Ciências ULisboa
Faculdade de Ciências da Universidade de Lisboa

M.Sc. *Informatics Engineering*
Deep Learning class 2024/2025

Multi-Label Classification of Retinal Diseases from Fundus Photography

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Objectives

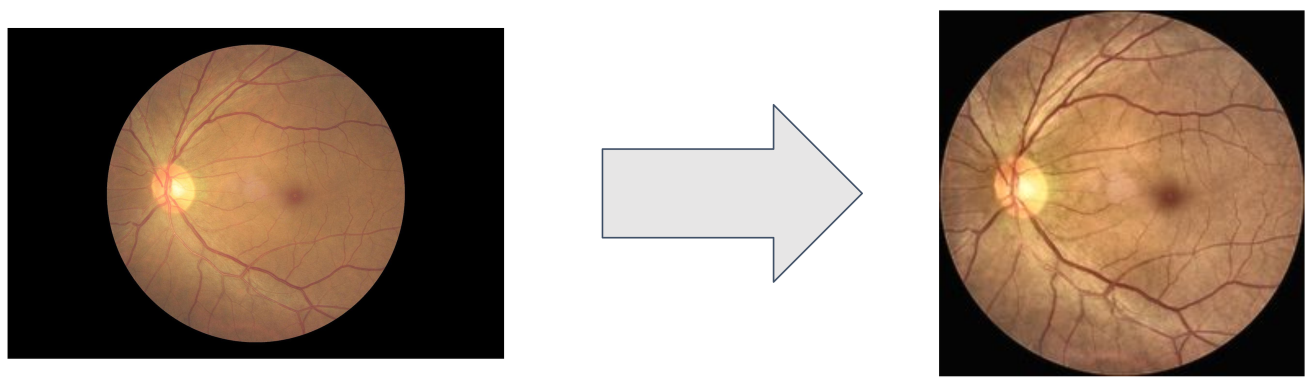
- Develop a model for **multi-label classification of retinal diseases** using fundus photography.
- Explore **dual-branch architectures** for joint analysis of left and right eye images.
- Compare **CNN** and **Transformer-based** models in terms of performance on the ODIR-5K dataset.

Problem

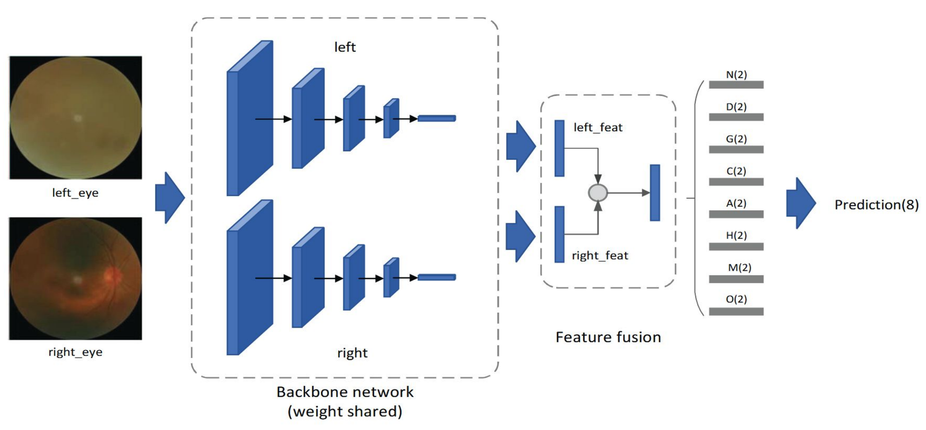
- Retinal diseases are often diagnosed manually, which is **resource-intensive** and requires **expert knowledge.**
- Many patients show **multiple concurrent conditions**; hence, single-label classification is insufficient.
- Often, other exams such as **Dilated Eye Exam, Optical Coherence Tomography (OCT) and Fluorescein Angiography** are needed. Developing a model that relies **only on fundus images** could **streamline diagnosis**.

Methodology

- **Preprocessing:**
  - Crop retina region via bounding box detection
  - Apply **CLAHE** for local contrast enhancement
  - Resize to **224x224** and normalize using ImageNet statistics



- **Models:**
  - CNNs: **EfficientNetB0, EfficientNetB4, ResNet18** (Pretrained on ImageNet & RetinaMNIST)
  - Transformers: **ViT-b16, ViT-b32**
- **Architecture:** Adapted existing models into a **dual-branch structure** to process left and right eye images **independently but jointly**

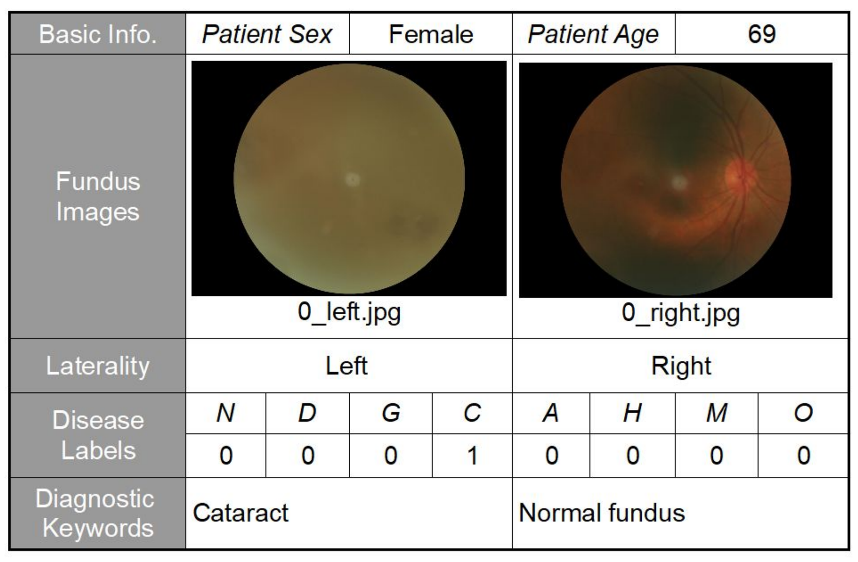


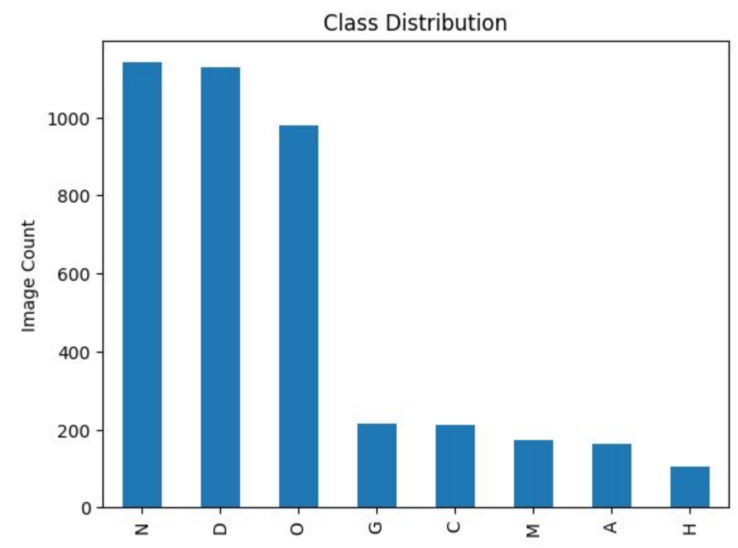
https://arxiv.org/pdf/2102.07978

- **Training:**
  - Optimizer: **Adam** with weight decay (1e-5)
  - Loss: **Sigmoid Focal Loss** for class imbalance
  - **Early stopping** based on validation loss

Dataset

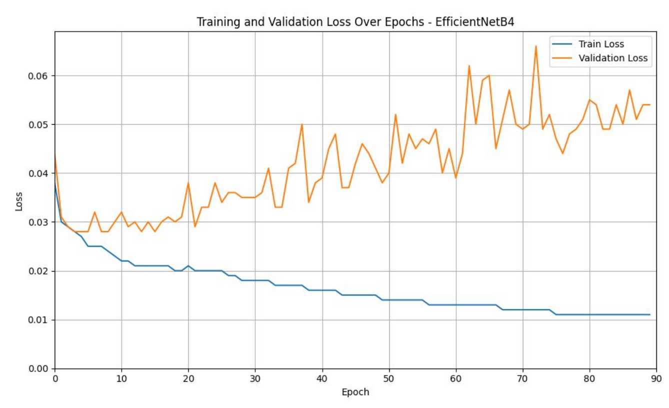
- **ODIR-5K Dataset:**
  - ~5,000 patient samples
  - Each sample includes left and right fundus images
  - **8 disease labels**: Normal (N), Diabetes (D), Glaucoma (G), Cataract (C), Age-related Macular Degeneration (A), Hypertension (H), Myopia (M), Other(O)
- Split: 60% Train, 20% Validation, 20% Test
- Labels are **multi-label binary vectors**

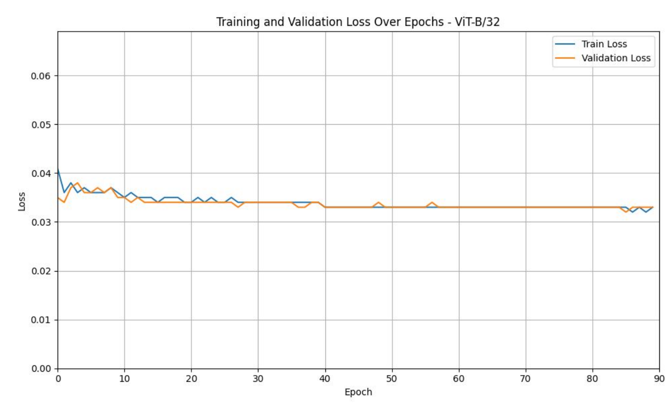




https://odir2019.grand-challenge.org/dataset/

Results

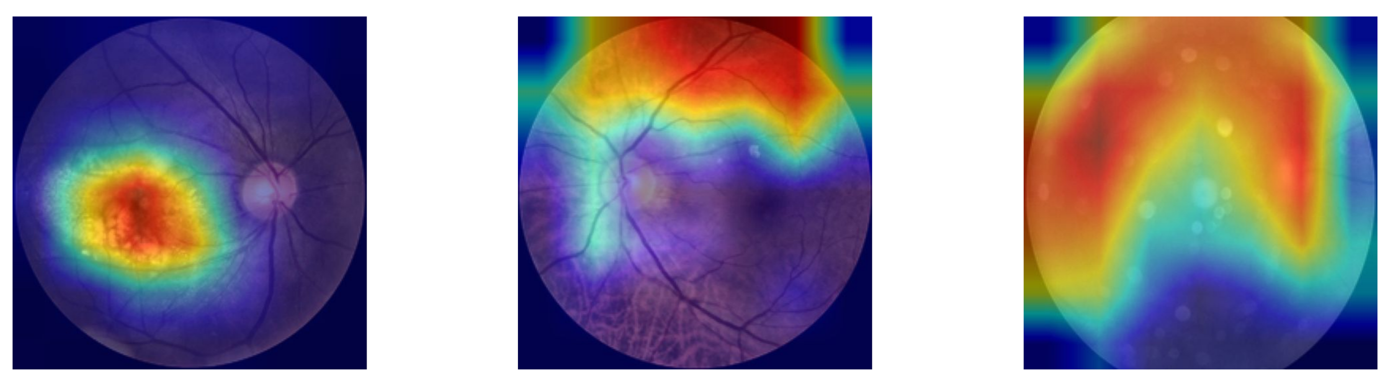




Model	Avg Loss	Accuracy	AUC	F1	Precision	Recall	PR AUC
EfficientNetB0(ImageNet)	**0.0273**	0.8750	0.8345	0.5371	**0.5322**	0.6065	0.5736
EfficientNetB4(ImageNet)	0.0298	**0.8786**	**0.8434**	**0.5685**	0.5221	**0.6608**	**0.5825**
ViT_b_32(ImageNet)	0.0326	0.8527	0.6613	0.3332	0.2454	0.7227	0.2689

Class	Precision	Recall	F1 Score	PR-AUC
N	0.483	0.675	0.563	0.534
D	0.652	0.590	0.619	0.729
G	0.466	0.692	0.557	0.531
C	0.825	0.767	0.795	0.840
A	0.297	0.688	0.415	0.484
H	0.096	0.529	0.162	0.207
M	0.875	0.848	0.862	0.887
O	0.403	0.681	0.506	0.446

EfficientNetB4 per-class Metrics



AMD | Hypertension | Cataract

Conclusions

- Deep learning models can perform **multi-label classification** of retinal diseases using **paired fundus images**, with CNNs currently outperforming transformer-based architectures under limited training conditions.
- ViT showed **underfitting,** likely due to insufficient data.
- **Preprocessing** steps significantly enhanced model **learning** and **convergence.**

Future Directions

- Address **class imbalance** using techniques like **focal loss tuning, or SMOTE**.
- Apply **more aggressive regularization** to CNN models to mitigate overfitting.
- Investigate **hybrid or ensemble models** that combine CNNs and transformers.

References

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Acknowledgements: This poster session is kindly sponsored by:

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