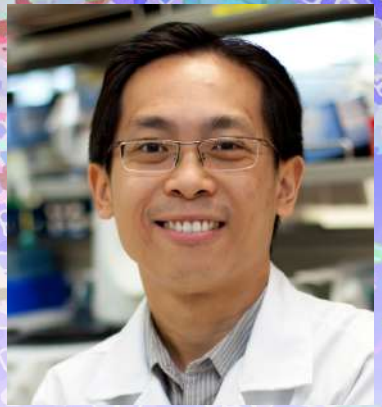

Cellular Image Informatics Division

Dr Hwee Kuan Lee has 15 years experience in the use of Machine Learning and Artificial Intelligence for the improvement of healthcare. His laboratory develops AI diagnostics for oncology, cardiology, dermatology and hematology. His laboratory also uses AI for agriculture technology.

Dr. Weimiao Yu is an image processing and AI/ML expert in computational digital pathology. His research outcomes were published in top international peer-reviewed journals, such as Nature Cell Biology, Nature Communication, Breast Cancer Research and Current Biology.



Dr. Lit-Hsin Loo's background is in computational pharmacology and toxicology. His research group develops high-throughput imaging-based phenotypic profiling methods and software tools to identify markers and build computational models that are predictive of the therapeutic or adverse effects of drugs or chemicals.

Using modelling and bioimaging to study biophysical problems arising in biology and medicine, such as cell migration which occurs in wound healing or cancer metastasis, as well as applications to cultured meat and pose and behavioural tracking in animals.

Dr Bhanu Prakash has 18 years experience in the use of AI/ML for healthcare data analytics. His group develops novel clinical data analysis algorithms to extract meaningful information which enables detection, characterization, and quantification of clinically significant information. Focus areas are - Neuroimaging data analytics, Metabolism studies, and Cardiology.


Computer Vision
and
Pattern Discovery
Laboratory

Development of AI research for:

- Digital Pathology and oncology
- Cardiovascular diseases
- Protein structures and drug discovery
- Agriculture technology
- others

Institute of Materials Research and Engineering IMRE
Institute of High Performance Computing IHPC
Institute for Infocomm Research I2R
Institute of Bioengineering and Bioimaging IBB
Institute of Molecular and Cell Biology IMCB
Genome Institute of Singapore GIS
Experimental Drug Development Centre EDDC
Nanyang Technological University Singapore
Duke-NUS Medical School
NUS National University of Singapore
National Skin Centre National Healthcare Group
National Heart Centre Singapore SingHealth
NUHS National University Health System
Tan Tock Seng Hospital National Healthcare Group
NUH National University Hospital
Singapore General Hospital SingHealth
National Cancer Centre Singapore SingHealth

Single Cell In Situ Spatial Omics (SCISSOR)

Lin Li

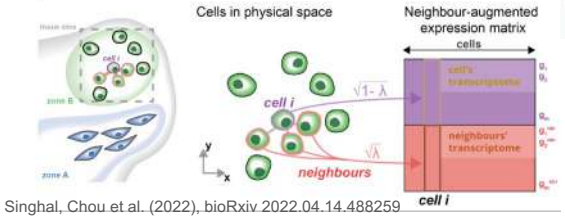
Study cancer **in collaboration with Shyam Prabhakar LAB** (Genome Institute of Singapore).

RNA/DNA expression and location detection
(Spatial Omics techniques: MERFISH)

- Tissue structure
- Diagnostic mutations
- Immuno-therapy
- Liquid biopsy

Application

1. BANKSY: Discovering tissue structures in Spatial Omics data.

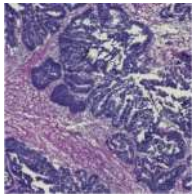


Genome Institute of Singapore
GIS

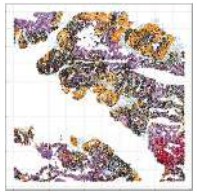
Singhal, Chou et al. (2022), bioRxiv 2022.04.14.488259

2.RNA merFISH allows detection of specific spatial niches in epithelial cells.

Colorectal Cancer (CRC) tissue - H&E

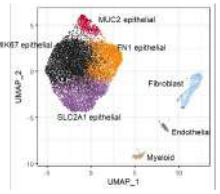


RNA merFISH on CRC tissue



-Epithelial markers: FN1 MKI67 MUC2 SLC2A1
-Fibroblast markers: COL3A1
-Myeloid markers: CD14

UMAP of **cells** in merFISH runs



Digital Pathology

Tan Tock Seng Hospital
National Healthcare Group

Automated Prostate Cancer Grading

Digital histopathology slide

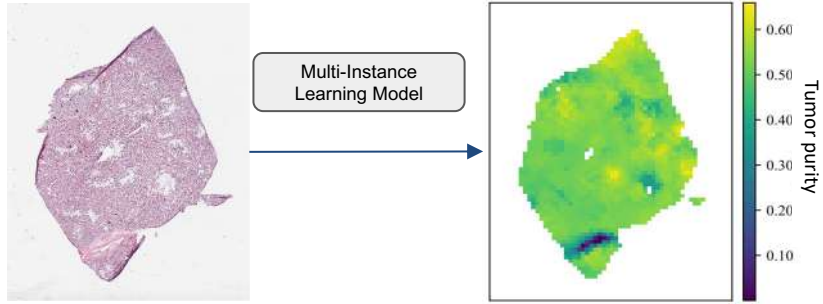
Suspicious regions map

Oner et al. Patterns 3 (12),100642 (2022).

Automated Spatial Tumor Purity Maps

TCGA LUAD cohort

Malay Singh, Tianyi

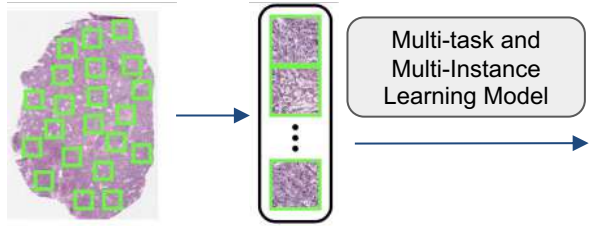


Digital histopathology slide

Tumor Purity Map

Oner et al. Patterns 3 (2),100399 (2022).

Intra-tumor Heterogeneity Quantification



Digital histopathology slide

Bag of Patches

Predictions:--

1. EGFR Mutation Status,
2. Relapse Risk,
3. Tumor Purity,
4. Tumor Mutation Burden,
5. …

Singapore General Hospital SingHealth
National Cancer Centre Singapore SingHealth
Genome Institute of Singapore GIS
NUS National University of Singapore

CellFACE – Imaging-based flow cytometry for hidden hematology biomarker

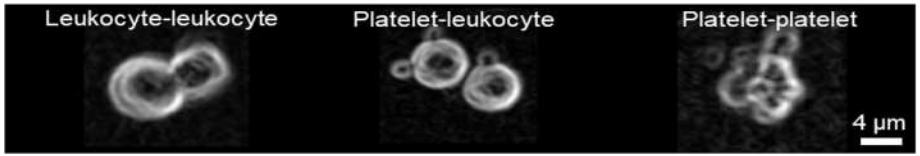
Liu Wei

Objective: Developing a point-of-care compatible label-free imaging flow cytometer with analysis software, to characterize and quantify blood cell a kers for

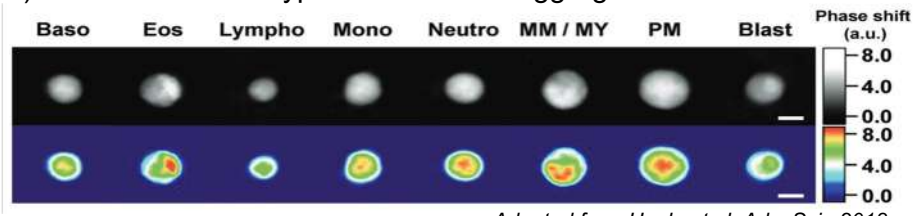
Patient blood sample

Imaging flow cytometry

Our goal at current stage:



1) to detect different types of blood cell aggregations



Adapted from Ugele et al, Adv. Sci., 2018

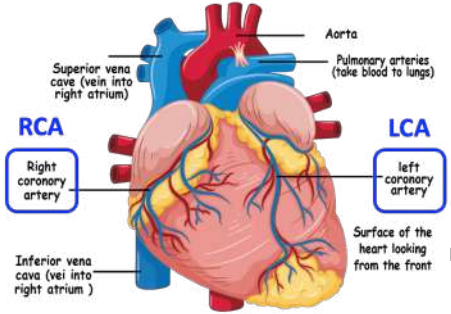
2) to discover unique morphological characteristics of white blood cells from phase distributions.

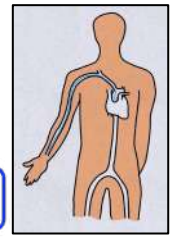
Catheter X-ray guided Angiography

Tiana, Liu Wei

Coronary angiogram is the gold standard technique to visualise coronary arteries of the heart. It is performed to detect blood vessel narrowing (stenosis), found in coronary artery diseases.

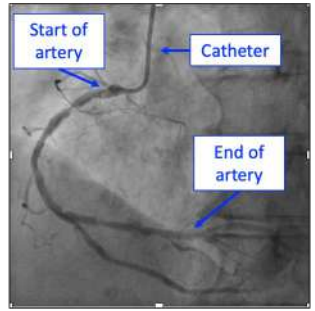
Vessels in the heart



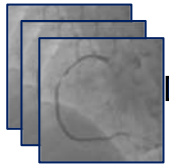


Insert catheter, Inject contrast dye

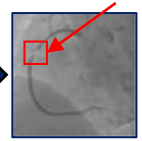
Angiography video



Video Sequence



Deep Learning



Detect Stenosis

Results:

Original | **True Labels** | **Prediction**

We aim to explore AI approaches **for stenosis detection** with X-ray angiography video sequences.

Infectious Diseases Labs ID LABS
NUHS National University Health System
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
TUMCREATE
Technical University of Munich
National Heart Centre Singapore SingHealth
DukeNUS Medical School
Institute of Bioengineering and Bioimaging IBB

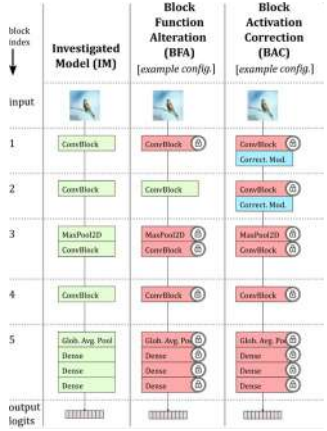
eXplainable AI (XAI) to understand the mechanisms of adversarial perturbations

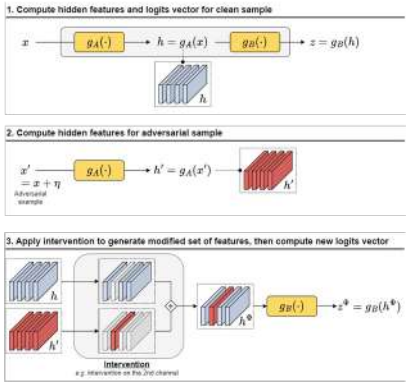
Davide

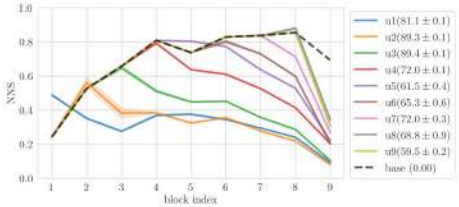
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

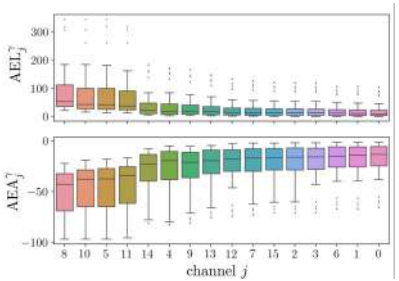
Adversarial perturbations are an unresolved security issue of all AI models, which limits their trustworthiness and robustness in critical settings

Frameworks have been developed to diagnose the vulnerable components of a CNN model, that can teach us how to fix them









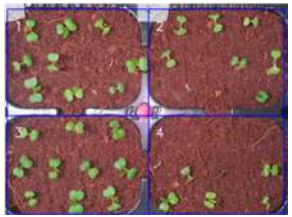
Automated analysis of plant seed germination using mobile images

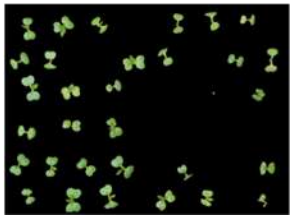
Davide

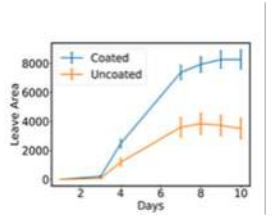
Institute of Materials Research and Engineering IMRE

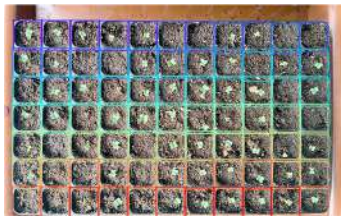
Many insights on the future growth of a plant can be learned just by observing its initial germination stage

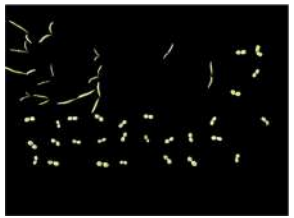
A software is being developed to track and measure the growth of a plant using pictures from a mobile phone

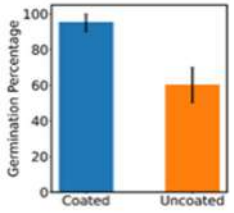










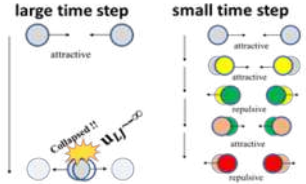


Spatial-temporal Renormalisation Group Approach for AI driven molecular/spin dynamics

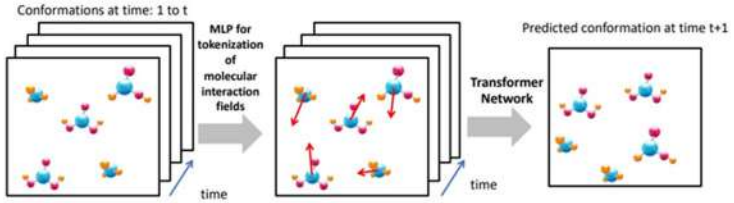
Sojeong, Liu Wei

Off-lattice Lennard-Jones fluid

Large time step molecular dynamics simulations cause fatal numerical instabilities. AI enhanced molecular dynamics can speed up simulations by > 10x



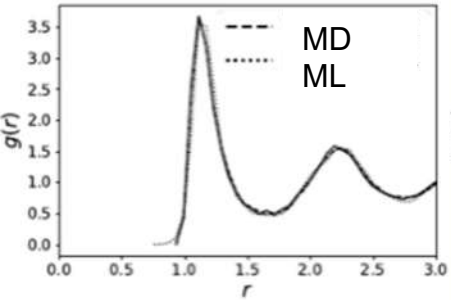
A spatial temporal renormalization approach as local multibody interactions



With local update steps using neural networks, inference from trained models at different thermodynamics microstate

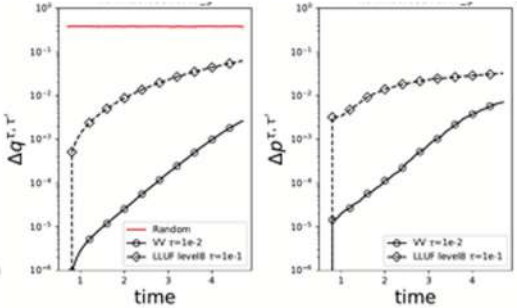
Radial distribution function

n=128, Gas-liquid phase



Divergence on the two trajectories

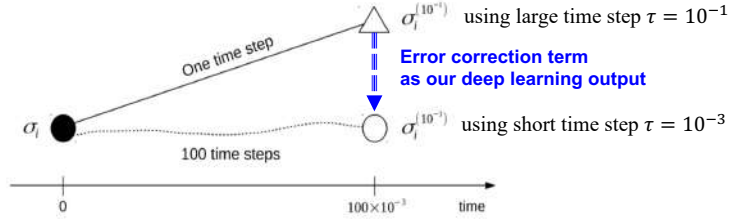
n=64, Gas phase



On-lattice classical Heisenberg

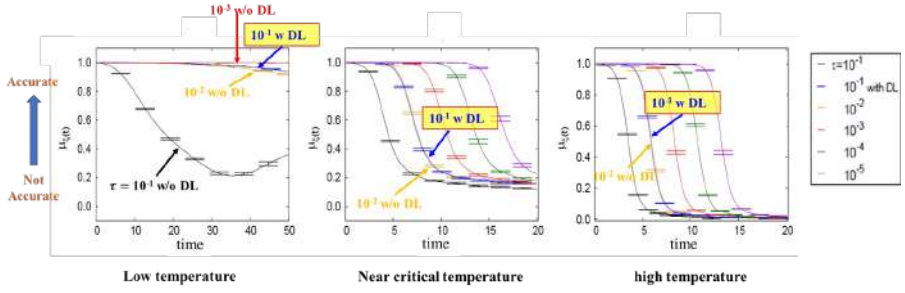
The Heisenberg equations of motion dynamical system can be solved by using symplectic algorithm which have the limitations of requiring the integration time step.

Deep Learning approach to Spin Dynamics



10x speed up at the same simulation accuracy

Dynamic properties : Spin-spin correlations



AI driven national Platform for CT cOronary angiography for clinicaL and industriaL applicatiOns

Malay Singh
Nicholas
Eddy
Augustine
Mary

National Heart Centre Singapore
SingHealth

NUH
National University Hospital
A member of the NUHS

Tan Tock Seng Hospital
National Healthcare Group

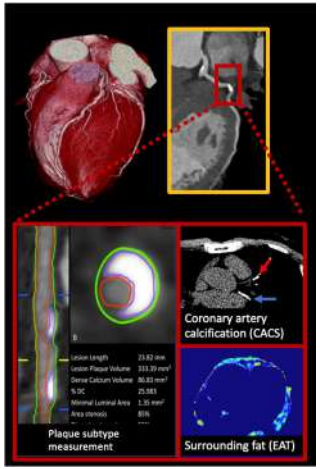
Agency for Science, Technology and Research
SINGAPORE

DukeNUS Medical School

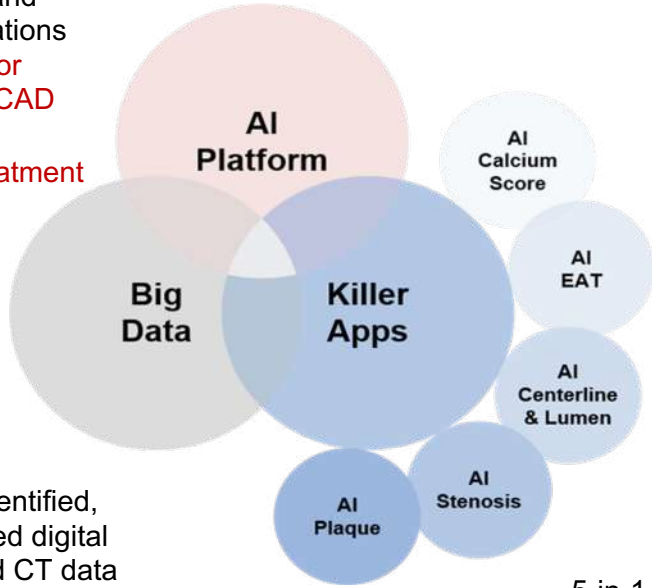
Nanyang Technological University
SINGAPORE

AI driven national Platform for CT cOronary angiography for clinicaL and industriaL applicatiOns (APOLLO)

- Cardiovascular disease – the **World's No.1 Killer**
- CT report generation requires **3 – 6 hours** of a CT specialist's time
- **No effective toolkit** to analyze and predict the disease progress



National platform to support clinical and industrial applications
One-stop-shop for comprehensive CAD assessment and personalized treatment

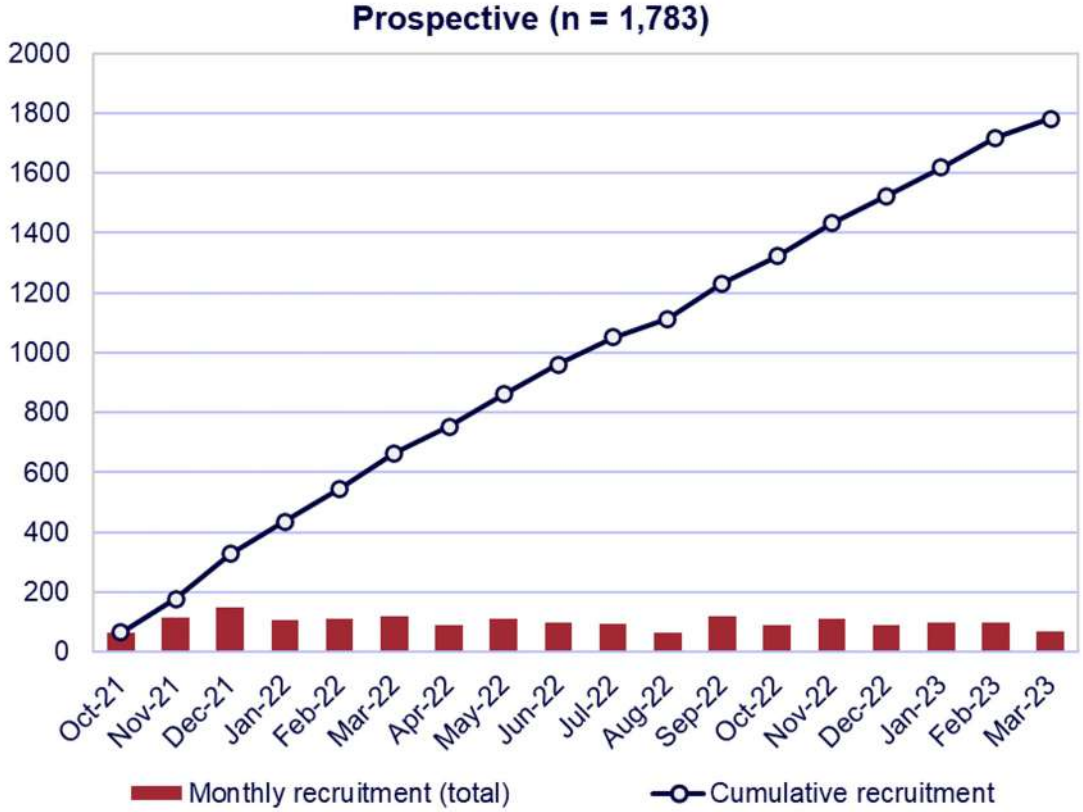


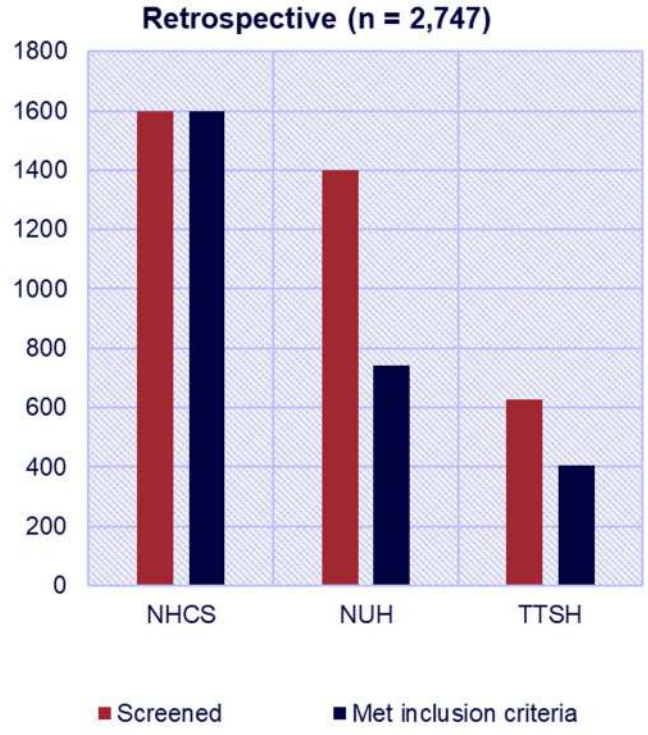
Large, shareable, de-identified, PDPA-compliant, curated digital warehouse of real world CT data
5,000 multi-ethnic Asian subjects (~3 mil images)

5-in-1 AI toolkits for automated post-processing

Current Recruitment Status

- Total target = 5,000 patients
- Currently achieved: 4,530 patients (90%)

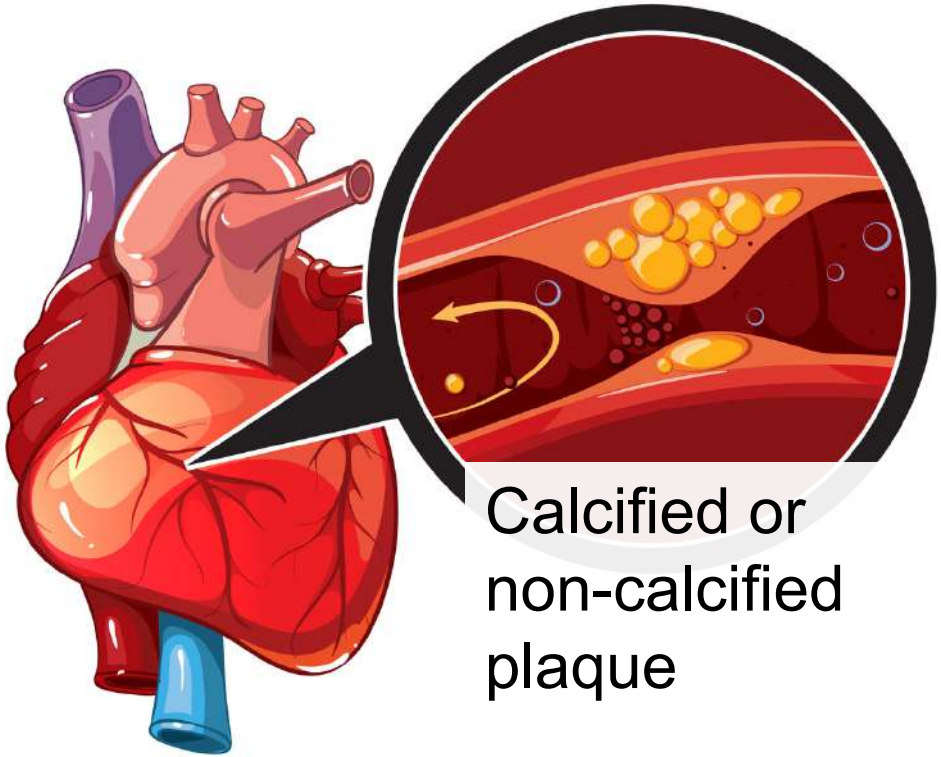




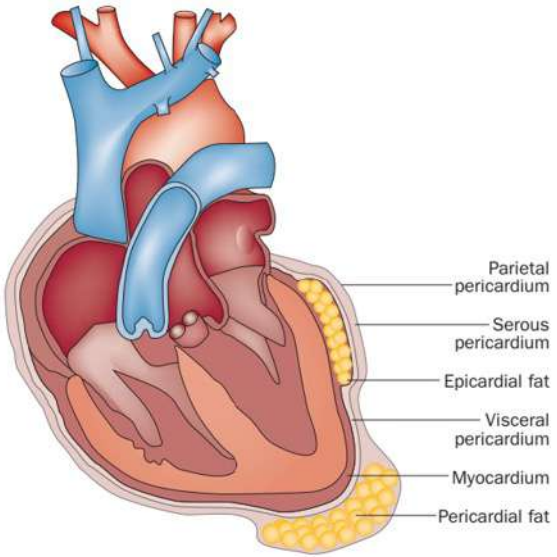
Clinicaltrial.org NCT05509010

Coronary Artery Disease

- Calcium scoring
- Epicardial Adipose tissue
- Stenosis
- Plaque analysis



Calcified or non-calcified plaque



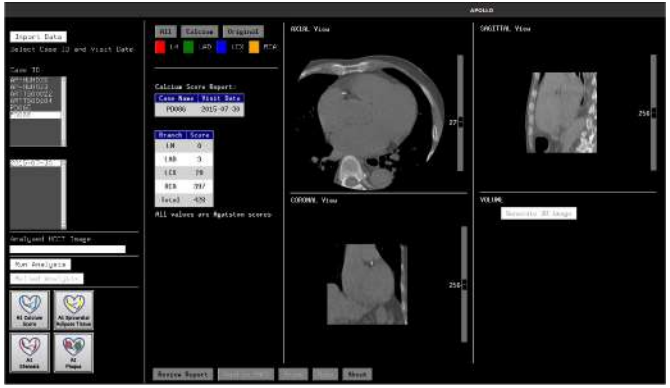
https://www.thekeyholeheartclinic.com/blog/coronary-artery-disease-causes-treatments-and-prevention-methods/

Graphical User Interface of APOLLO

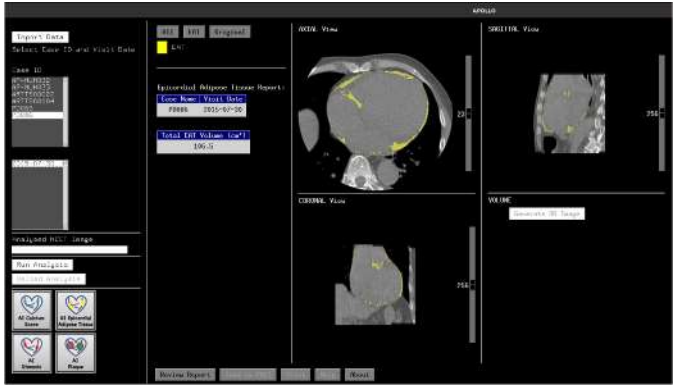
Bioinformatics Institute
BII

Institute for Infocomm Research
I²R

Malay Singh
Augustine



Calcium



EAT

Stenosis

Plaque

National Heart Centre Singapore
SingHealth

Patient Name: Json
DOB: 1800-06-06
Performing: Dr. Ada
Procedure: CT Coronary Angiogram

NRIC: S0000000A
Study Date: 2015-07-30
Case ID: PD086

Gender: Male
Referring Doctor: Dr. Lee
Institution: NHCS

Coronary artery branch	Items	Calcium score	EAT volume (cm³)	Plaque characteristics			Stenosis grade				
							Non-significant		Significant		
				Calcified plaque	Noncalcified plaque	Mixed plaque	Minimal (0% - <25%)	Mild (25% - <50%)	Moderate (50% - <70%)	Severe (>70%)	Occluded (100%)
LM		0	106.5								
LAD	Proximal	3				✓			✓		
	Mid					✓			✓		
	Distal										
	Ramus										
	D1										
	D2										
LCX	Proximal	28				✓		✓			
	Distal					✓		✓			
	OM1										
	OM2										
	L-PLB										
	L-PDA										
RCA	Proximal	397				✓		✓			
	Mid										
	Distal										
	R-PLB										
	R-PDA										
Total		428	106.5								

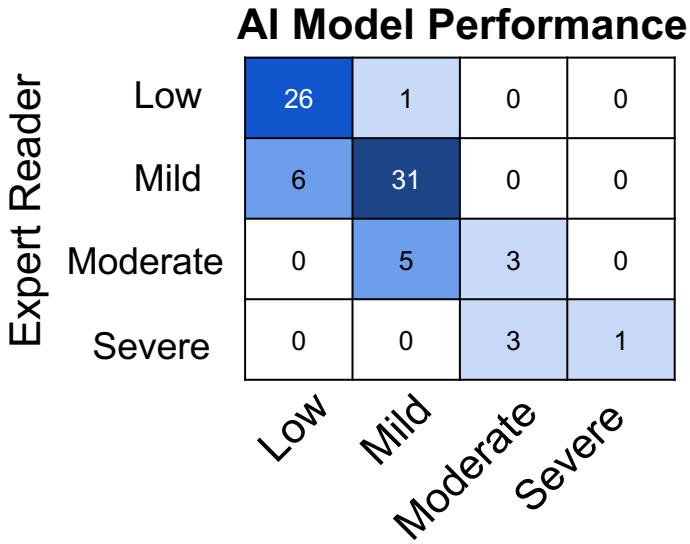
AI Report

APOLLO : AI Killer Apps - AI Calcium Score and AI Epicardial Adipose Tissue

AI Calcium Score

Eddy

Modified ResNets model automatically derives the coronary artery calcium (CAC) score from non-contrast CT scan



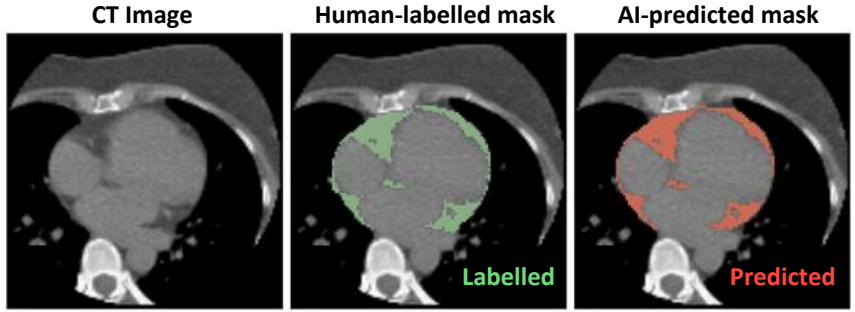
Scoring in National Heart Centre Singapore

Current Challenges:
Highly unbalanced dataset for calcium deposits in different arteries

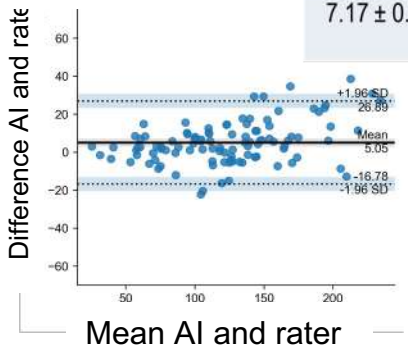
AI Epicardial Adipose Tissue (EAT)

Nicholas

3D UNet model automatically segments the EAT and quantify the EAT volume from non-contrast CT scan



Bland-Atlman plot



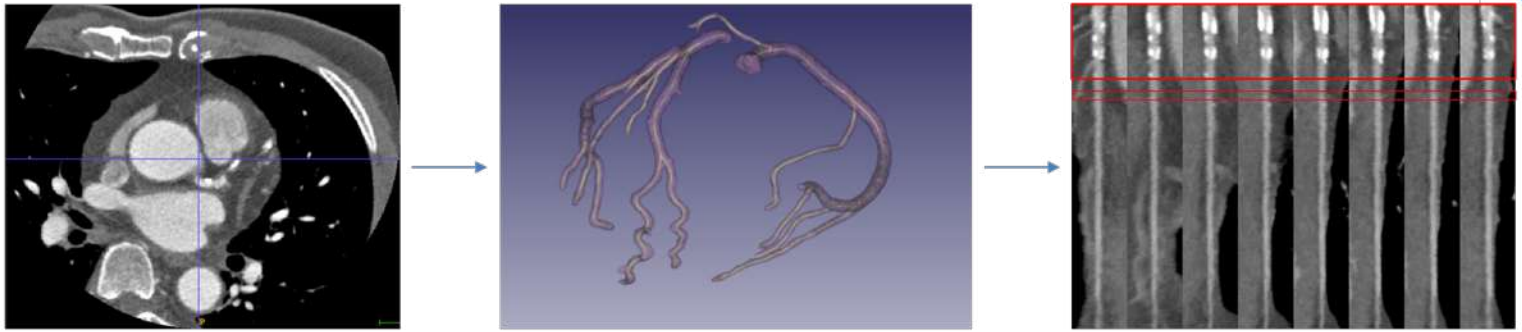
EAT Volume error (%)		EAT Dice Score	
Mean	*Worst*	*Mean*	*Worst*
7.17 ± 0.51	23.82	0.902 ± 0.002	0.843

Current Challenges:
AI EAT Segmentation at the apex of the heart is poorer due to poor tissue contrast

APOLLO : AI Killer Apps - AI Centerline & Lumen, AI Stenosis and AI Plaque

Institute for Infocomm Research
I²R

AI Centerline & Lumen ***AI Stenosis and AI Plaque***



CTCA Centerlines and Lumen Stenosis and Plaque

- Plaque in the arteries is a fatty, waxy or calcified substance that deposits in the artery wall, causing stenosis (narrowing) of the artery
- AI centerline and lumen traces and segments the coronary arteries in 3D – prerequisite for coronary stenosis and plaque assessment.
- A multi-task AI model is applied to achieve stenosis and plaque type classification simultaneously.

AI Models' Performance

Centerline and Lumen Segmentation	94.96% centerlines are within 1mm from ground truth; 96.52% within 2mm.
Stenosis significance classification	accuracy = 0.84, 0.79, 0.84 (at lesion, vessel, patient level)
Plaque type classification	accuracy = 0.81 (lesion level)

APOLLO Media Releases

LinkedIn People ▾ Margaretta Colangelo

Singapore Scientists Integrate AI Tools To Improve Diagnosis of Heart Disease

Margaretta Colangelo
Leading AI Analyst Consulting at Insilico Medicine (41,000+ followers)
Published May 13, 2022

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Singapore is a hotbed of AI innovation. 80 of the world's top 100 technology companies have a strong presence in Singapore enabling innovation and accelerating adoption of AI. This month, a team of leading physicians, AI scientists, and tech experts at the **Agency for Science, Technology and Research (A*STAR)**, **National Heart Centre Singapore (NHCS)**, **National University Health System (NUHS)** and **Tan Tock Seng Hospital (TTSH)** announced the development of a new AI platform called **APOLLO** (AI-driven national Platform for CT cOronary angiography for clinicaL and industriaL applicatiOns) to help doctors improve diagnosis and treatment of cardiovascular disease.

THE STRAITS TIMES TECH

New supercomputer to speed up heart disease, future pandemic research

The supercomputer is expected to take the AI used by clinicians to make sense of diseases and escalate it. ST PHOTO ILLUSTRATION: ARIFFIN JAMAR

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SINGAPORE - A new national supercomputer to speed up healthcare research using large and complex sets of patient data is slated to launch this year.

预计今年内投运 中央医院将配备超级电脑支援医学研究

2 Mar 2022 | Lianhe Zaobao

本地企业KooliLogix总裁张炯杰（左）向副总理王瑞杰（右）展示公司的超级电脑冷却系统3D打印模型。张炯杰说，这套冷却系统也可应用于数据中心。

新加坡国立超级电脑中心、新保集团和英伟达昨天在2022年超算亚洲会议上签署三项合作协议。三方将合作打造立基于超级电脑的科研软硬件生态系统，加强和提升现有的医学研究与创新项目。英伟达将开放其软件开发工具包和开源预训练（pre-trained）人工智能模型的访问权限。

新加坡中央医院将配备一台超级电脑，支援本地医学研究与创新，预计今年内投入运作。

三个将获得提升的项目之一是通过磁共振造影（CT血管造影）的人工智能国家平台（APOLLO）。有了超级电脑的帮助，放射科医生用于解读电脑断层扫描或磁共振造影扫描所需的时间，将可以从原来的两至四小时缩短至10分钟以内。

Challenges in the APOLLO project

- Highly unbalanced data for different coronary arteries (main branch of left artery has little calcium deposit)
- Low tissue contrast between apex of heart and background in CT scans
- Inter-rater variability for stenosis, plaque type and EAT

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Institute of Bioengineering and Bioimaging IBB
Institute of Molecular and Cell Biology IMCB
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Experimental Drug Development Centre EDDC
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Supplementary Slides