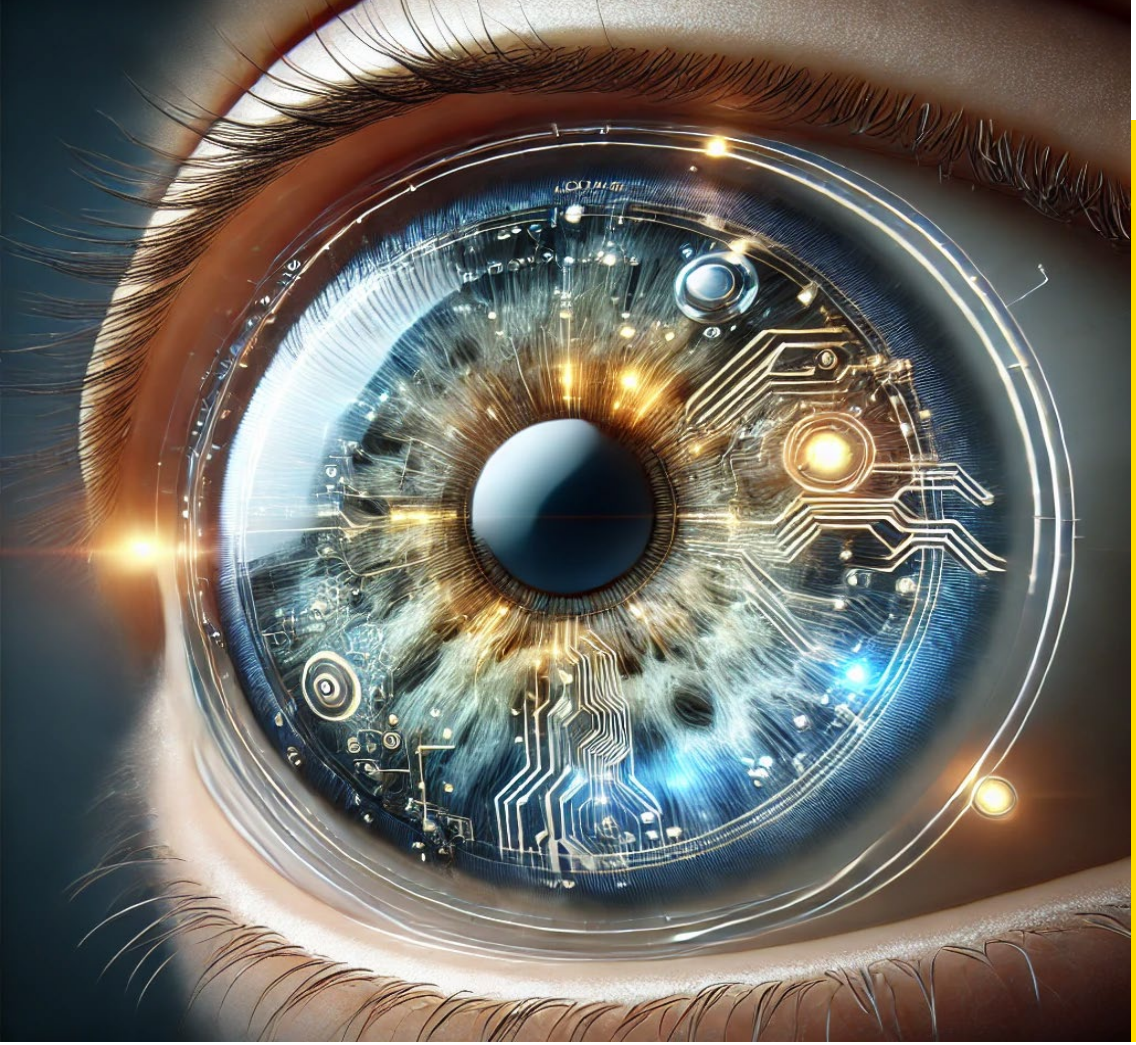


UNSW AI Symposium, 21 November 2024

Eye on the Future: Transforming Medical Diagnostics with AI and Ocular Imaging

OIV
Optical Imaging and Visualization Lab

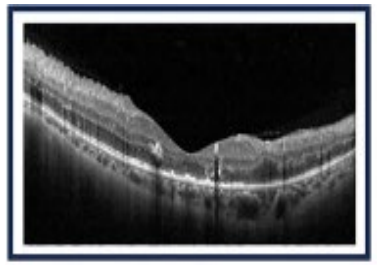
A/Professor Maitreyee Roy
Director, Optics and Radiometry Laboratory
School of Optometry and Vision Science
Faculty of Medicine and Health
UNSW Sydney

UNSW SYDNEY

AI in Ophthalmology: Pathway to Real-World Eye Clinics

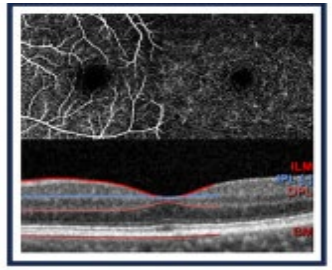
- Image Analysis
- Treatment Recommendations
- Dose Optimisation
- Risk Prediction
- Data Integration and Decision Support
- Research and Drug Discovery

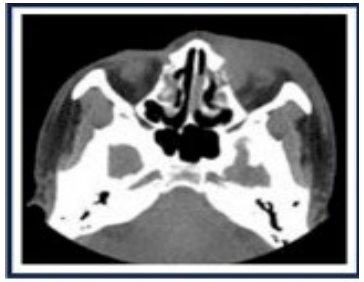

Fundus diseases

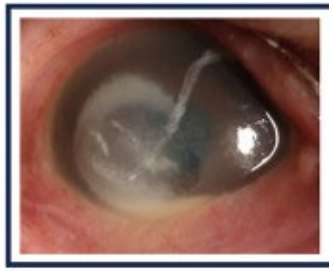

Macular diseases


Posterior segment

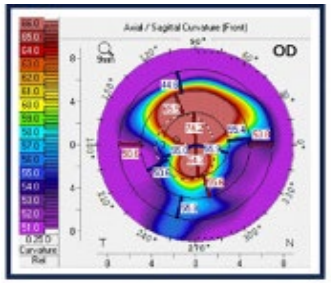

Retinal vascular diseases


Retinal and choroidal diseases


Orbital diseases

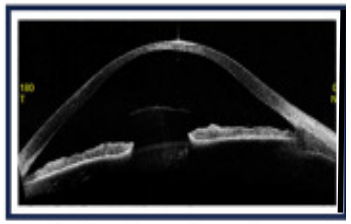

Anterior segment

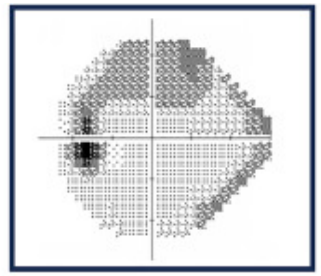

Anterior segment



Corneal abnormalities


Anterior chamber


Anterior chamber abnormalities

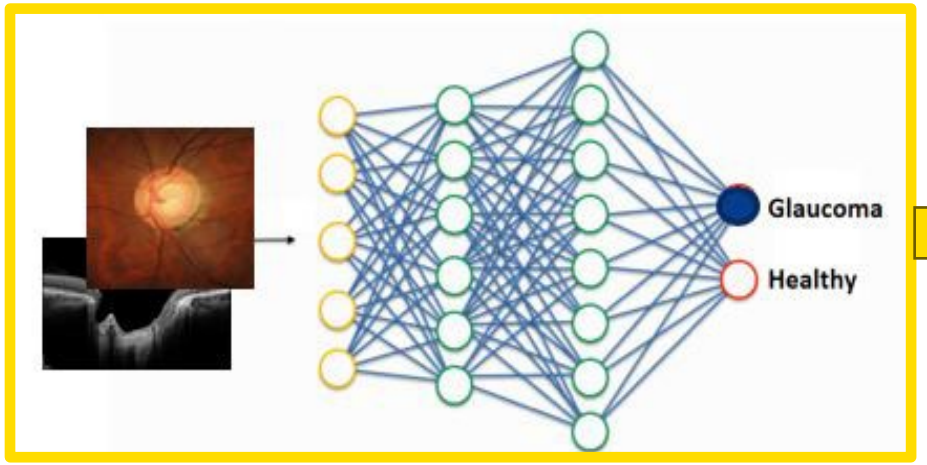

Visual field abnormalities

Glaucoma

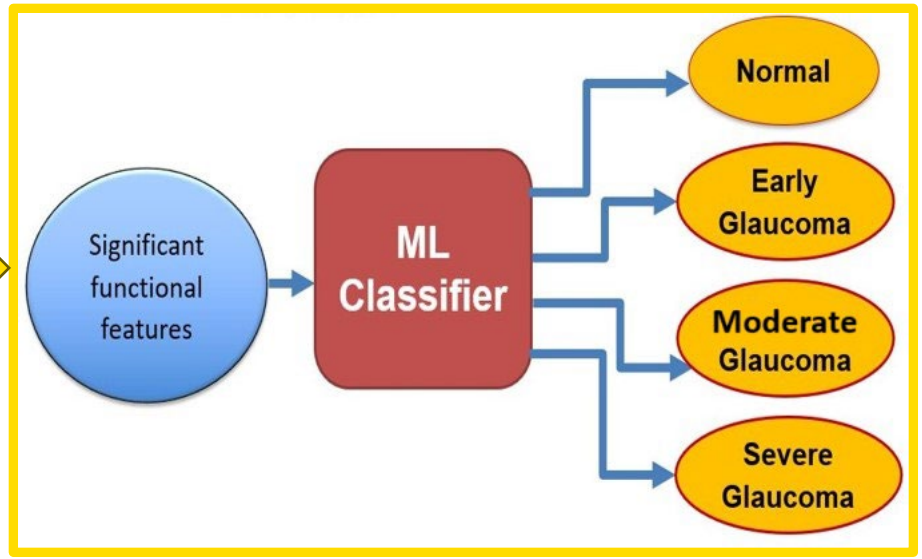
- Complex, multifactorial, progressive, irreversible disease that can lead to vision loss if left untreated
- Increasing prevalence over time
- 50% undiagnosed – around the world

UNSW SYDNEY

Automated Detection and Classification of Glaucoma from OCT Images Using Machine Learning Techniques



1. Glaucoma detection using deep learning from OCT images



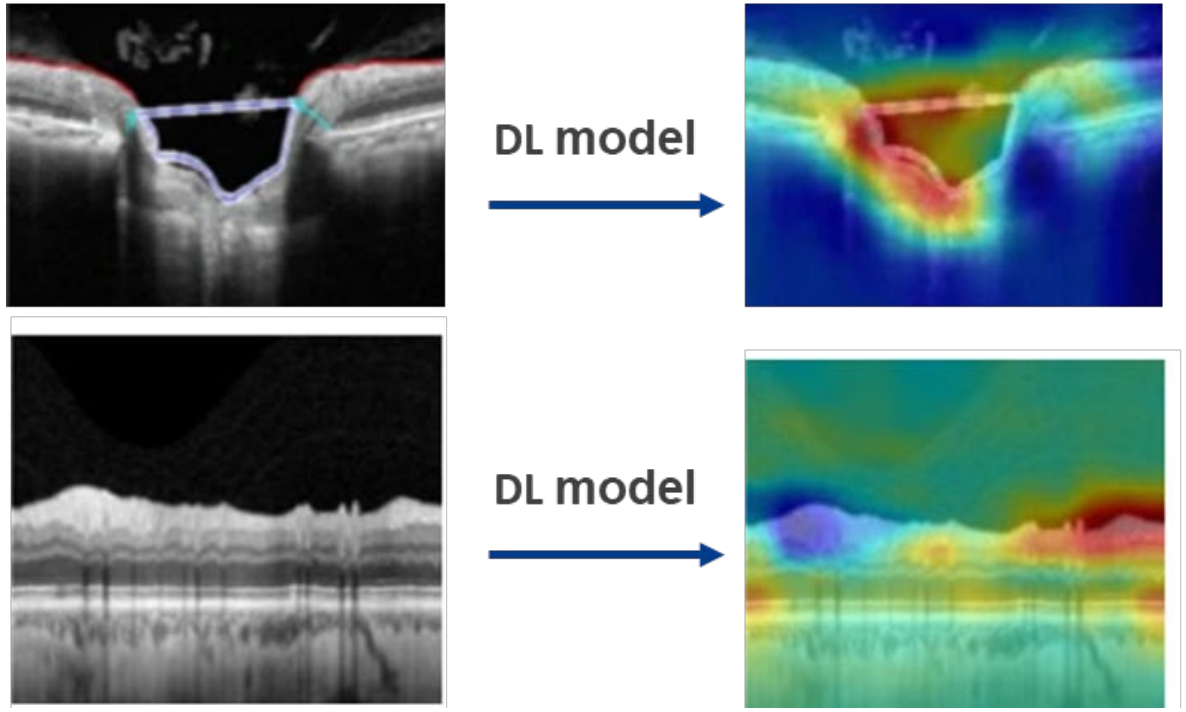
2. The resultant binary output is fed into another ML classifier model and combined with functional features to classify the stages of glaucoma

Overall accuracy: 90.7% and F1 score: 84%

Akter, N.; Fletcher, J.; Perry, S.; Simunovic, M.P.; Briggs, N.; Roy, M. ***Glaucoma diagnosis using multi-feature analysis and a deep learning technique***. Scientific Reports, 12, 8064 (2022).

UNSW SYDNEY

Deep Learning-Based Glaucoma Detection and Feature Visualisation from OCT Images



DL model localised the deformation of optic nerve head on Glaucomatous eye. Accuracy: 98.6% (pilot study)

*Thinning of the RNFL indicates glaucomatous damage (**Red:** affected RNFL, **Blue:** Healthy RNFL), Accuracy: 93%*

Akter, N.; Perry, S.; Fletcher, J.; Simunovic, M.P.; Stapleton, F.; Roy, M**. Glaucoma detection and feature visualisation from OCT images using deep learning.** medRxiv (2023).

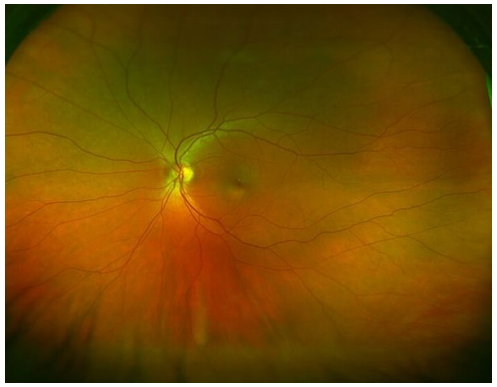
UNSW SYDNEY

Diabetic Retinopathy

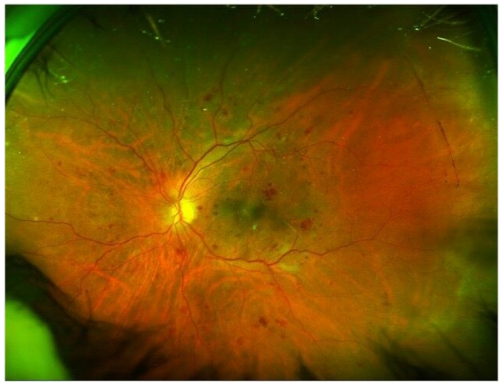
- DR, a leading cause of blindness, traditionally detected via fundus exams, but misses peripheral retinal areas.
- Wide-field cameras address this issue but are costly, limiting accessibility.
- We aim to develop an AI algorithm that leverages ultra-widefield Optos images as ground truth to assess DR severity in affordable 45-degree fundus images, improving accessibility.

UNSW SYDNEY

Deep Learning Model for Detecting Peripheral Lesions of Diabetic Retinopathy Using a Standard Camera



Optos images show no signs of DR

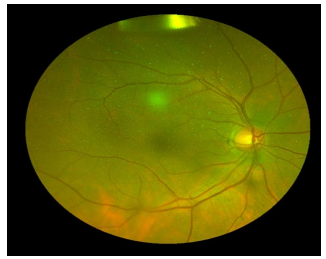


Optos images showing signs of Severe NPDR

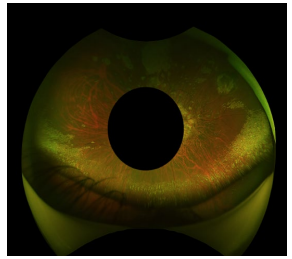
- Preprocess and augment the dataset, creating two subsets: the original and one masked for a smaller field of view.
- Apply transfer learning using a pre-trained VGG16 model from ImageNet for image classification into five predefined classes.

UNSW School of Optometry and Vision Science: Diabetes Research Grant from the Elizabeth O'Beirne and Robert and Emmy Mather Trust Fund, 2023.

Optos Images (200° FOV)



Conventional Images (45° FOV)

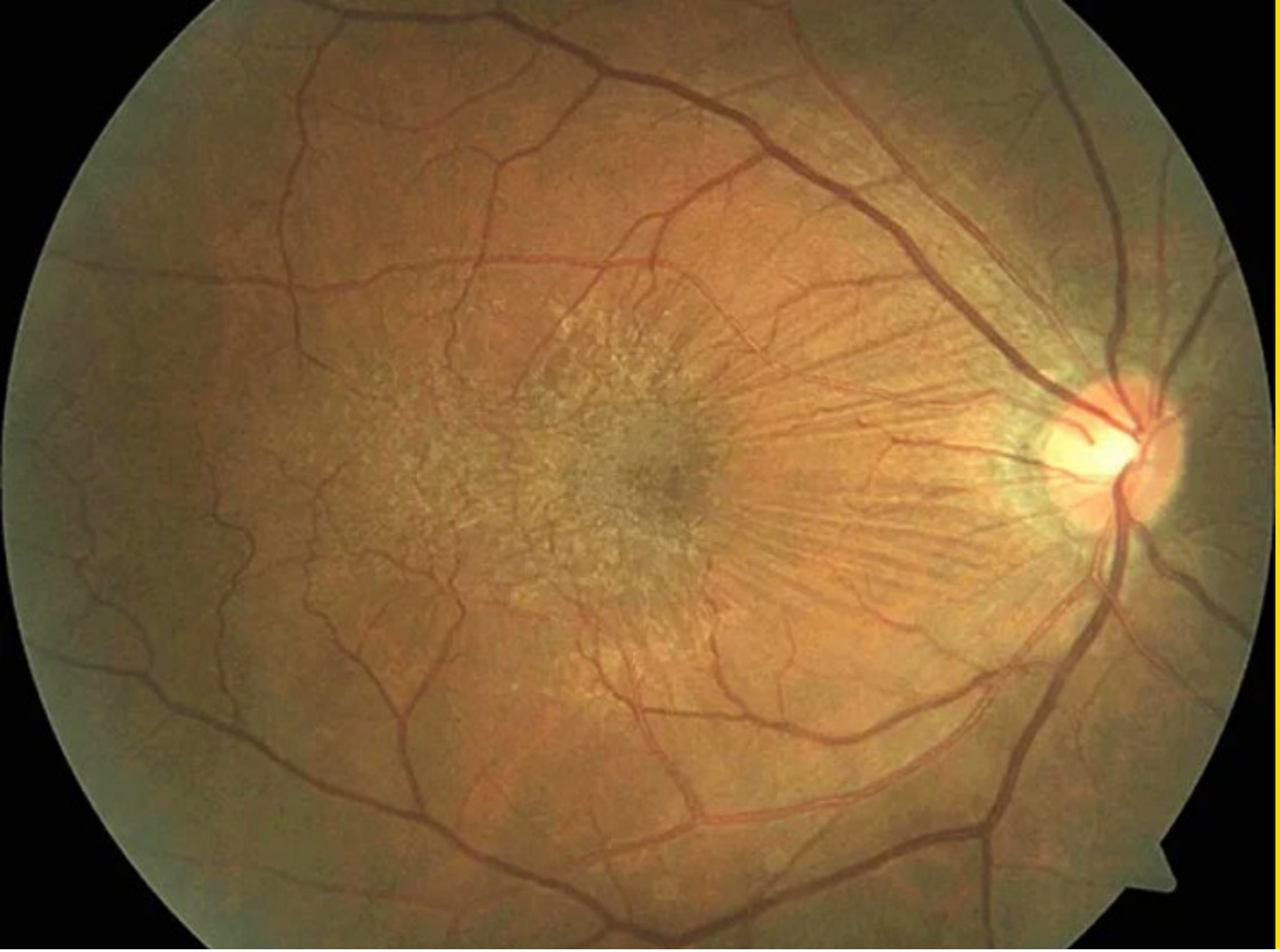


Remaining rim

Grading of DR	Precision	Recall	F1-score	Accuracy
No DR	0.97	1.00	0.98	0.97
Mild NPDR	0.97	0.94	0.96	0.97
Moderate NPDR	0.98	0.97	0.97	0.97
Severe NPDR	0.97	0.98	0.98	0.97
PDR	0.97	0.97	0.97	0.97

Roy, M. Khan TMA, R.; Raman, S.; Hebbale, S.; Bajaj, A.; Maseedupally, V.; Raman, R. Deep learning model using ultra-wide-field Optos images for early detection of diabetic retinopathy in 45-degree single-field. To be submitted, The Association for Research in Vision and Ophthalmology (ARVO), Salt Lake City, Utah, USA, 4-8 May 2025.

UNSW SYDNEY



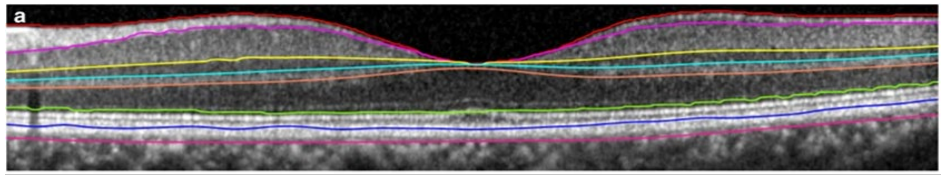
Epiretinal Membranes

- ERM causes vitreous contraction and detachment and increases with age, affecting up to 20% over 75.
- ERM complications include retinal tears, hemorrhage, edema, and macular holes, impairing vision.
- We aim to develop an automated deep-learning system to detect ERM in OCT images.

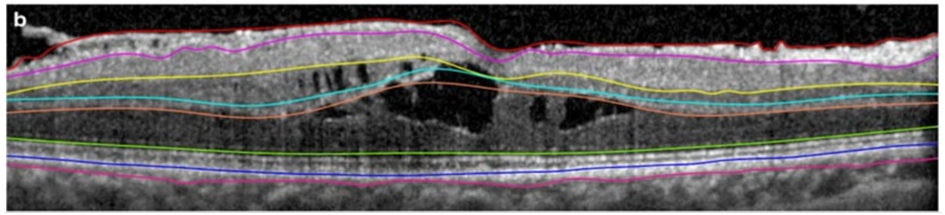
Image source:
https://www.retinavitreous.com.au/epiretinal-membrane

UNSW SYDNEY

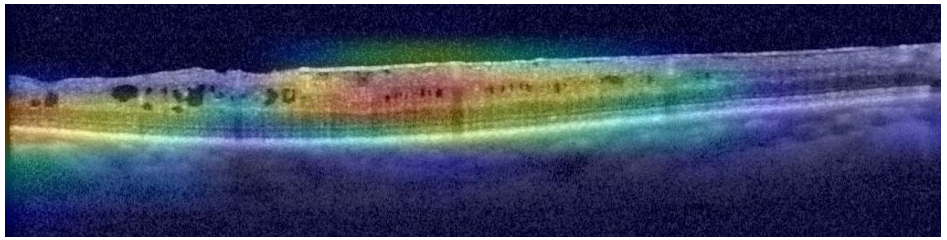
Deep Learning Model for Detecting Epiretinal Membranes



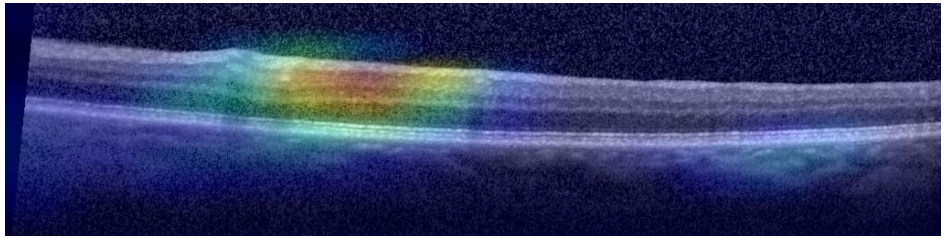
Normal Eye



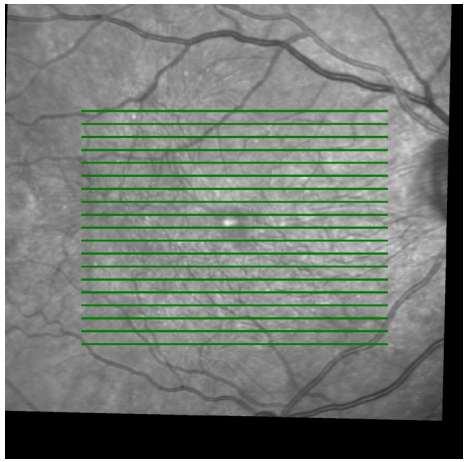
Eyes with ERM



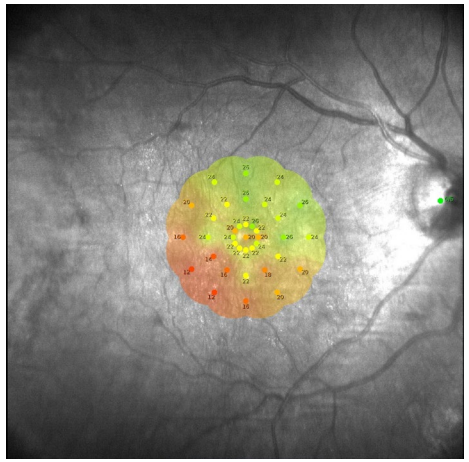
Grad-CAM image of ERM



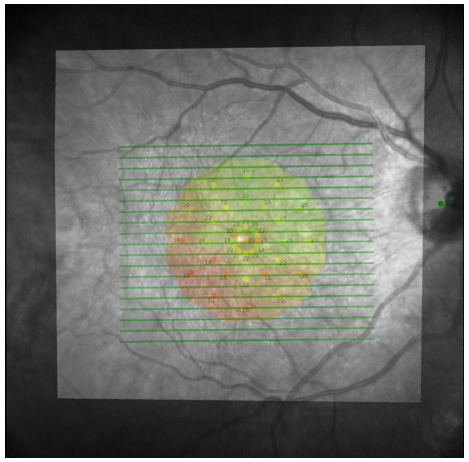
Grad-CAM image of non-ERM



OCT Fundus Image



Sensitivity Map



Superimposed Image

Model	Accuracy (%)	Sensitivity (%) Non_ERM	Specificity (%) Non_ERM	Sensitivity (%) ERM	Specificity (%) ERM	ROC-AUC (%)	F1 Score (%)
InceptionV3	93.7	94.07	93.31	93.7	93.7	94	94
ResNet50	86.43	84.25	88.66	84.06	88.8	86	86
VGG16	**96.75**	**97.54**	**95.97**	**97.54**	**95.97**	**97**	**97**
XceptionNet	90.67	91.6	89.67	91.18	90.16	91	91

Sala Uddin Pathan, AQM.; Jessup, A.; Kanhere, S.; Simunovic, M; Chang, A.; Raman, R.; Roy, M. **Automated anaemia detection from retinal images using artificial intelligence**. To be submitted, The Association for Research in Vision and Ophthalmology (ARVO), Salt Lake City, Utah, USA, 4-8 May 2025.

UNSW SYDNEY

The Eye: A Gateway to Systemic Disease Prediction with AI-Driven Ocular Imaging

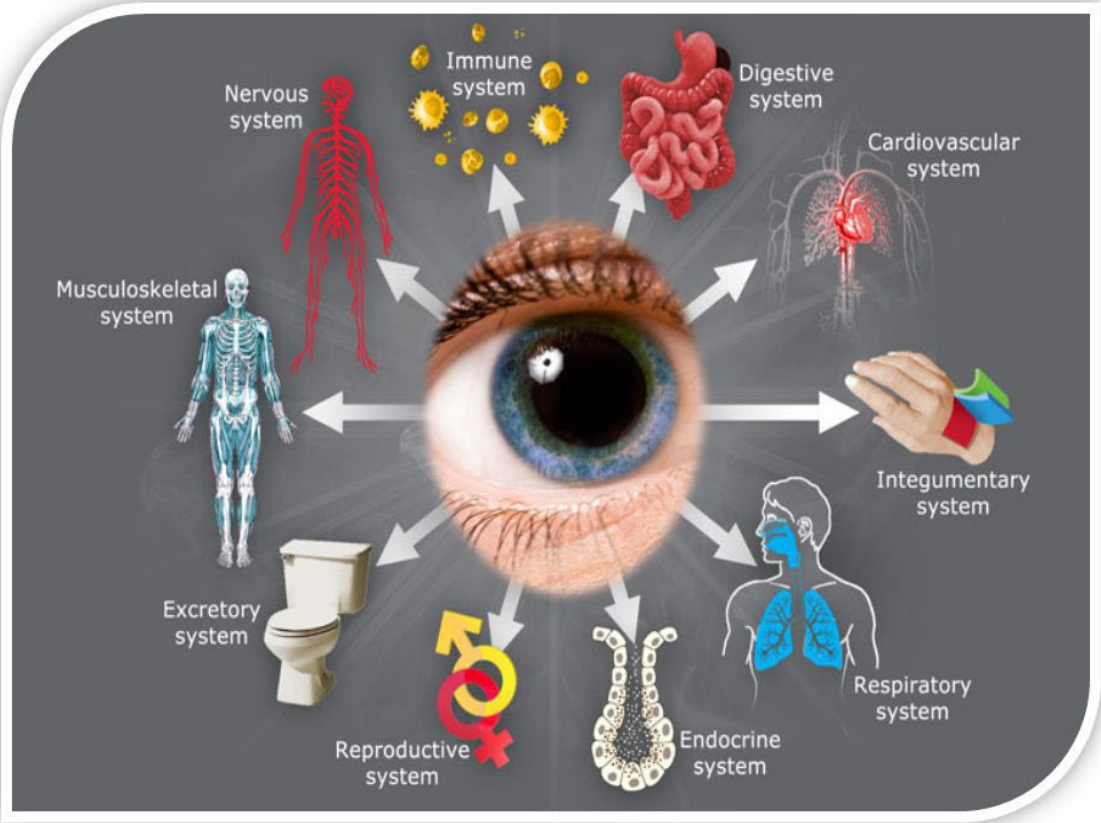


Image source: The University of Waikato Te Whare Wānanga o Waikato (Modified).

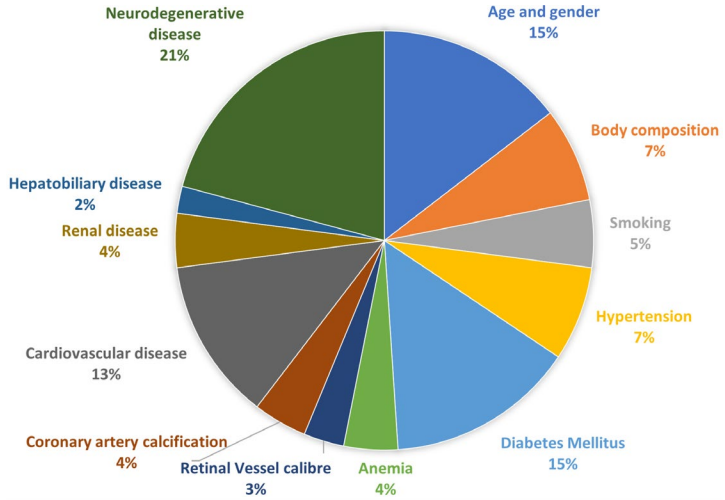


Fig: Number of articles per disease

WIREs DATA MINING AND KNOWLEDGE DISCOVERY

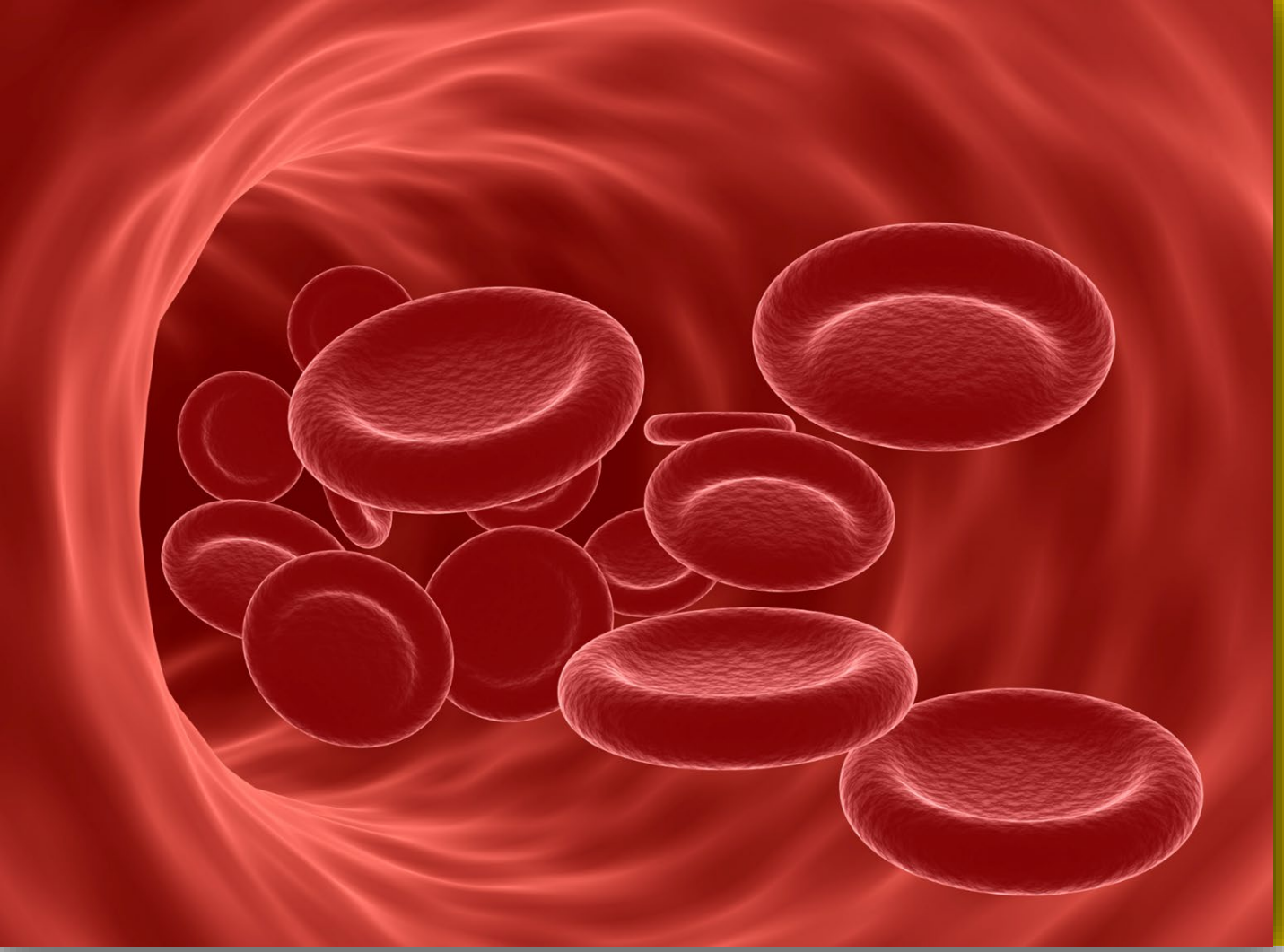
Advanced Review | Full Access

Use of artificial intelligence algorithms to predict systemic diseases from retinal images

Rehana Khan, Janani Surya, Maitreyee Roy, M. N. Swathi Priya, Sashwanthi Mohan, Sundaresan Raman, Akshay Raman, Abhishek Vyas, Rajiv Raman

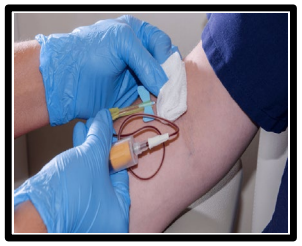
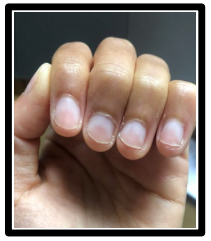
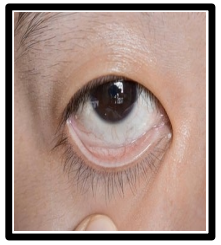
First published: 16 May 2023 | https://doi.org/10.1002/widm.1506

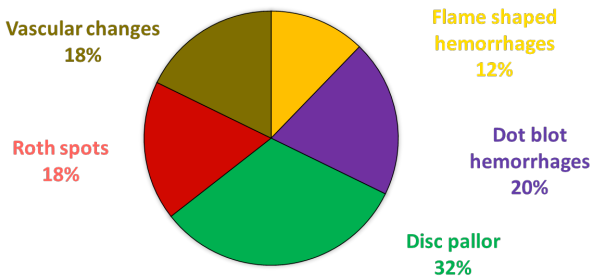
UNSW SYDNEY



Anaemia

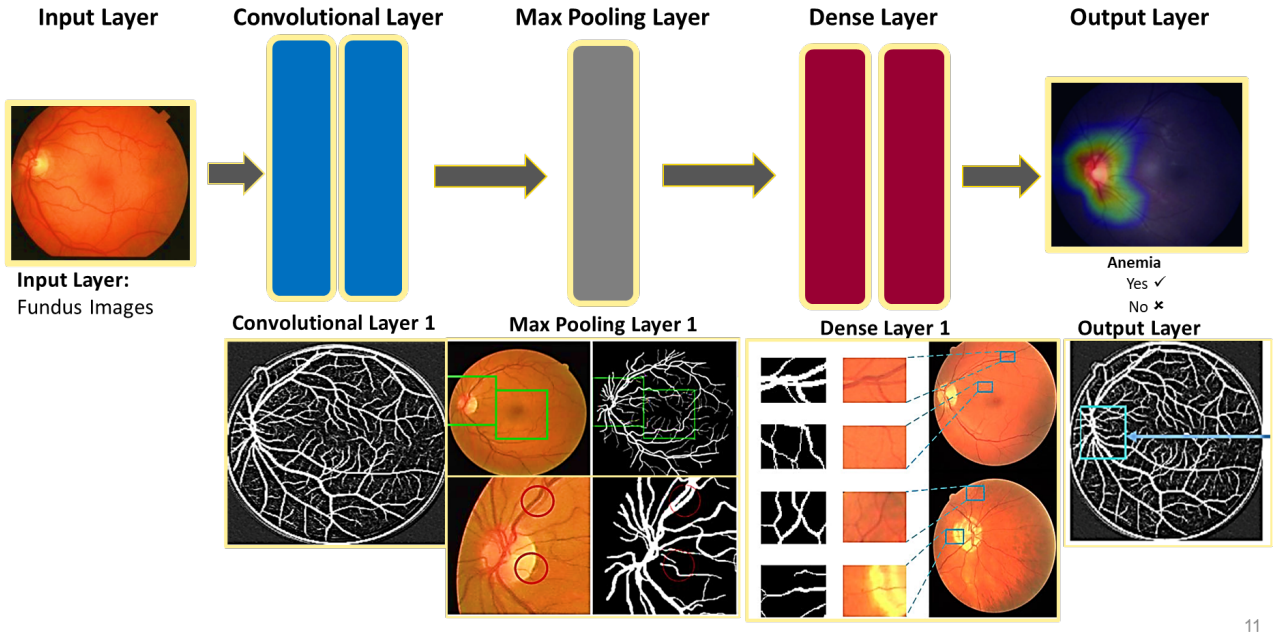
- Anaemia affects 1.92 billion individuals globally.
- Hemoglobin concentration is the most reliable measure of anemia.
- Invasive tests: Painful, infection, biohazardous.
- Non-invasive tests: Lack of sensitivity
- We aim to develop a deep-learning model for anaemia detection, Hb estimation, and retinal features analysis from fundus images.

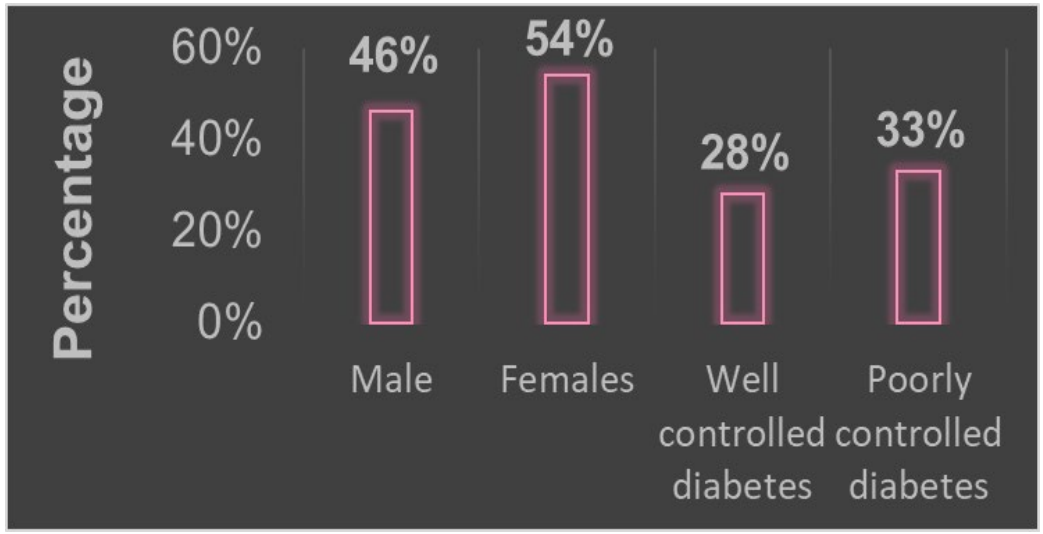






UNSW SYDNEY

Deep Learning Models for Automated Anemia Detection and Hemoglobin Level Estimation from Retinal Images





Architecture	AUC (mean ± SD)	Accuracy (mean ± SD)	Sensitivity (mean ± SD)	Specificity (mean ± SD)	Precision (mean ± SD)
ResNet50	0.97 ± 0.004	0.97 ± 0.21	0.99 ± 0.12	0.95 ± 0.22	0.95 ± 0.21
VGG16	0.97 ± 0.001	0.97 ± 0.16	0.99 ± 0.11	0.95 ± 0.18	0.95 ± 0.19
InceptionV3	0.98 ± 0.006	0.98 ± 0.15	0.99 ± 0.12	0.97 ± 0.13	0.97 ± 0.12

1. Khan, R.; Maseedupally, V.; Thakoor, K.; Raman, R.; Roy, M. ***Non-invasive anaemia detection and haemoglobin estimation from retinal images using deep learning: A scalable solution for resource-limited settings***. TVST, Under revision (2024).
2. Khan, R.; Sala Uddin Pathan, AQM.; Lin, SH.; Kelleher, P.; Maseedupally, V.; Raman, R.; Roy, M. ***Automated anaemia detection from retinal images using artificial intelligence***. The Association for Research in Vision and Ophthalmology (ARVO) , Seattle, USA, 5-9 May 2024.

UNSW SYDNEY

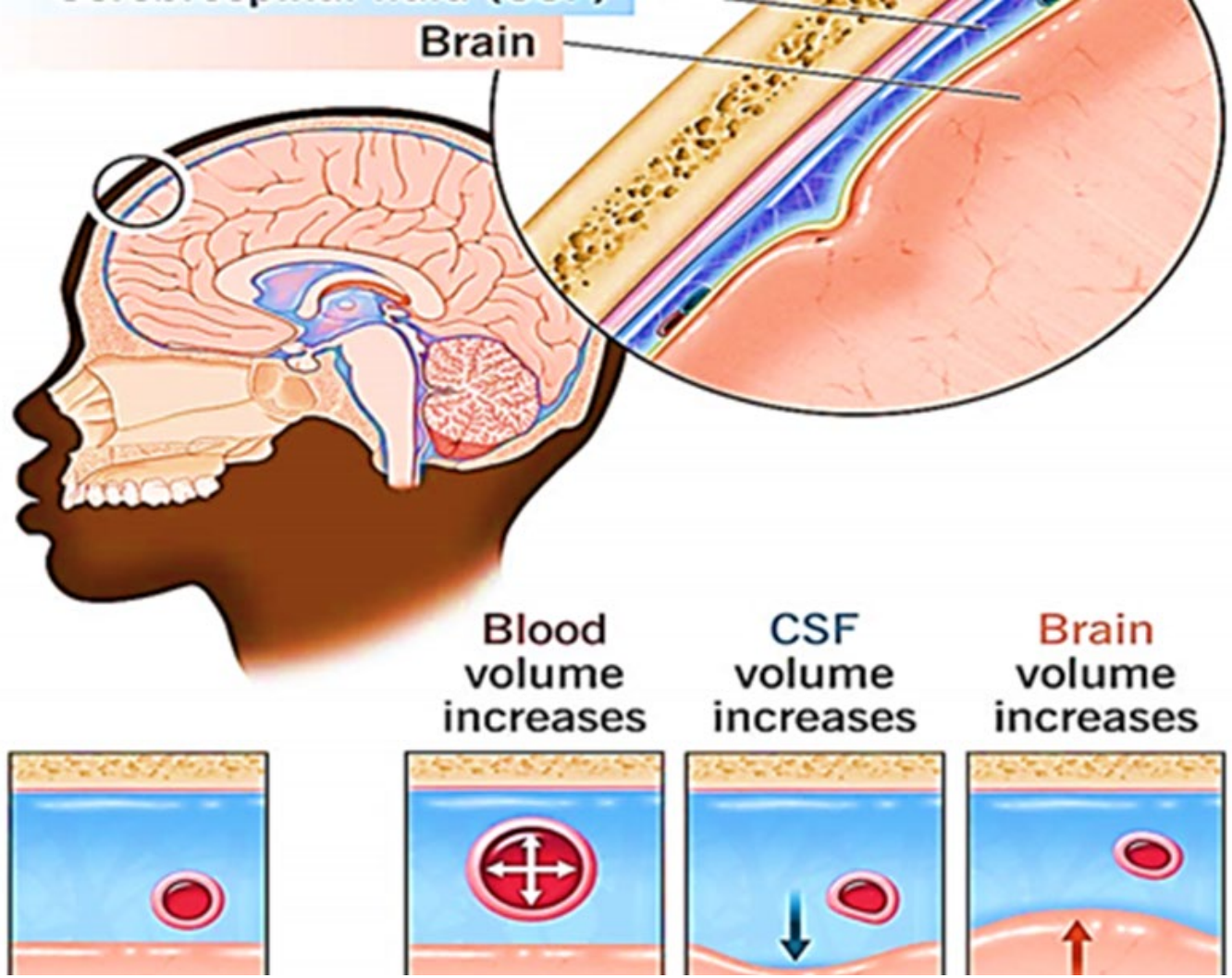


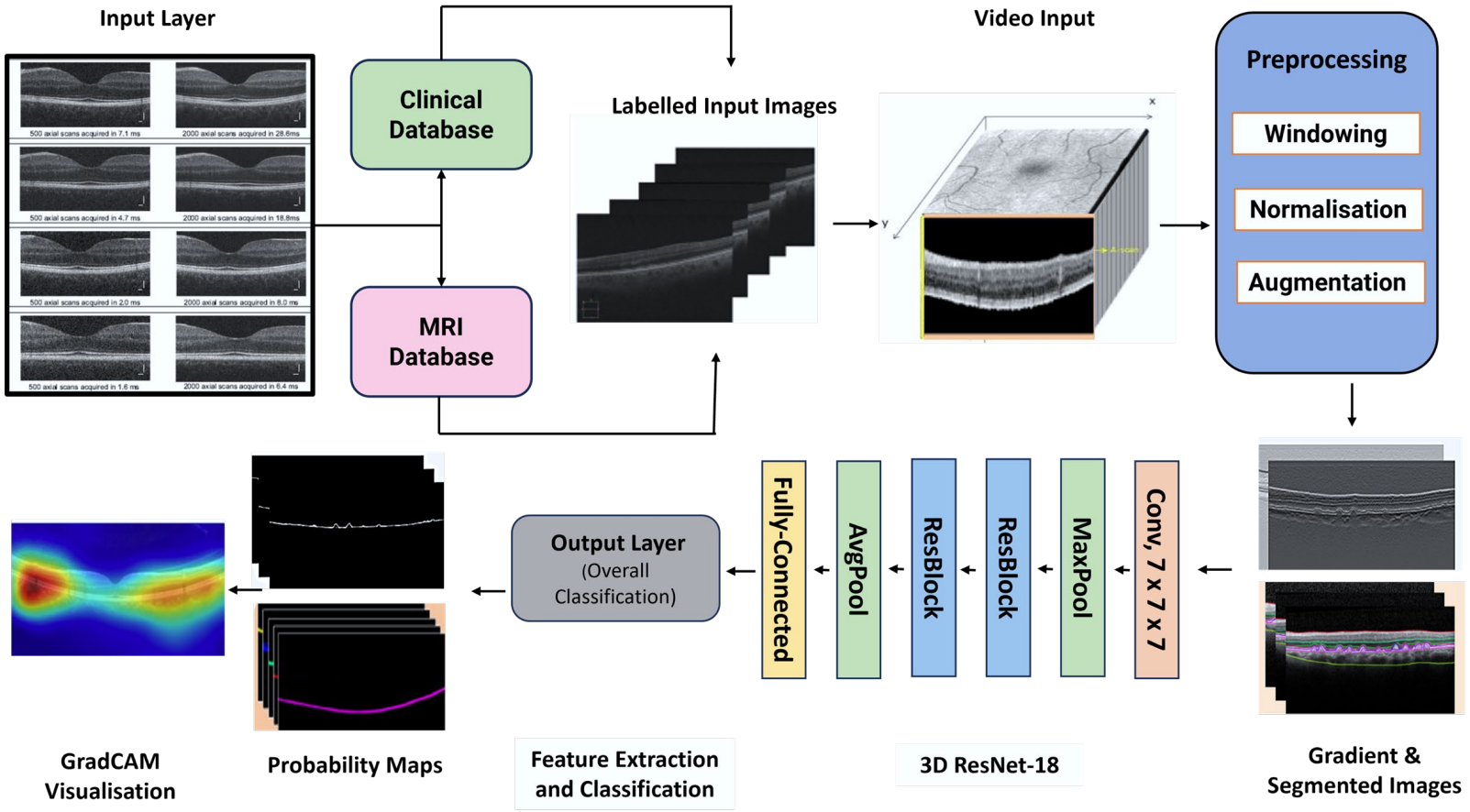
Image source: Cleveland Clinic

Intracranial Pressure

- Detecting elevated intracranial pressure (ICP) is vital for managing neurological conditions.
- Current detection methods are invasive, costly, risky, and require anesthesia. Symptom-based non-invasive methods lack accuracy.
- Our aim is to develop deep learning with OCT scans for non-invasive ICP prediction.

UNSW SYDNEY

Deep Learning Framework for Intracranial Pressure Prediction Using Retinal Images



Accuracy	**0.9942**
Precision	**0.9982**
Recall	**0.9923**
Area Under Precision-Recall Curve	**0.9893**
Area under ROC curve	**0.9943**

Khan, R.; Garg, A.; Raman, S.; Maseedupally, V.; Raman, R.; Roy, M. ***Deep learning framework for intracranial pressure prediction using optical coherence tomography***. American Academy of Optometry, Indianapolis, November 6-9, 2024.

UNSW SYDNEY

Collaborations & PhD Students












UNSW SYDNEY
Optometry & Vision Science

SANKARA NETHRALAYA

Centre for Eye Health

SYDNEY RETINA™

personalEYES

BITS Pilani
Pilani | Dubai | Goa | Hyderabad | Mumbai

UNSW SYDNEY

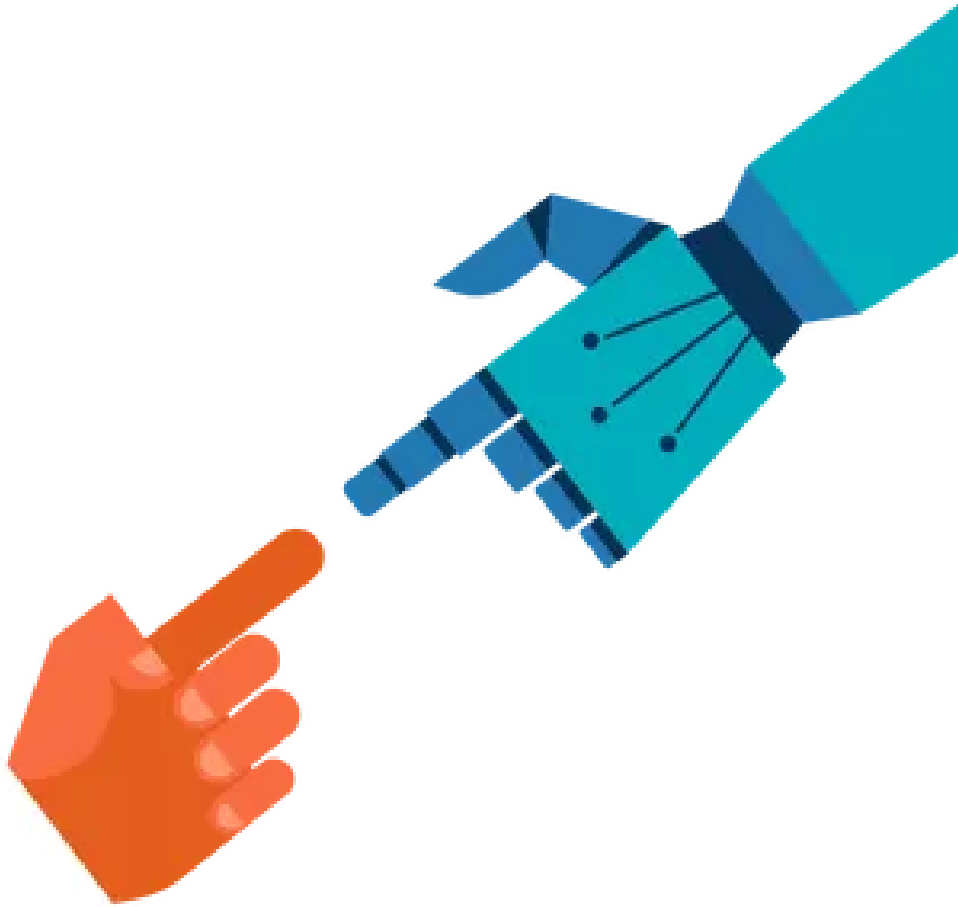
Why prioritise AI-driven healthcare initiatives?

Significance lies in the potential to reform healthcare delivery

Anticipates a significant reduction in patient referrals, leading to more efficient healthcare systems and better patient outcomes

The far-reaching societal and economic benefits emphasise the urgency and importance of advancing research in this field

UNSW SYDNEY



Join us in Shaping the Future of Predictive Healthcare through Ocular Imaging and Artificial Intelligence!

THANK YOU!

maitreyee.roy@unsw.edu.au