A deep learning approach to patient alignment and retina tracking

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PURPOSE

Optical nerve head (ONH) can be used as a key point to track the eye motion. ONH tracking can be used for:

- Initial patient alignment
- Registration of montage images for widefield fundus images
- Registration of images among different visits

Robust patient alignment and retina tracking using deep learning

We demonstrate a deep learning based approach for fast, accurate, and robust ONH tracking using the **widefield infrared (IR) fundus imaging mode** in CLARUS™ 500 instrument (ZEISS, Dublin, CA)

METHODS

Data Collection:

- Widefield IR preview images were collected on a CLARUS 500 instrument as part of an IRB approved study
- Images were collected @ **10 frames per second**
- Some subjects were asked to intentionally look around to simulate poor fixation
- A total of six eyes were imaged

Deep learning algorithm:

- Input images were preprocessed by down sampling the images by a factor of 24
- An optimized U-Net* architecture was used with three contraction/expansion layers
- Ground truth was created by manual annotation of ONH in the input images
- Dice coefficient was used as loss function and sigmoid activation was used in the final layer

(*O. Ronneberger, P. Fischer, T. Brox, "U-net: Convolutional networks for biomedical image segmentation", *Proc. Med. Image Comput. Comput.-Assisted Intervention*, pp. 234-241, 2015.)

CONCLUSION

We demonstrated a **deep learning** based algorithm that detects **ONH location** in the widefield IR images in CLARUS 500 instrument robustly with an **accuracy of > 85% in detecting the ONH** in an image. This algorithm can enable fast and reliable automated patient alignment and can be used to register repeated acquisitions and subsequent patient visits.

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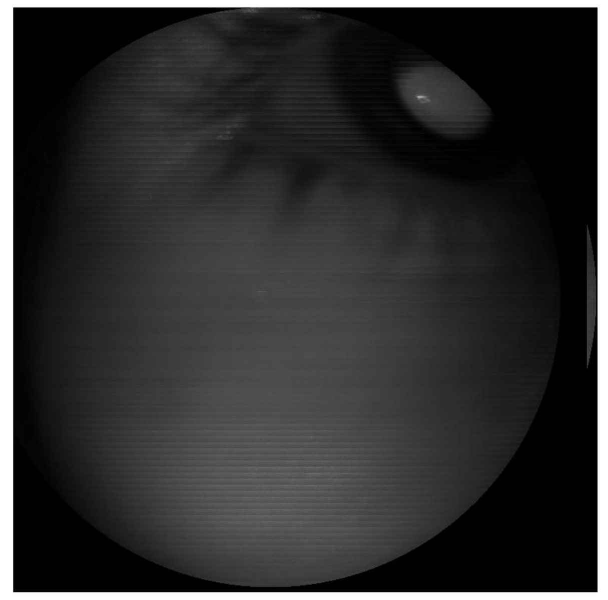
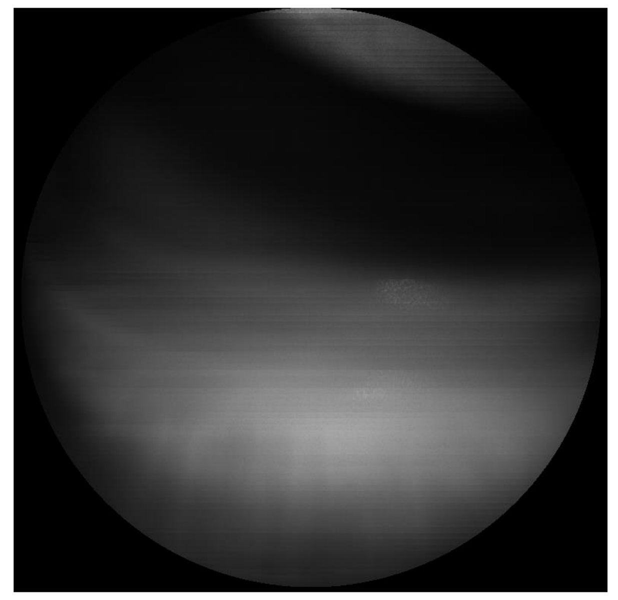
RESULTS

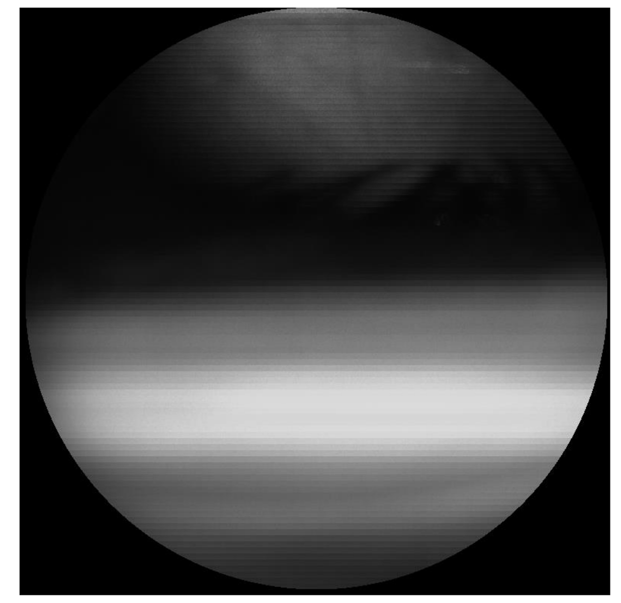
Typical true positive images; perfectly focused and without shadows



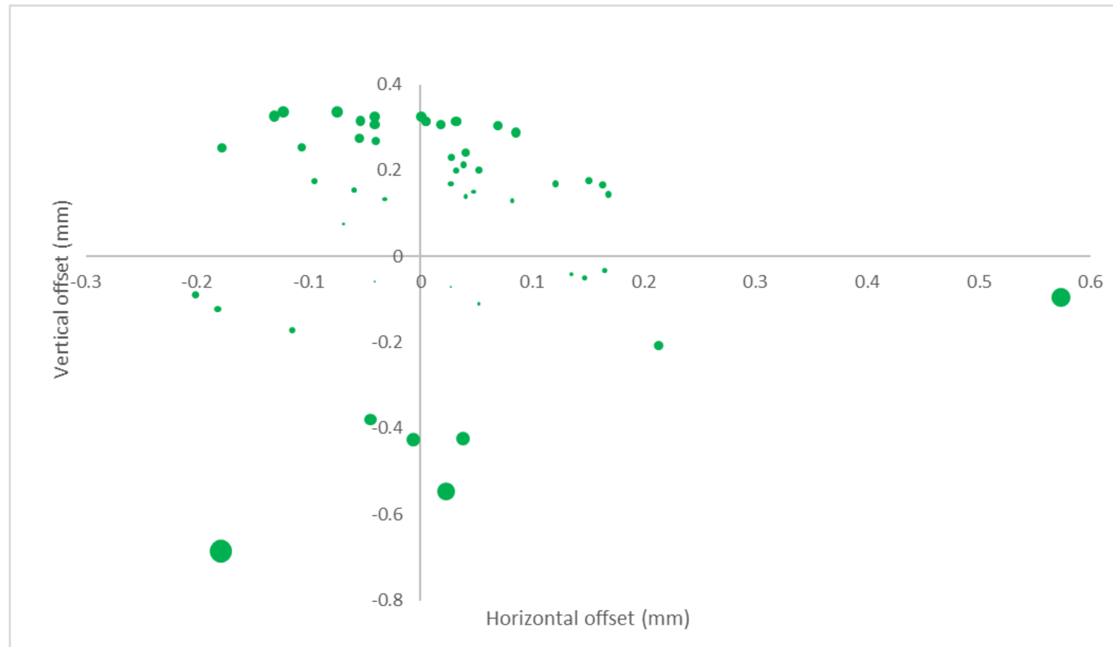
Typical false positive images where algorithm erroneously detects iris



Typical false negative images where ONH is obscured by shadows



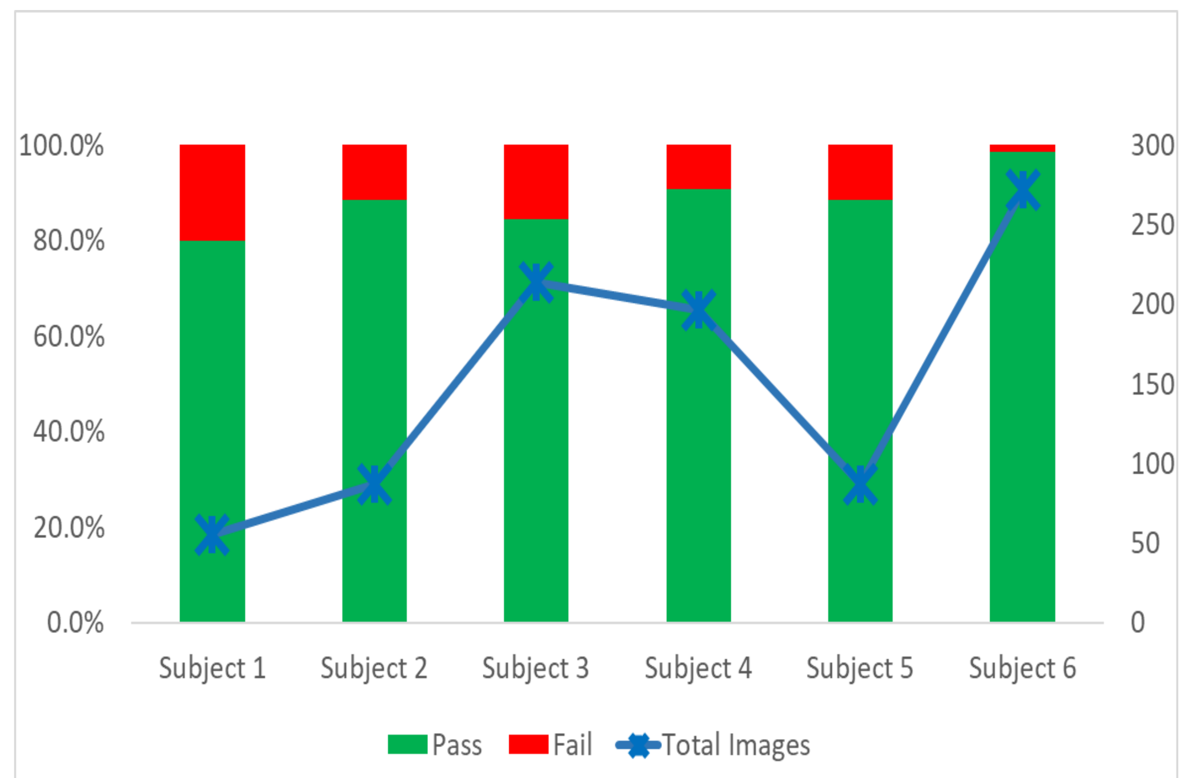
Typical true negative images when ONH is completely obscured



Tracking results with the center of circles showing motion of detected ONH during alignment and the size representing the error in detection of the ONH compared to ground truth

Average statistics for six human subjects with a total of 912 test images

Average Algorithm Performance	
Correct detection rate (%)	88.5%
False negative rate (%)	6.2
ONH detection accuracy (pixel)	1.25
ONH detection accuracy (µm)	267
Running time (ms)	< 100



Deep learning algorithm performance for six human subjects