Optic nerve head localization in OCT en face images via deep ellipse regression

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PURPOSE

- The U-Net is a state-of-the-art machine learning model for image segmentation and localization problems but requires pixel-level ground truth annotations. The acquisition of such annotations is expensive.
- Furthermore, the U-Net model could yield false segmentations and localizations of multiple connected components.
- We aimed to develop a machine learning algorithm for optic nerve head (ONH) localization in OCT en face images with limited annotation requirements that additionally overcomes the aforementioned problem.

METHODS

- The proposed deep ellipse regression model to localize the ONH in OCT en face images requires only three-point annotations and always yields information to segment and localize a single connected component.
- We utilize a convolutional neural network (CNN) with six convolution blocks and a final fully connected layer to predict the centroid, vertex and co-vertex location of an axially parallel ellipse.
- The CNN receives 2D images of size 256×256 pixels as inputs and yields four values, namely the coordinates of the three aforementioned points.
- The mean, minimum and maximum Euclidean distances between the predicted and true ONH centroid and vertex locations are calculated to evaluate the ONH localization performance.

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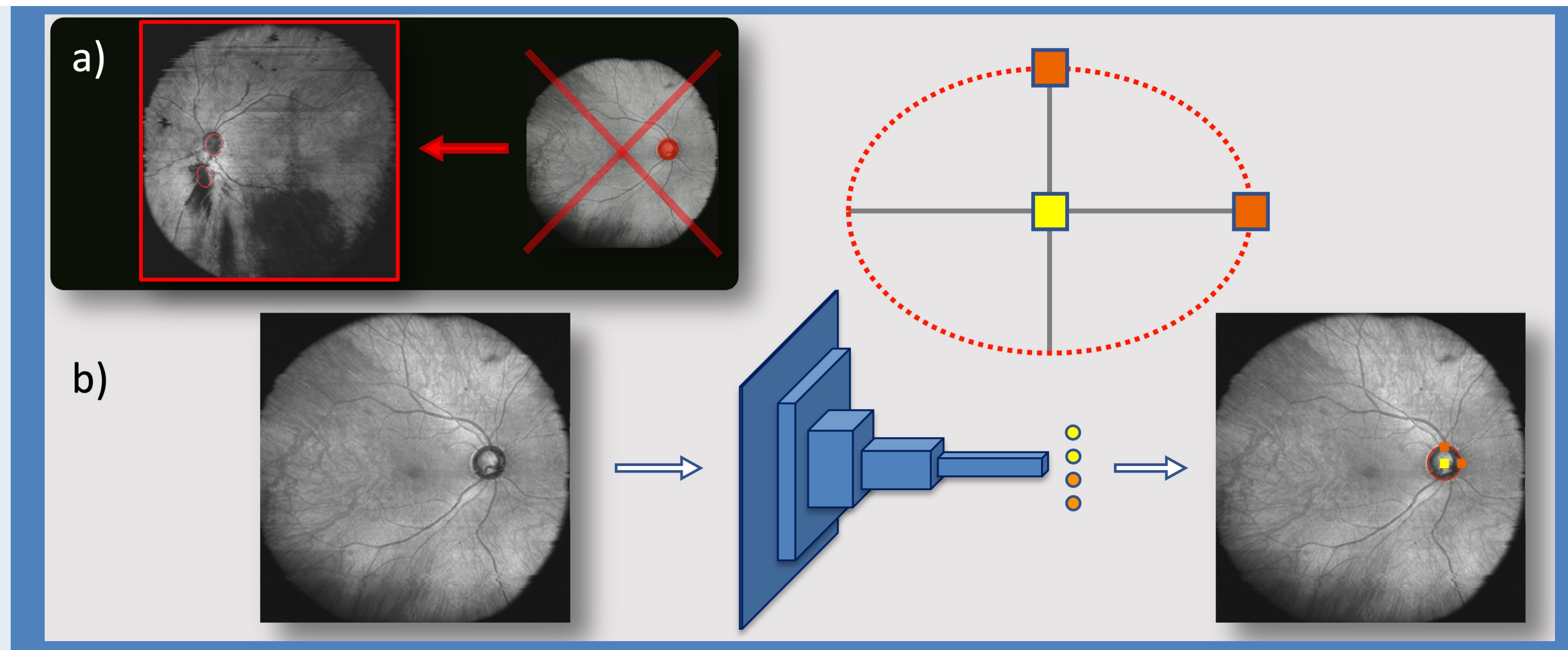

Figure 1. (a) U-Net based automated segmentation problem and (b) proposed CNN-based deep ellipse regression model to predict 4 values of an ONH enclosing ellipse.

Table 1. Quantitative evaluation results. Euclidean distances between the predicted and true locations of the centroid and vertices of an ellipse that encloses the optic nerve head.

Euclidean distances [px]	mean	min	max
Centroid locations	2.46	0.37	5.33
Vertex locations	1.28	0.40	3.62

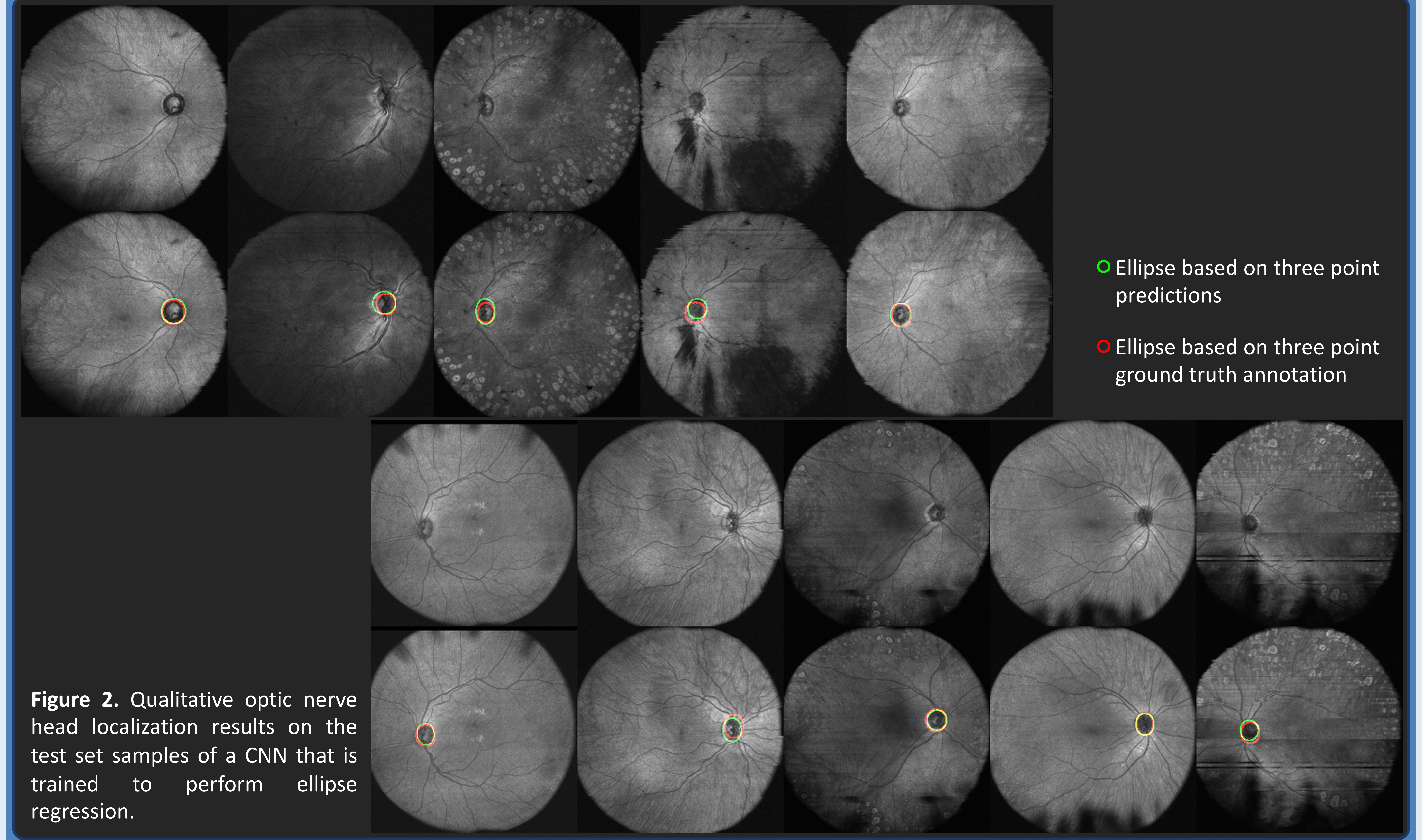

Figure 2. Qualitative optic nerve head localization results on the test set samples of a CNN that is trained to perform ellipse regression.

Disclosures: ThS (C), MN (C), KH (C), AP (F), WD (C,F), RL (C,F), TiS (E) – Carl Zeiss Meditec, Inc.; HS, USE – None

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RESULTS

- The model was trained on 100, validated on 10 and tested on 10 en face projections from volumetric 60 degree widefield swept-source optical coherence tomography (SS-OCT) scans acquired with a 1.7 MHz prototype OCT device.
- Qualitative evaluation results of the proposed model on test set samples are shown in Figure 2.
- The presented deep ellipse regression model shows high accuracy in predicting the ONH locations (centroid locations) and in predicting the size and shape of the ONH (vertex locations).
- Corresponding quantitative evaluation results are shown in Table 1.

CONCLUSIONS

- The proposed deep ellipse regression model has low annotation requirements and always yields information to localize a single connected component.
- Results demonstrate that the proposed approach predicts the ONH location, size and shape with high accuracy.
- The three predicted ellipse-parameterizing values can be directly used to identify the pixels of the enclosed area, which provides a good ONH segmentation approximation.