Automatic detection of corneal neovascularization

MUDr. Adéla Klézlová, FEBO
Bc. Mačák Adrián

Křížová D., Šikudová E., Studený P.

Department of Ophthalmology, FNVK and 3. LF UK
Head: Doc. MUDr. Pavel Studený, PhD., MHA.

Charles University, Faculty of mathematics and physics
Department of Software and Computer Science Education

Corneal neovascularization

- cornea is physiologically an avascular tissue
- corneal neovascularization is process of pathologic ingrowth of vessels from the limbal vascular plexus into the cornea
- occurs due to a variety of ocular insults, such as corneal hypoxia, infection, injury or immunological processes

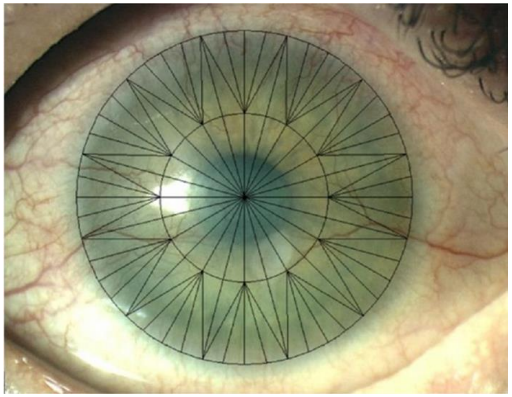
Consequences for the patient

- immature, newly formed vessels may lead to lipid exudation, persistent inflammation and scarring
- they can reduce corneal transparency and cause visual impairments
- in patients with corneal grafts may contribute to graft rejection

Detection of corneal neovascularization

- Till today =manual detection (naked eye of the ophthalmologist)
- This method was described in 2014 in study lead by our team

  Krizova D, Vokrojova M, Liehneova K, Studeny P. Treatment of Corneal Neovascularization Using Anti-VEGF Bevacizumab. J Ophthalmol. 2014;2014:178132.



- Manual assessment proves to be inaccurate as it is not comparable over time and data is not possible to save and analyze again
- Automatic detection of corneal neovascularization removes all negative aspects of the manual assessment

Goal of the project

- Development of a software application, which uses machine learning for automatic detection of corneal neovascularization and its quantification

Method

Two phases of application development:

1. Development of computing part
   - learning of the neural network
     (the neural network can on the picture of the eye identify corneal vessels, which are processed and then quantified)

2. Development of user interface part

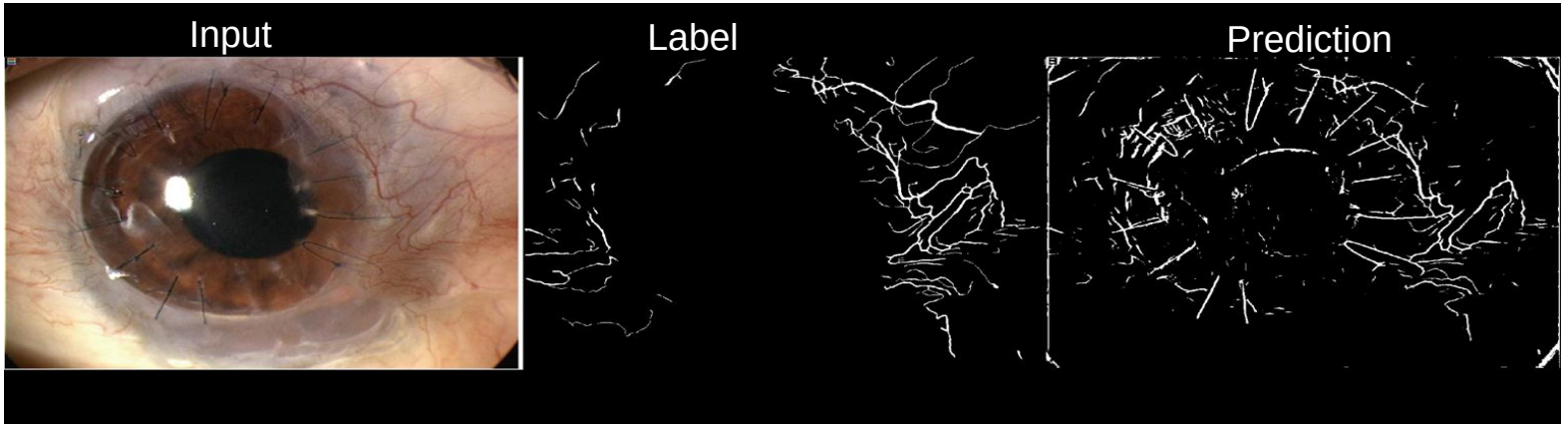
   - allow users to detail viewing and comparing of the pictures

Neural network learning

- learning with the dozens of supplied images of anonymous patients
- at the beginning the application detects also other structures of the eye as the vessels (corneal sutures, eyelashes, iris crypts)
- not able to detect fine vessels
- further neural network learning improvements and manual corrections were done to eliminate all errors

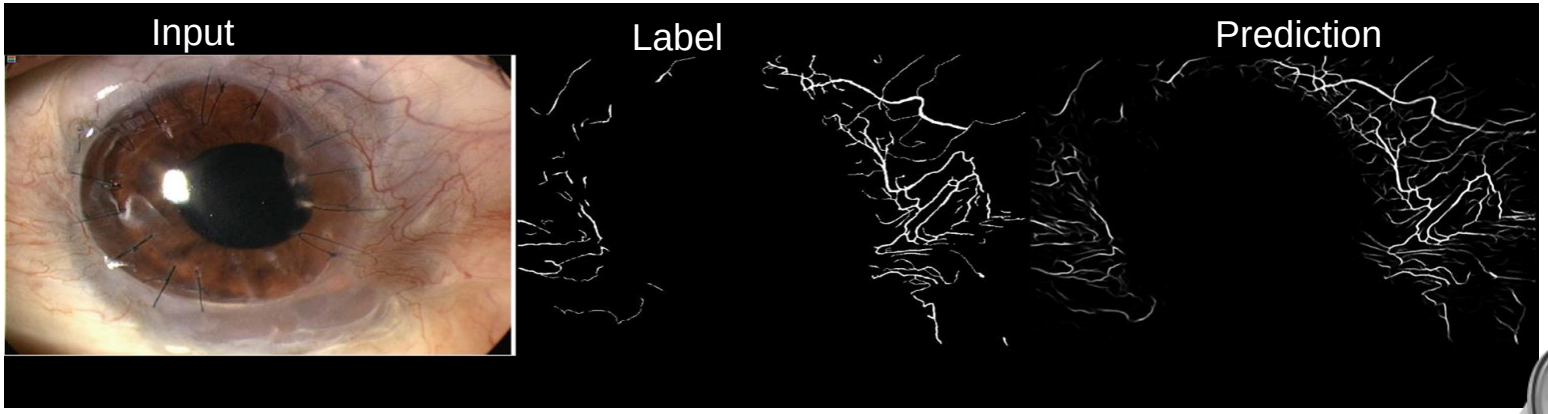
Improvement in vessel detection

Image 1: with errors in prediction



- RV-GAN (for similar problem - Retinal Vessel Segmentation) - prediction on three models and voting

Image 2: after error elimination



- Our current results - U-NET and data augmentation

Project results

- unique software application for automatic detection of corneal neovascularization
- automatically detects presence of pathologic vessels and quantifies them
- user (ophthalmologist) can simply evaluate, compare over time and observe in detail the images in the user interface

Automatic detection of corneal neovascularization

MUDr. Adéla Klézlová, FEBO
Bc. Mačák Adrián

Křížová D., Šikudová E., Studený P.

Department of Ophthalmology, FNVK and 3. LF UK
Head: Doc. MUDr. Pavel Studený, PhD., MHA.

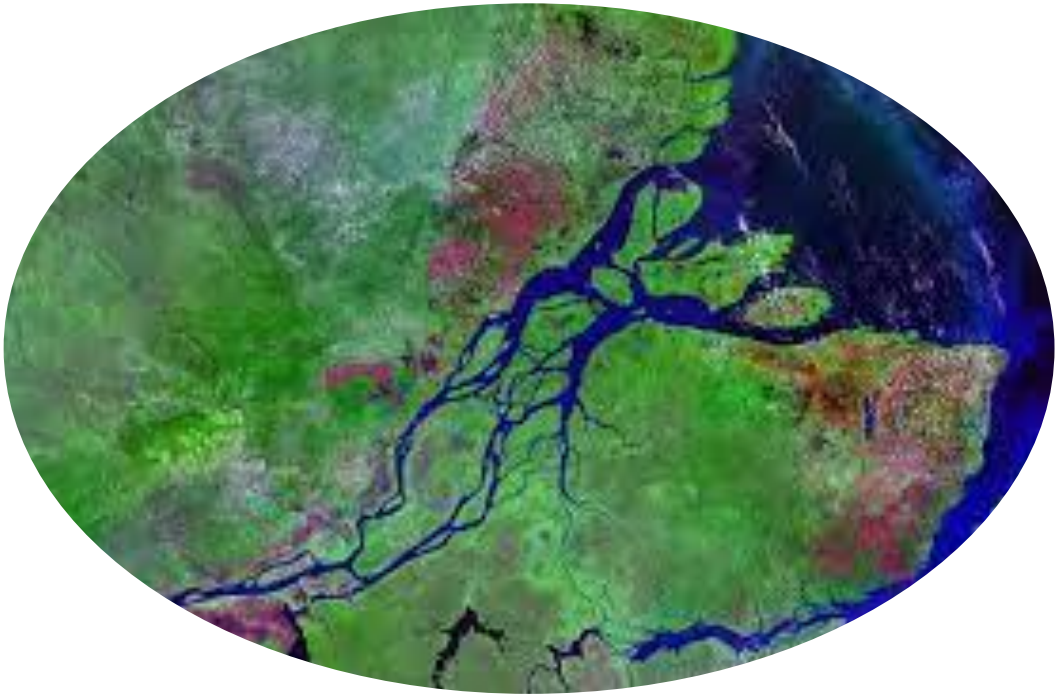
Charles University, Faculty of mathematics and physics
Department of Software and Computer Science Education

Conclusion

- till now it has been possible to assess the presence and progression of the corneal neovascularization just with the naked eye of the examiner

- unique automatic software application detecting and quantifying the corneal neovascularization could help to the ophthalmologists worldwide more precisely and easily assess this pathology and thus better target and monitor the treatment

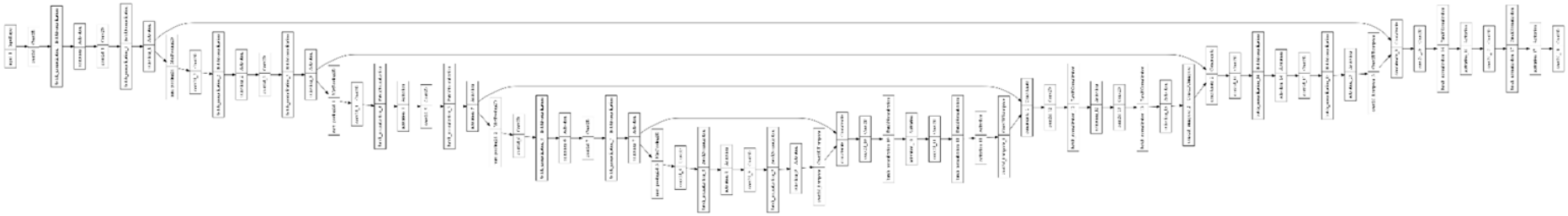
Thank you for your attention!



adela.klezlova@fnkv.cz
adrian.ado.macak@gmail.com

Appendix

Model



- based on UNET architecture

  “U-Net: Convolutional Networks for Biomedical Image Segmentation”. (2015)

- Data augmentation were used to increase model accuracy

- Training for 400 epoch took about 2 hours

Training of our model for 400 epochs

- 10 epochs
- 100 epochs
- 250 epochs
- 400 epochs