Assessment of Ocular Torsion from Fundus Images and Oculography Videos

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Introduction

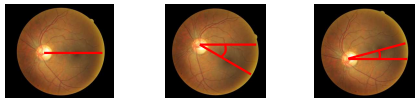
- Ocular torsion is eye rotation about the line of sight. Torsion can reveal abnormalities present in the vestibular-ocular-motor pathway.
- Torsion is clinically assessed by analyzing the disc-foveal angle (DFA) in fundus images or through the ocular counter-roll test during in-person visits, or recorded by video-oculography (VOG).
- This is time-intensive and cannot be done with telemedicine. Clinicians need computer-based technologies for rapid and automatic ocular torsion assessment for both in-person and virtually.

Objectives

To build deep learning models for automatic assessment of static and dynamic ocular torsion from images & videos

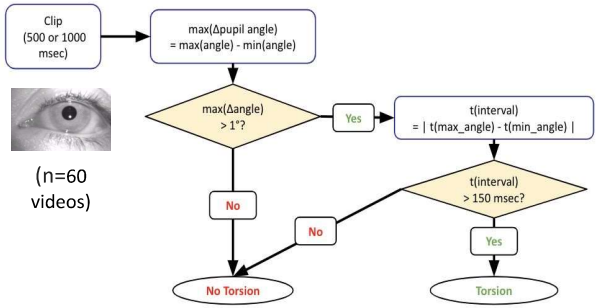
Approach and Data

Images (n=240 images)



no torsion | extorsion | intorsion

Videos: Training Label Generation

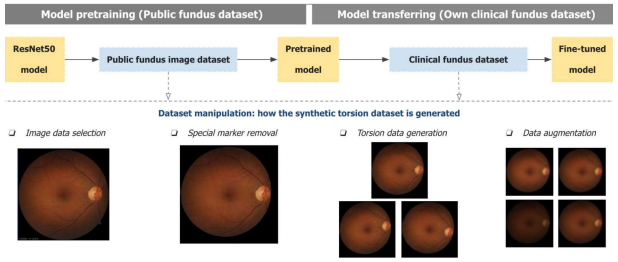


(n=60 videos)

Models

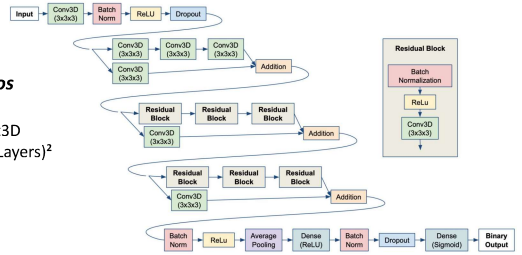
Images

ResNet50 Model Transfer[1]

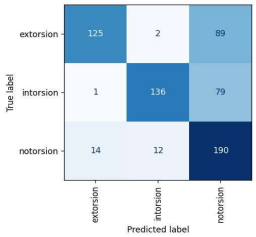


Videos

ResNet3D Model (11 Layers)[2]



Results



Class	Precision	Recall	F1 score	# Images
Ex-torsion	0.89	0.58	0.70	216
In-torsion	0.91	0.63	0.74	216
No torsion	0.53	0.88	0.66	216
Overall	0.78	0.70	0.70	648
Overall Acc	0.70			

Fig. 1 - Confusion matrix (left) and numerical evaluation metrics (right)
The transferred ResNet50 model obtained 70% testing accuracy on synthetic clinical dataset. The results showed the model performed well in finding images with intorsion and extorsion, but there are still many "no torsion" examples are misclassified.

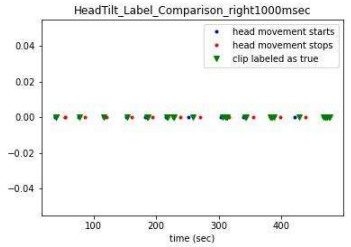
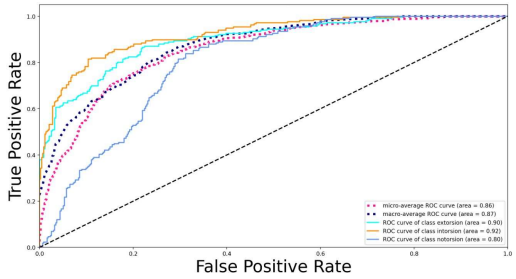


Fig. 3 - Label Confirmation
To check our label-generation algorithm, we plotted clips labeled true for torsion against the start and end of head tilts. As expected, each head tilt is accompanied by one or more clips labeled true for torsion, confirming the accuracy of our labels.

Fig. 2 - ROC curve
The ROC curve illustrates the classification performance of transferred model on synthetic clinical dataset. The overall area under the curve (AUC) is 0.87. The model achieved higher AUC value in intorsion and extorsion classes, whereas the AUC value of class "no torsion" is relatively low.



Conclusion

With data synthesis, augmentation and model transferring, ocular torsion can be well detected from fundus images. The model performance can be further improved when more image data become available for training and fine-tuning. Label generation method for video classification is reliable, but more ML training and validation is needed in the future.

References

1. He, K., Zhang, X., Ren, S., & Sun, J. (2015, December 10). *Deep residual learning for image recognition*. arXiv.org. Retrieved April 29, 2022, from https://arxiv.org/abs/1512.03385
2. Dubey, S., Boragule, A., & Jeon, M. (2020, February 4). *3d resnet with ranking loss function for abnormal activity detection in videos*. arXiv.org. Retrieved April 29, 2022, from https://arxiv.org/abs/2002.01132