with an unprecedented surge in data analytics and machine learning applications, securing computational methods that protect user privacy is paramount. Homomorphic Encryption (HE) presents a formidable solution by enabling operations directly on encrypted data, thereby ensuring data privacy remains intact during processing. This PhD project focuses on enhancing HE for efficient implementation in machine learning tasks, specifically through optimizing matrix multiplication—a critical operation in numerous algorithms, including neural networks. The specific tasks are as follows: • Task 1 on Algorithms for Homomorphic Encryption-enabled Matrix Multiplication (HE MM). The goal is to develop novel element-wise algorithms to perform HE MM. Unlike existing methods which have dimensional or single-operation constraints, our approach will focus on algorithms capable of handling arbitrary matrix dimensions and multiple successive operations. We will leverage the SIMD scheme to enhance the efficiency of operations on packed ciphertexts, incorporating advanced techniques such as slot rotation and scalar multiplication to optimize computation. • Task 2 on Applying HE MM to Machine Learning. With the novel algorithms from Task 1, this task will integrate these advancements into the training and inference phases of neural networks, focusing on maintaining privacy without sacrificing computational efficiency. This will involve optimizing the packing and rotation of data within neural networks to match HE operation constraints effectively.	

	The successful development of efficient HE algorithms for matrix multiplication could revolutionize the field of privacy-preserving analytics by making it feasible to implement these methods in real-world machine learning tasks. This has profound implications for sectors where data sensitivity is paramount, such as healthcare and finance, allowing for the broad adoption of AI solutions without compromising user privacy.
Program/Center Website(s)	NA
Additional Information (e.g., files with project details)	NA

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4. Dissecting the molecular functions of CLPTM1L as a lipid-flippase with oncogenic roles

Date Posted	1 July 2024	
Home University	Nanyang Technological University	
Partner University	Technical University of Munich	
Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	CLPTM1L is a protein that has recently been described as a lipid flippase that can thus change the composition of both leaflets of biological membranes (Wang et al., PNAS, 2022). At the same time multiple studies point towards CLPTM1L being involved in the development of different forms of cancer, e.g. cervical cancer (Koel et al., Hum Mol Genet, 2023) and lung cancer (Mandour et al., Adv Resp Med, 2020). The links between the molecular functions of CLPTM1L and its role in cancer development have remained unclear and will be explored during this project. Specifically, we will: **Analyze the flippase functions of CLPTM1L**: Using lipidomics of different cellular organelles, we will assess if CLPTM1L overexpression or knockout changes the lipid composition of cell organelles. **Define the CLPTM1L-affected proteome**: Lipid composition of membranes can affect membrane protein stability and/or their signalling which may be related to a role of CLPTM1L in cancer. Using CLPTM1L overexpression or knockout we will define by proteomics and RNAseq which proteins and /or pathways are affected in cells. **Perform drug screens to modulate CLPTM1L function**: Based on the aforementioned parts of the project, we will aim to develop a high-throughput capable screen for the functions of CLPT1ML that can serve as a basis to screen for inhibitors of CLPTM1L taking its role in cancer development into account.	

	Together, this project will define the functions of an ill-defined but strongly cancer related lipid flippase and set the basis for inhibitor screens for this protein.
Program/Center Website(s)	NA
Additional Information (e.g., files with project details)	NA

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5. Investigating Cytokine Receptor Biogenesis and Protein Quality Control in Immune Cells during *Enterococcus faecalis* Infection

Date Posted	1 July 2024	
Home University	Nanyang Technological University	
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Supervisors	**Home**	**Partner**
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Project Description (200-300 words)	The endoplasmic reticulum (ER) plays a pivotal role in the biogenesis and quality control of secreted and membrane proteins, including cytokine receptors critical for immune cell signaling. Disruptions in protein quality control (PQC) can lead to misfolding and malfunction of these receptors, affecting immune responses. This project aims to investigate the mechanisms of cytokine receptor biogenesis and PQC in immune cells during *Enterococcus faecalis* infection, leveraging single-cell RNA sequencing (scRNA-seq) data to uncover novel insights. Using advanced techniques in protein biogenesis and immunology, we will analyze the production and quality control of cytokine receptors, such as IL-12Rα, but also cytokines in immune cells from infected tissues. Our preliminary scRNA-seq data have identified key immune cell populations and pathways affected by *E. faecalis* infection. We will focus on the ER's role in managing the biogenesis and quality control of these receptors. Specifically, we will: **Characterize the ER Stress Response and PQC Mechanisms**: Identify and analyze PQC factors affecting cytokine and receptor biogenesis during infection. **Investigate Cytokine Receptor Biogenesis**: Explore how *E. faecalis* infection impacts the biogenesis and cell surface expression of cytokine receptors, using CRISPR/Cas9 and siRNA approaches. **Rational Engineering of Cytokine Receptors**: Engineer cytokine receptors with enhanced stability and function	

	under ER stress conditions to improve immune responses during bacterial infections. This project will provide insights into protein quality control, cytokine receptor biogenesis, and immune responses during bacterial infections. By combining expertise from both labs, we aim to develop innovative therapeutic strategies targeting the ER to enhance immune function and combat infections.
Program/Center Website(s)	NA
Additional Information (e.g., files with project details)	NA