



Cellular Image Informatics Division

Computer Vision and Pattern Discovery
Lee Hwee Kuan

Complex Cellular Phenotype Analysis
Loo Lit Hsin

Biophysical Modeling
Chiam Keng Hwee

Computational Digital Pathology
Yu Weimiao



Computer Vision and Pattern Discovery

Lee Hwee Kuan

PhD students	Postdocs	RA & SGUnited Trainees
Mustafa Umit Oner	Mahsa Paknezhad	Lin Li
Park Sojeong	Mohammad Alfatah	Achal Rayakar
Brian K Chen	Nicholas Cheong	Ng Mei Ying
Isaac Cheong Jiasheng	Liu Wei	Rengarajan Hamsawardhini
Davide Coppola	Eddy Tan Wei Ping	Robin Ramdin
Kenta Shiina		



Scope of the lab

Synergies within the institute

Digital Pathology
(with Comp. Digital Pathology Lab in BII)

AI driven protein structure simulations
(with Biomolecular Structure to function)

Machine Learning for Infectious diseases
(with Biomolecular sequence to function)

Translational clinical research

Cardiology

Dermatology

Oncology

AgriTech

Basic research makes good applications

Applied Biomedical AI technology development (TRL3)

Biomedical inspired basic research in AI (TRL2)



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Real world problems
inspire basic research

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Synergies with external parties

Co-supervision of PhD students



Tan Tock Seng HOSPITAL
National Healthcare Group

Pathology
- Prostate cancer



NUS
National University of Singapore



Singapore General Hospital
SingHealth

Pathology / Radiology
- Lung cancer
- Interventional Radiology



NUS
National University of Singapore



National Heart Centre Singapore
SingHealth

Cardiology

- X-ray Coronary Angiography
- CT Coronary Angiography
- Heart electric signal disorder



DukeNUS
Medical School



NANYANG TECHNOLOGICAL UNIVERSITY
SINGAPORE



NATIONAL SKIN CENTRE

Dermatology
- Photoacoustics imaging



CHOSUN UNIVERSITY



National Cancer Centre Singapore
SingHealth

Oncology

- Radiotherapy of Nasopharyngeal
- Chemotherapy assessment
- Lung cancer



NUS
National University of Singapore



Synergies within A*STAR



Tan Tock Seng HOSPITAL
National Healthcare Group

Pathology
- Prostate cancer



Genome Institute of Singapore
GIS

Spatial Omics
SCISSOR



Genome Institute of Singapore
GIS



Singapore General Hospital
SingHealth

Pathology / Radiology
- Lung cancer
- Interventional Radiology



Institute of Molecular and Cell Biology
IMCB



Genome Institute of Singapore
GIS



National Heart Centre Singapore
SinaHealth



National University Hospital

Cardiology
- X-ray Coronary Angiography
- CT Coronary Angiography
- Heart electric signal disorder



Institute of High Performance Computing
IHPC



Institute for Infocomm Research
I²R

Nanopore sequencing



Genome Institute of Singapore
GIS



NATIONAL SKIN CENTRE

Dermatology
- Photoacoustic imaging



Singapore Bioimaging Consortium
SBIC

Deep Learning
Lifelong learning



Institute for Infocomm Research
I²R



National Cancer Centre Singapore
SingHealth

Oncology
- Radiotherapy of Nasopharyngeal
- Chemotherapy assessment
- Lung cancer



Institute of Molecular and Cell Biology
IMCB

De novo Genome assembly



Genome Institute of Singapore
GIS



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Basic research makes good applications

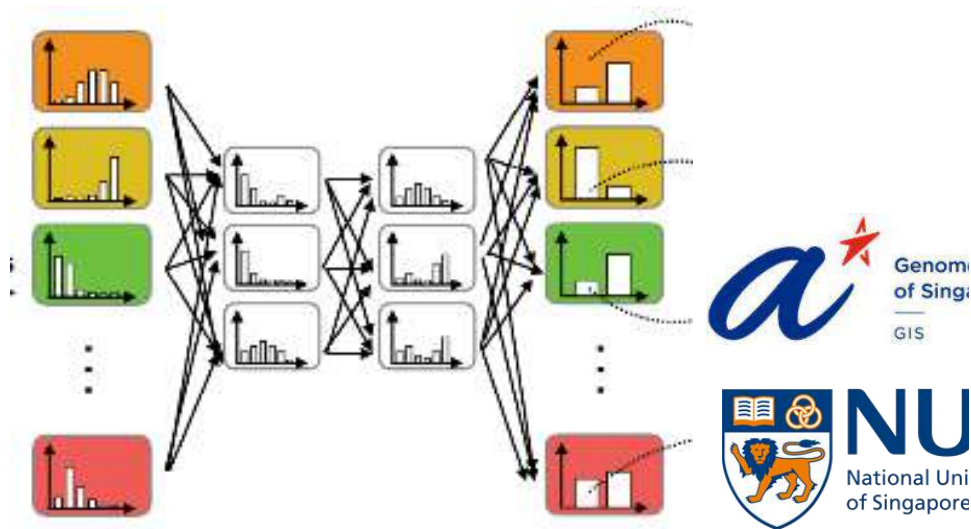
Biomedical inspired basic research in AI (TRL2)





Theoretical Deep Learning

Distribution Regression



Capture the relationship between distributions of two phenomena

e.g. how does the distribution of stock prices today affect the distribution of stock prices next week

How does the frequency of drinking of an individual affects the probability of her/him getting a fatty liver in the next 10 years time

Analysis of huge histopathology slides – linking genomics to images, cancer grading etc



Sener et al. Weakly supervised clustering by exploiting unique class count, ICLR, 2020

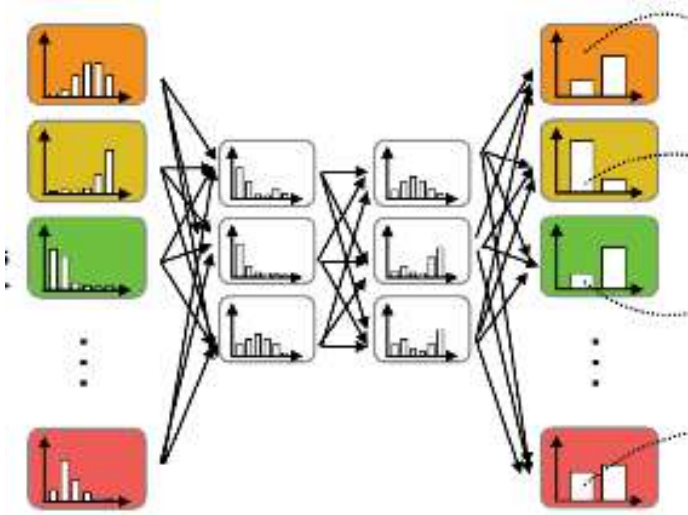


Wu et al. Enhancing Transformation-based defenses against adversarial attacks with a distribution classifier, ICLR, 2020

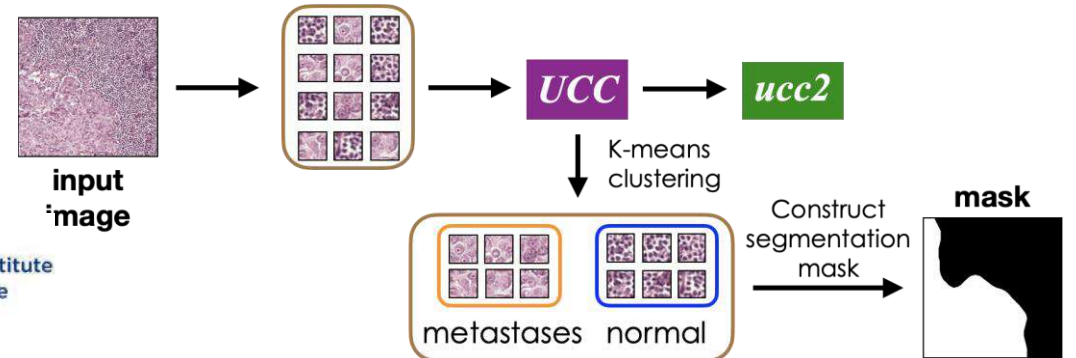


Theoretical Deep Learning

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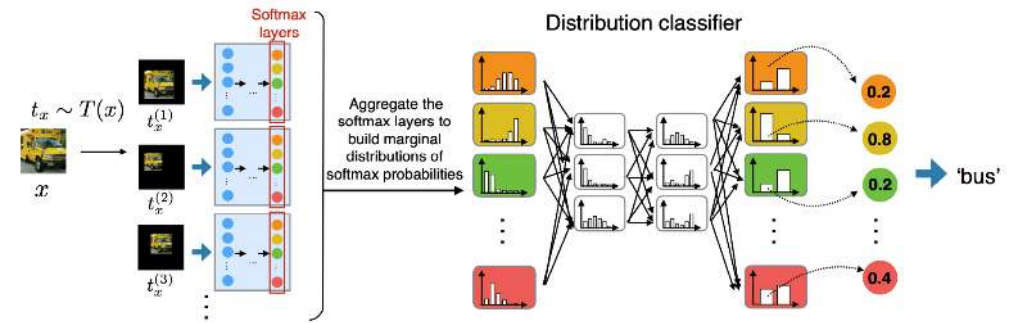


Oner et al. Weakly supervised clustering by exploiting unique class count. *ICLR, 2020.*

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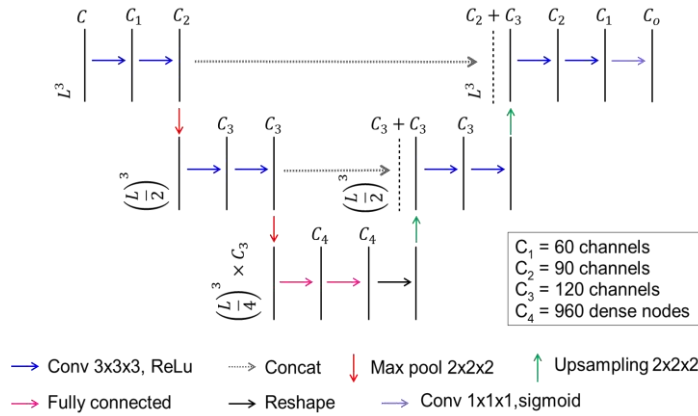


Kou et al, Enhancing Transformation-based defenses against adversarial attacks with a distribution classifier, *ICLR, 2020*



Theoretical Deep Learning

Predicting magnetization on a lattice: **10x faster**

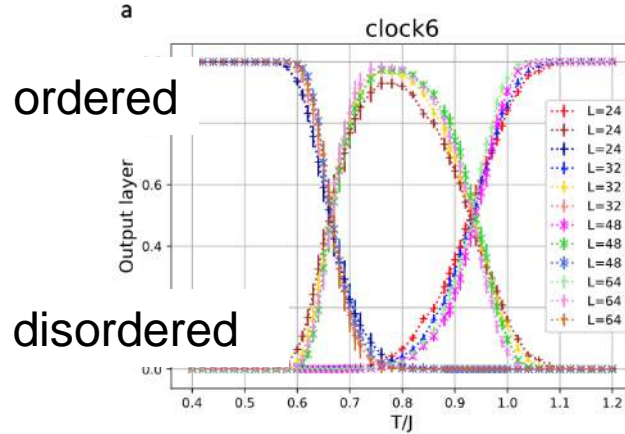


Park et al. Accelerated spin dynamics using deep learning corrections. *Sci Rep*, 2020.



TOKYO METROPOLITAN UNIVERSITY
首都大学東京

Study of phase transitions



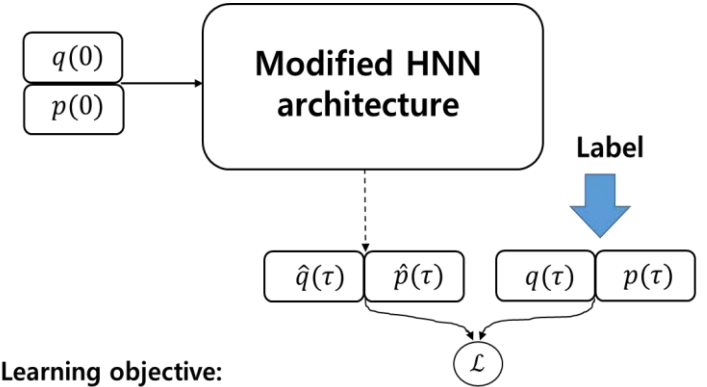
Shiina et al, Machine Learning studies on spin models, *Sci Rep*, 2020

2949 downloads in 2020



CHOSUN UNIVERSITY

AI driven Molecular dynamics with Biomolecular Structure to function division



Learning objective:

Prediction (from one large time step)

$$\mathcal{L}(\theta) = \|\hat{q}(\tau) - q(\tau)\|^2 + \|\hat{p}(\tau) - p(\tau)\|^2$$

Label (from n number of small time steps)

$$\mathcal{L}_{HNN}(\theta) = \left\| \frac{\partial H_{\theta}}{\partial p} - \dot{q} \right\|^2 + \left\| \frac{\partial H_{\theta}}{\partial q} + \dot{p} \right\|^2$$



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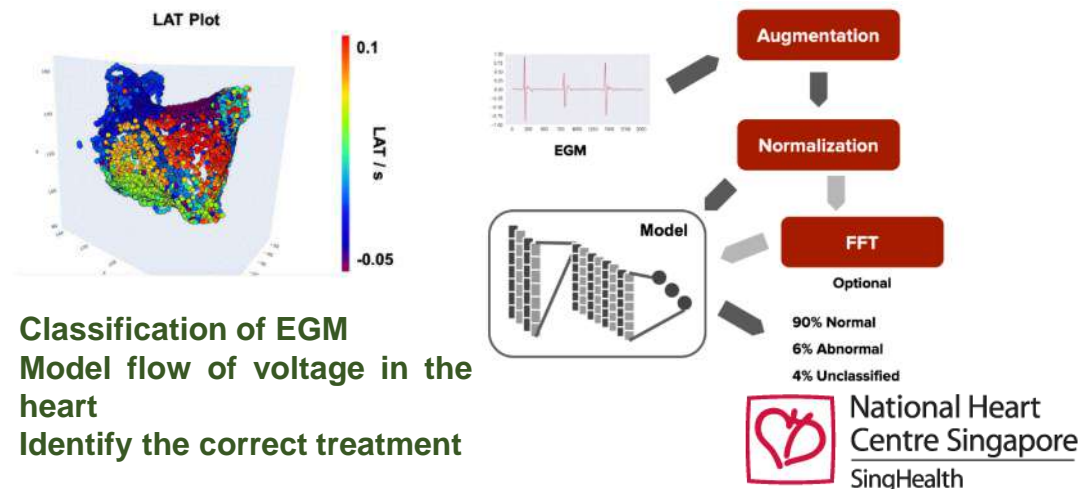
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Medical AI applications

Analysis of heart electric circuits - Tachycardial

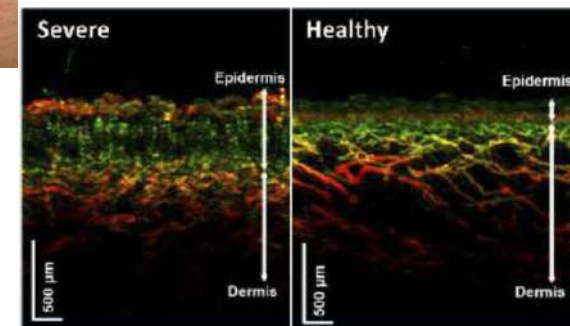


Analysis of 3D Optoacoustic Mesoscopic (RSOM) Images for the Classification of Atopic Dermatitis (AD)

97% Healthy vs Diseases



Atopic Dermatitis
Park et al. Model Learning Analysis of 3D Optoacoustic Mesoscopic Images for the Classification of Atopic Dermatitis, Biomedical Optics Express, 2021



Spring calcium deposit in coronary arteries

Using Deep Learning to detect and score calcium deposits in gated 3D CT images.



Scoring includes classification of calcium in different arteries

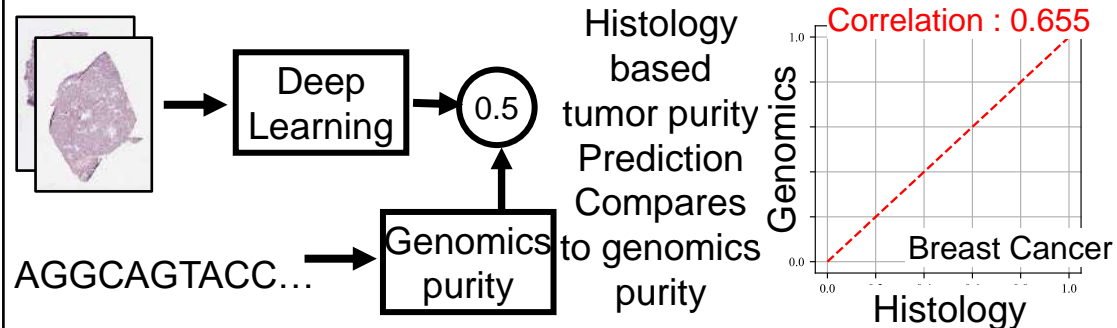


Pan Cancer Tumor Purity



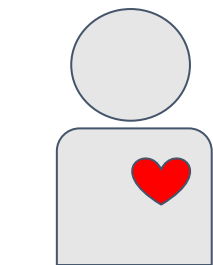
Spearman's correlation coefficients

Breast	Brain (GBM)	Brain (LGG)	Lung A.	Lung S.	Ovarian	Prostate	Uterine
0.655	0.572	0.418	0.515	0.467	0.581	0.424	0.579

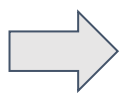




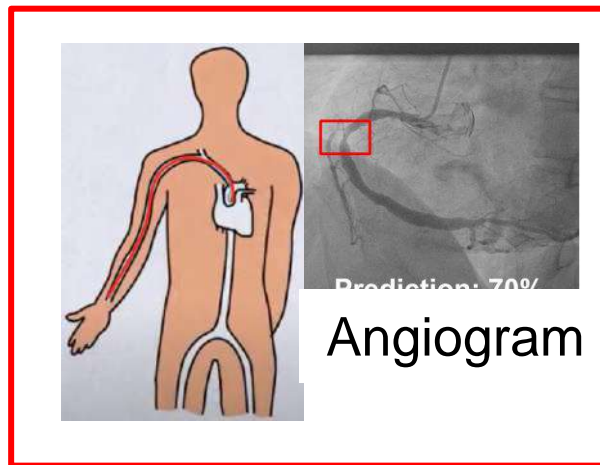
X-ray Fluoroscopy Coronary Angiography



Chest pain



ECG
CT



Treatments

- Angioplasty
- Medication
- others

Current practice of manual annotations are

- Laborious
- Prone to errors

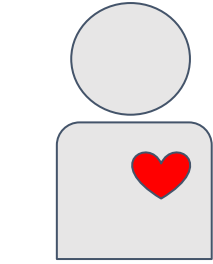
Trained AI for assessment and reporting of angiograms



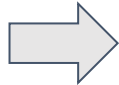
- AI training is supported by big data, over 110,000 videos
- We achieved
 - 81% classification accuracy on stenosis severity
 - 89% F1 score for vessel segmentation



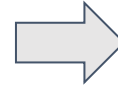
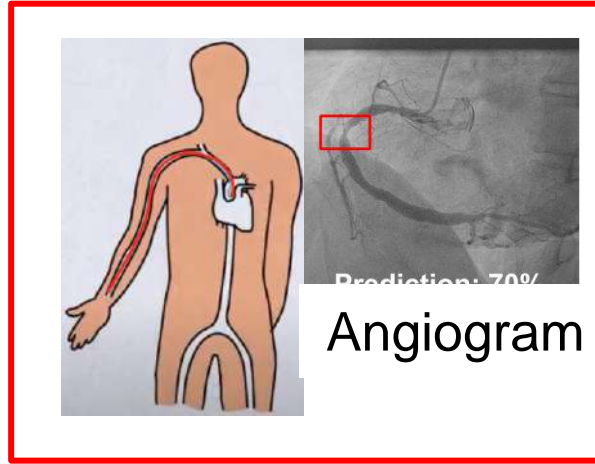
X-ray Fluoroscopy Coronary Angiography



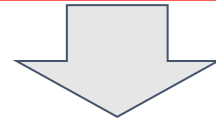
Chest pain



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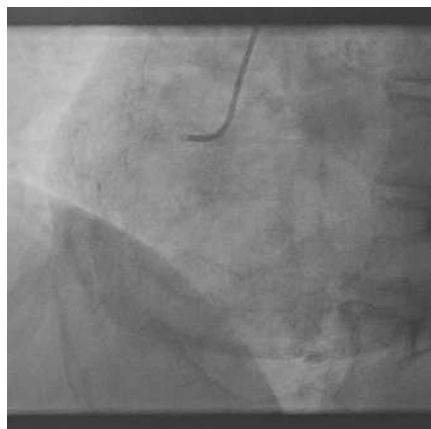


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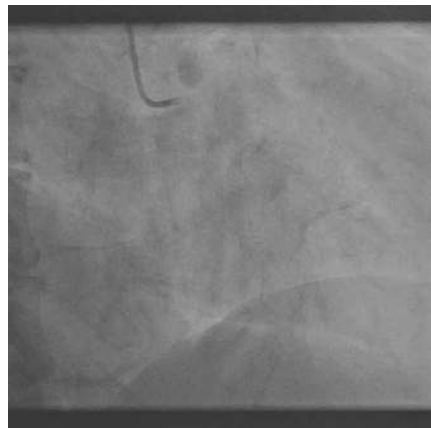


X-ray Fluoroscopy Coronary Angiography

Other views not shown due to space limitations



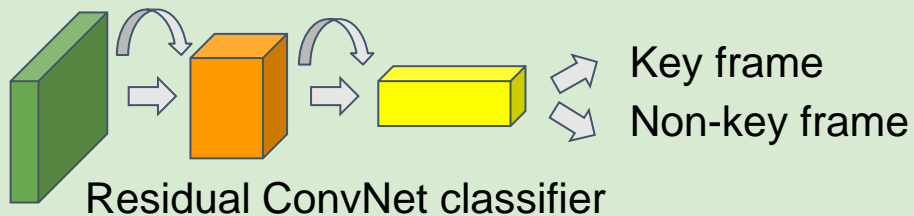
Left Anterior Oblique view



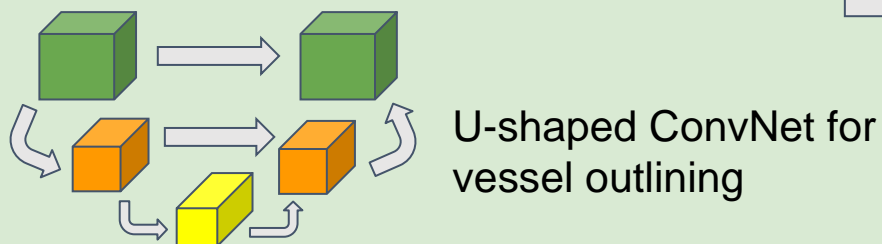
Right Anterior Oblique view

Input: Video sequences from 11 view angles for each patient

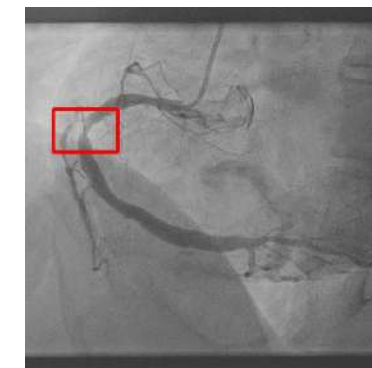
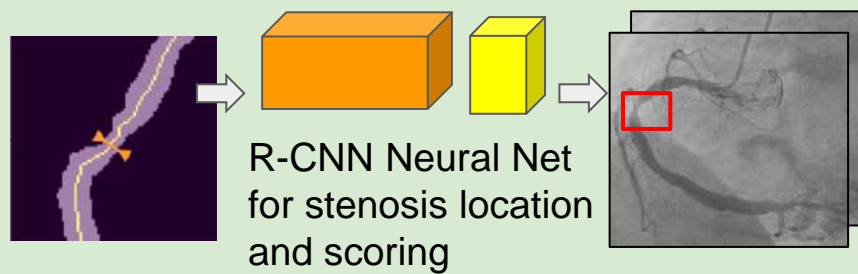
AI choose the part of the video showing vessels filled with dye



Outline the vessels on selected part of the video

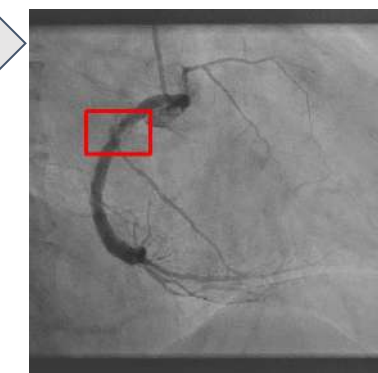


Multiview measure of vessel narrowing



Other views not shown due to space limitations

Left view



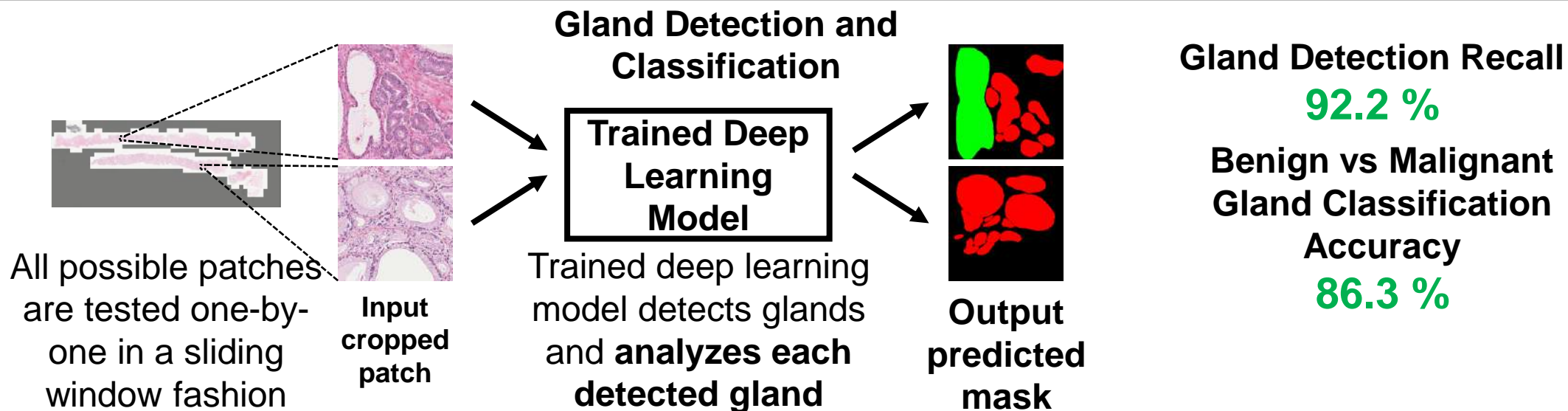
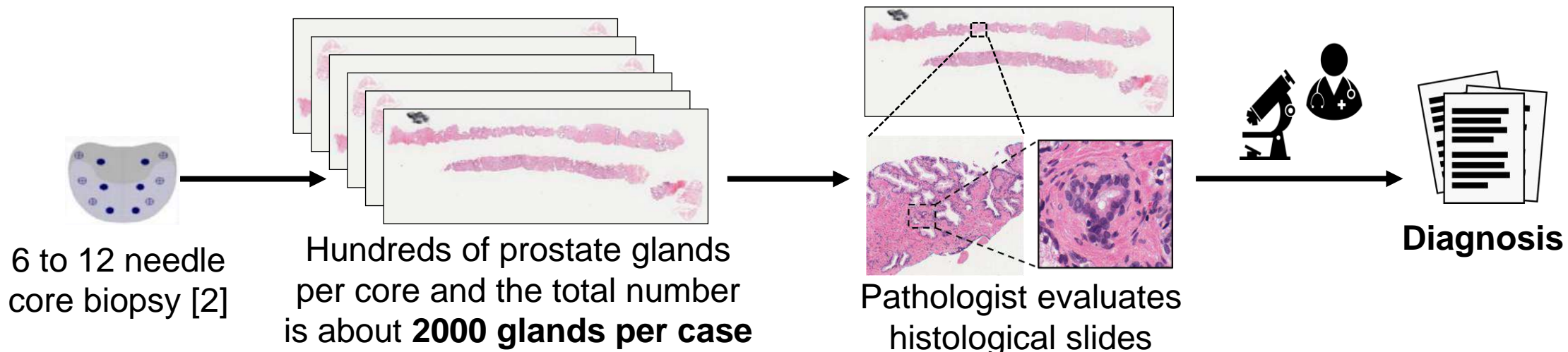
70% stenosis score prediction for this patient

Right view

Output: Multi-view reporting with stenosis boxed and quantified for rapid clinician decision

Using Deep Learning to Assist Pathologists in Prostate Cancer Grading

- ❖ Increased incidence rates of prostate cancer [1] → Increased workload
- ❖ Inter-observer and intra-observer variability
- ❖ Analysis of 1000s of glands per case → Tedious and time consuming
- ❖ Decreasing number of pathologists [3]





a★ Robotic Biopsy with NDR Medical Pte Ltd

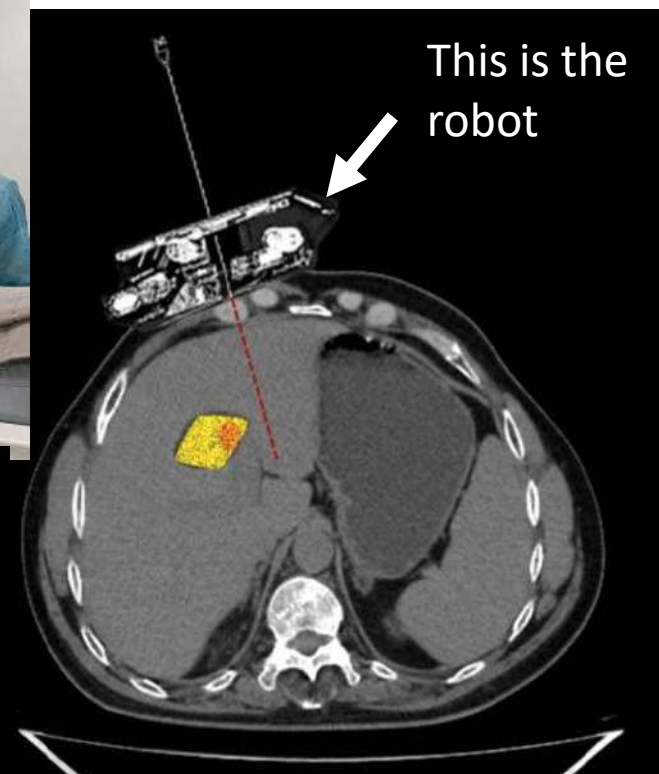
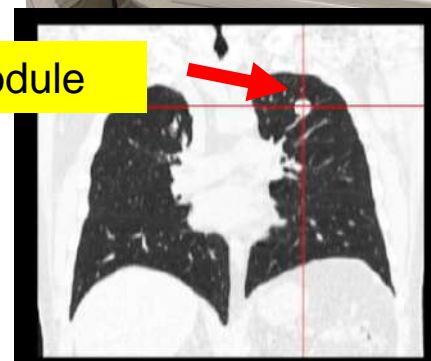


BII's AI technologies translated into NDR

- ❖ Lung nodules localisation and classification
- ❖ Compute safest and most effective entry point of biopsy needles
- ❖ Computational methods for accurate control of the robot parts

Additional values to NDR

- ◆ Guiding and consulting NDR engineers for
 - Making seamless AI-robot interface
 - Solving mathematical problems in robot controls, e.g. use of quaternions in robot rotations
- ◆ Developing talents in NDR through BII's guidance



NDR is a high potential startup who have won many awards

- 1st for Medtech innovator 2019
- 1st "Win the future" 2019
- 2nd Hello Tomorrow 2018
- 2nd Slingshot 2018



Digital health: Better Ultrasound for the future

Lee Hwee Kuan



University Medical Center Groningen

Data:

- ❖ Exclusive Imaging Access **3.5 million images** with full patient consents from **12 countries**
- ❖ Hand annotated images + matching MRIs + clinical data + patient outcomes

Applications:

- ❖ Automation to increase cost efficiency of all hospital echo labs
- ❖ Discovery by unlocking echo databases of raw unstructured images
- ❖ Companion diagnostic & prognostic tool for specific disease states

Len = 9.53cm
Area = 42.1cm²
 Top prize Slingshot 2019,
 MedTech Innovation Award 2019,
 Winner of Hello Tomorrow Feb2020,

Awarded US Patent,
 Contract with Janssen for hypertension studies
 Contract with AstraZeneca for heart failure studies



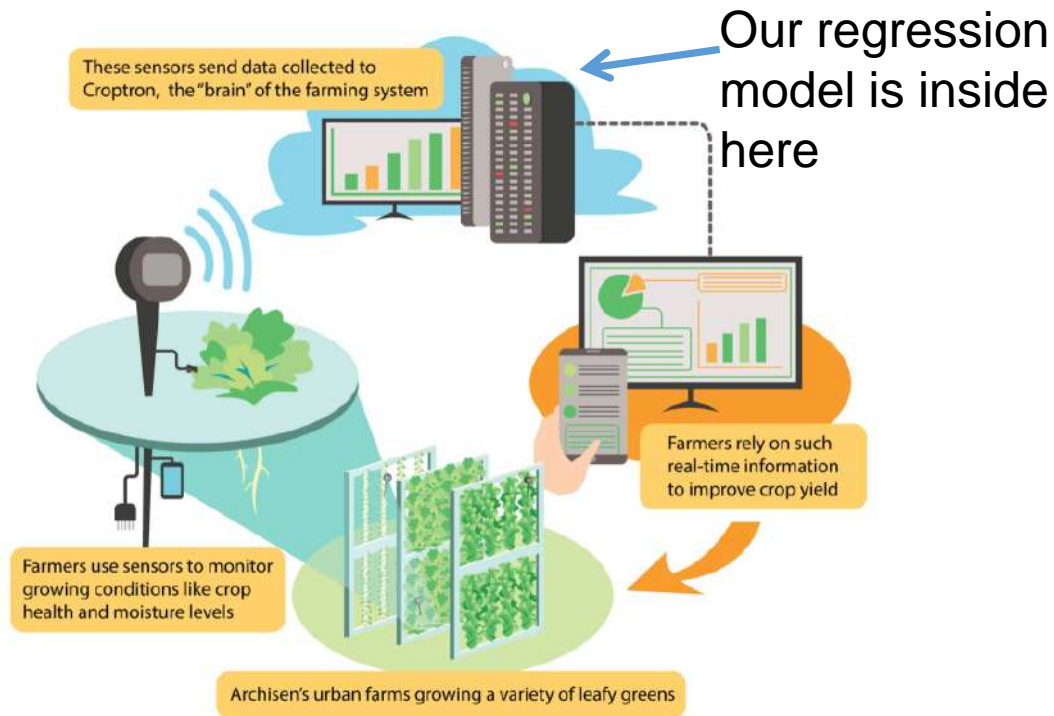
BII: View classification, *chamber segmentation and measurements
 I2R: *Active contour segmentation
 IHPC: M-mode, doppler analysis
 *segmentation is a big task, combine effort of I2R & BII



Grow more with less with Archisen Pte Ltd



We built a regression model for predicting and optimizing grow conditions for Kale and Lettuce plants. Producing highest yield at a lower cost and at a short growing time.



Archisen's Croptron system



Indoor farm managed by the Croptron system

Currently pending more funding from the Singapore Food Agency to do more plant species



Call for collaboration

We request for:

- Impactful applications in biomedical sciences and agriculture technology
- Applications to inspire the discovery of new fundamental AI problems

What we may give in return:

- Very focused on how to make algorithms work effectively in solving real world problems
- Development of novel AI algorithms targeted at solving real world impactful applications

Contact us:

leehk@bii.a-star.edu.sg. <https://web.bii.a-star.edu.sg/~leehk/index.html>