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Image-based Cataract Diagnosis

Using a Handheld Slit-lamp Device

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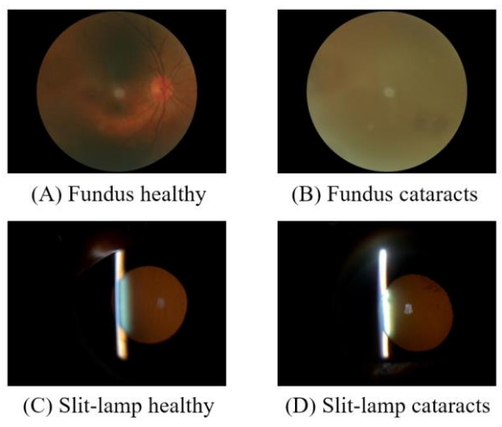
INTRODUCTION

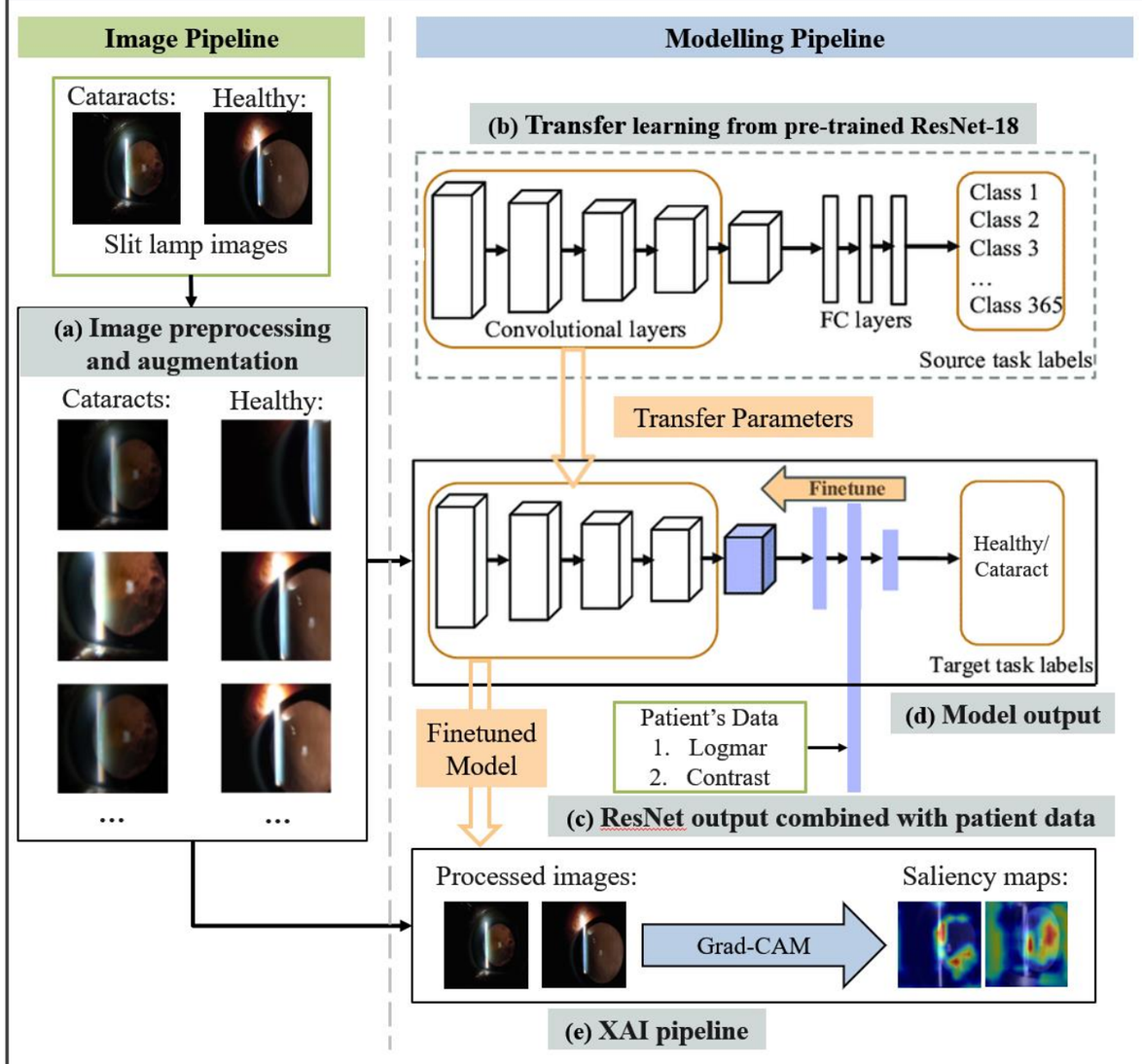
Cataracts, the clouding of the eye's lens, poses a global health challenge as a **leading cause of visual impairment**. Improved cataract screening is needed as traditional diagnosis methods are limited in access, involving expensive equipment and expertise.

Provide accurate and trusted cataract diagnosis by:

- Mitigating the poorer quality of the images (slit lamp images C & D compared to fundus images A & B)
- Training the model with small, imbalanced dataset using image augmentation
- Explaining the model's prediction using Grad-CAM saliency mapping



METHODOLOGY



Dataset: Images from handheld slit lamp camera collected from local hospitals.

Model validation: Performance metrics obtained from 20-fold cross validation.

Train-test split shown to the right

Image type	Train	Test	Total
Healthy	14	5	**19**
Cataract	163	5	**168**

RESULTS

Model	Accuracy	F1 Score	Sensitivity	Specificity
Image-only	0.740 ± 0.058	0.795 ± 0.041	0.960 ± 0.036	0.520 ± 0.122
Image+metadata	0.845 ± 0.048	0.863 ± 0.040	0.950 ± 0.056	0.740 ± 0.103
Image-only (augmented)	0.925 ± 0.042	0.928 ± 0.040	0.940 ± 0.050	0.910 ± 0.072
Image+metadata (augmented)	**0.960 ± 0.039**	**0.959 ± 0.041**	**0.960 ± 0.046**	**0.960 ± 0.036**

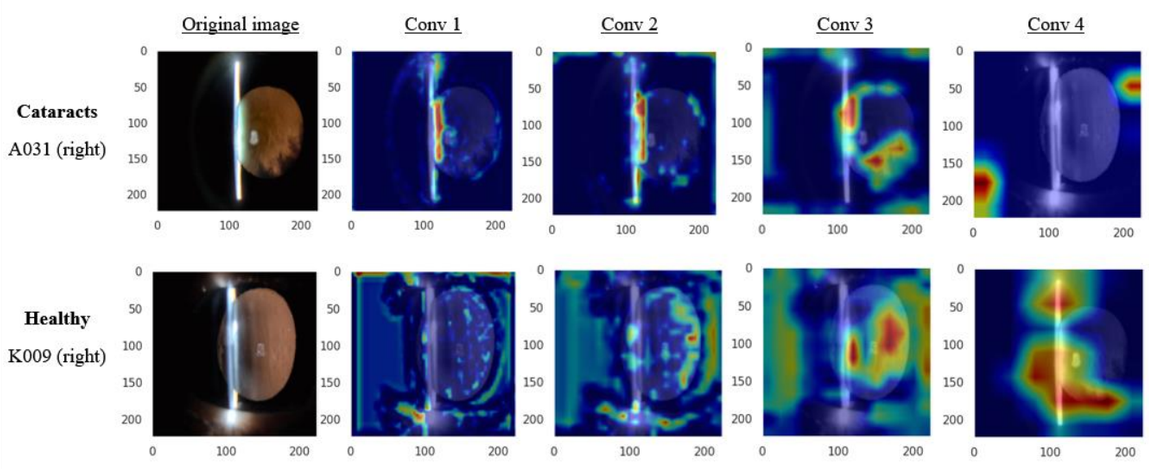
Best model was achieved with combining patient metadata and image augmentation:

- **Large improvement from combining patient metadata** like visual acuity and contrast sensitivity measurements
- Further **improvement in accuracy from image augmentation**, notably in specificity metric
- Best model **accuracy of 0.960 is competitive with other studies' accuracy** of 0.982 [1] and 0.966 [2]; performance gap explained by relatively much lower quality of slit lamp images and smaller original dataset size

[1] Hasan, M. K., Tanha, T., Amin, M. R., Faruk, O., Khan, M. M., Aljahdali, S., & Masud, M. (2021). Cataract Disease Detection by Using Transfer Learning-Based Intelligent Methods. *Computational and Mathematical Methods in Medicine*.

[2] Askarian, B., Ho, P., & Chong, J. W. (2021). Detecting Cataract Using Smartphones. *IEEE Journal of Translational Engineering in Health and Medicine, 9*, 1-10.

SALIENCY MAPS



- Conv 1 & 2 focus on fine details while Conv 3 highlights the general region used for diagnosis → recommended to **use Conv 3 for explaining diagnosis**
- Overall, model **focuses on features in the eye** and near the illumination

CONCLUSION

- **Transfer learning and combining patient data with eye images** of CNNs is effective for cataract diagnosis, even with small dataset and noisy samples.
- **Saliency maps complement the model's prediction** and **further validate the predictions** of the model.