Towards Identification of Incorrectly Segmented OCT Scans

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Agenda

Introduction

- Background
- What are OCT scans?
- Motivation

Main section

- Feature Extraction
- Dimensionality Reduction
- Outlier Detection

Conclusion

- Results
- Questions?

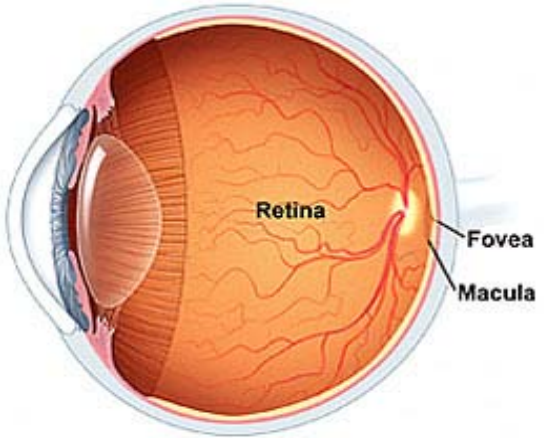
Background

- Medical Informatics at TU Wien
- Bachelorthesis topic at PRIP
- Cooperation with ophthalmologic department of the AKH Vienna
- Working on algorithms for automatically segmenting OCT scans
- Goal: Supporting the development of such algorithms
- First Review from CVWW (https://cvww2020.vicos.si/)
- Accepted at ACVRW (https://acvrw20.ist.tugraz.at/)

What are OCT scans?

Optical Coherence Tomographie

- Imaging technique, like ultrasound, but using light waves instead
- Used to generate images of the human retina
- One 3D OCT scan consists of 200 images



https://osg-ghana.org/retina/

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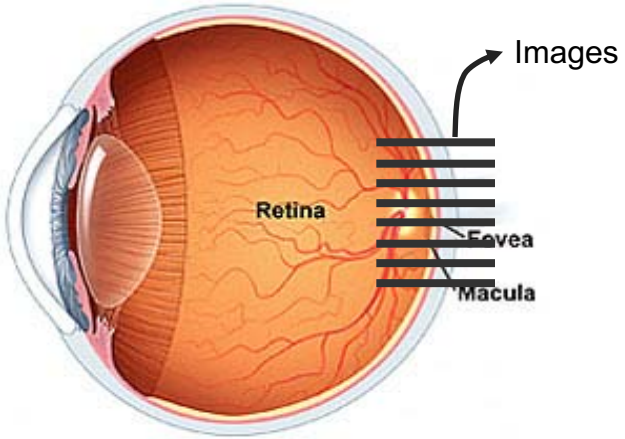
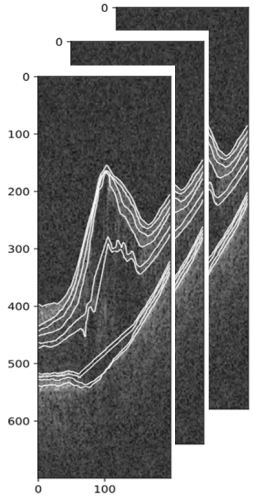


https://osg-ghana.org/retina/

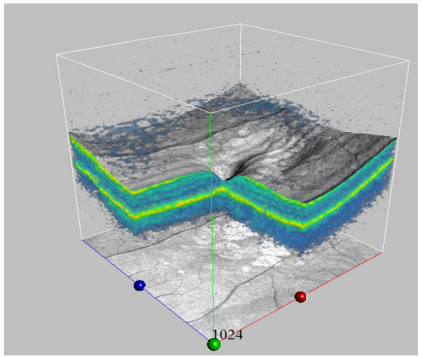
What are OCT scans?

- All images are cross-sectional slices of the retina, similar to CT scans

- 100 OCT scans from ophthalmologic department of the AKH Vienna, segmented with a specific algorithm[1], as well as manually segmented



0, 1, … 199
Images



http://augenzentrum-speckenbuettel.de/oct-untersuchung/3d-oct/

1 M. K. Garvin, M. D. Abramoff, X. Wu, S. R. Russell, T. L. Burns, and M. Sonka. Automated 3-d intraretinal layer segmentation of macular spectral-domain optical coherence tomography images. IEEE Transactions on Medical Imaging, 28(9):1436–1447, Sep. 2009

Motivation

- ~ 600.000 diabetes patients in Austria[1]
- Diabetic retinopathy is the leading cause of vision loss in working-age adults (20-65 years)[2]

- Frequent eye-screening is necessary to early detect eye-sight diseases[2]
- OCT is used as it provides 3D data of the retina

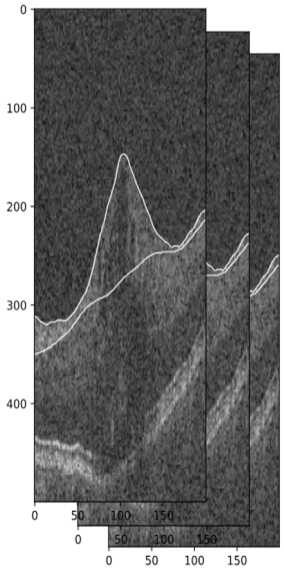
- 30.000 OCT scans/year at the Department of Ophthalmology at MedUni Vienna[3]
- ophthalmologic departments are working on automatically processing

1 https://www.sozialministerium.at/Themen/Gesundheit/Nicht-uebertragbare-Krankheiten/Diabetes.html
2 https://idf.org/our-activities/care-prevention/eye-health.html
3 https://www.meduniwien.ac.at/web/en/about-us/news/detailsite/2017/news-in-august-2017/line-field-oct-developed-at-meduni-vienna/

The method

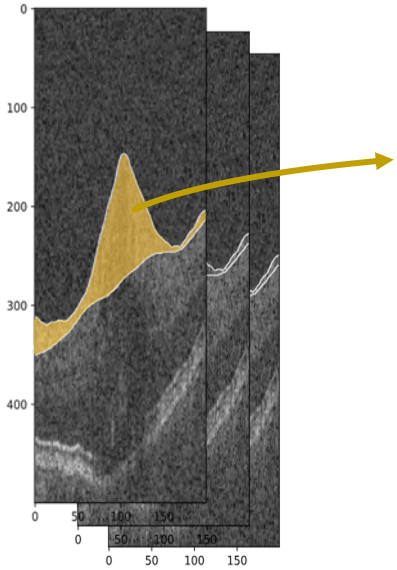
- Goal: Identify incorrectly segmented OCT scans
- Input: Manually and automatically segmented OCT scans
- The method is divided into 3 steps:

Feature Extraction



0, 1, … 199

Feature Extraction

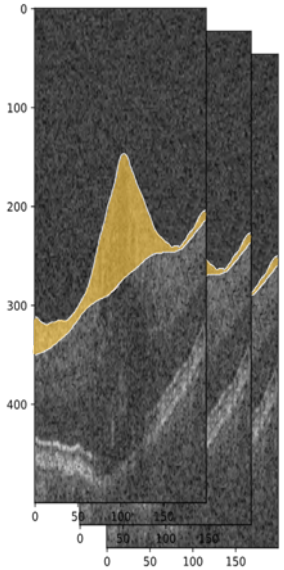


Extracting the feature „Area“

0, 1, … 199

- Area = Number of pixels belonging to a layer
- Focus on the first layer
- Result: „Area Curves“

Feature Extraction



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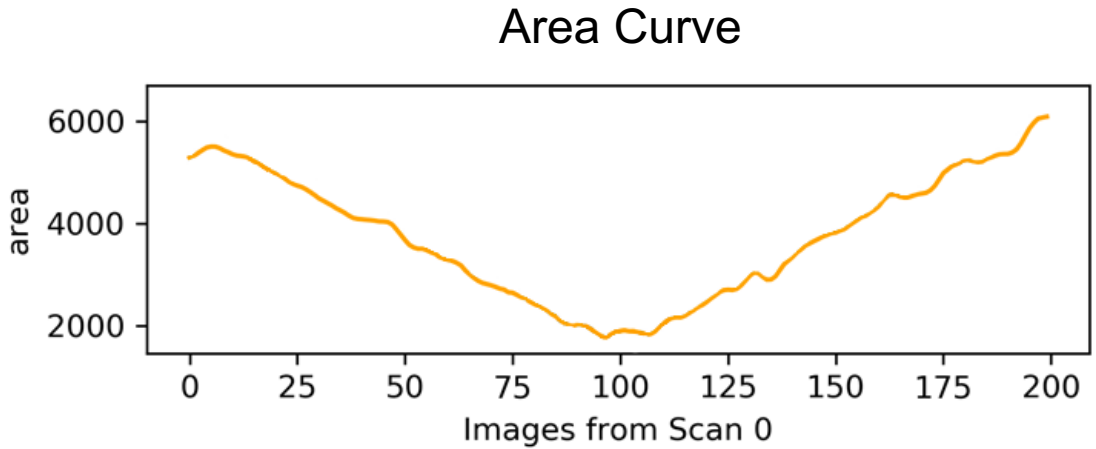
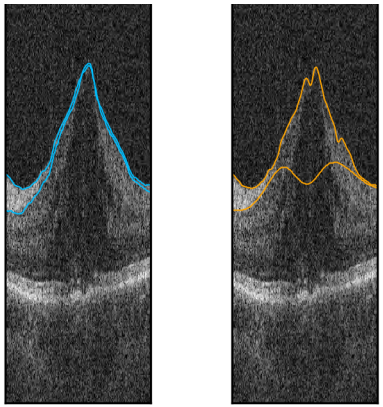
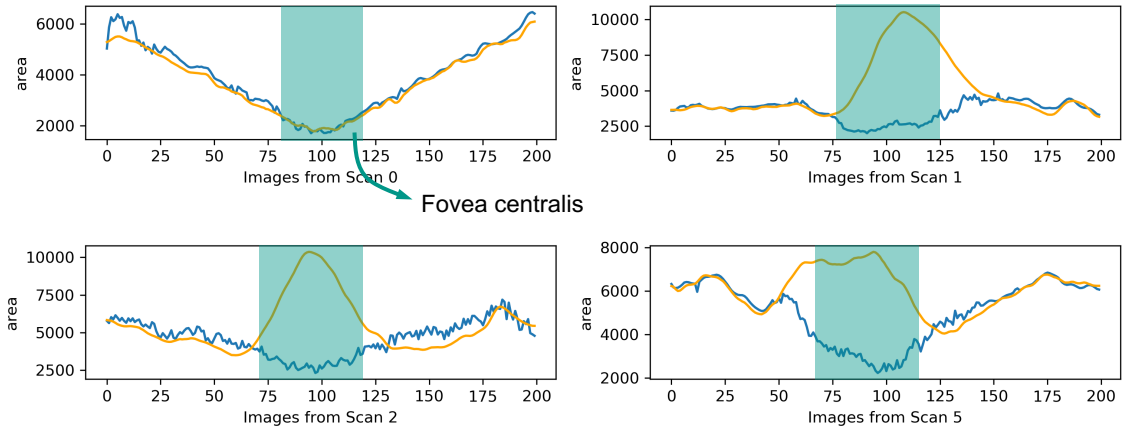


Feature Extraction

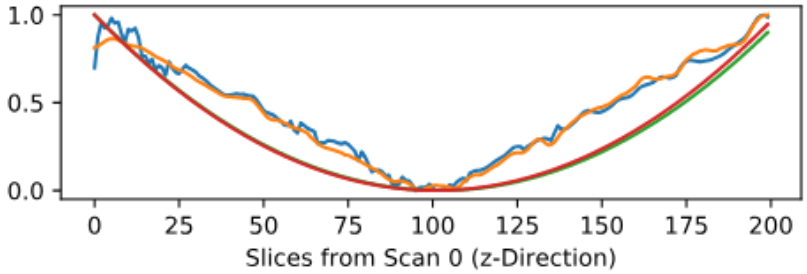
- Area curves from the manual segmentation (blue) all tend to have a global minimum
- At the "fovea centralis" the retinal layers usually become thinner
- Some area curves from the automatically generated segmentation (orange) have a global maximum

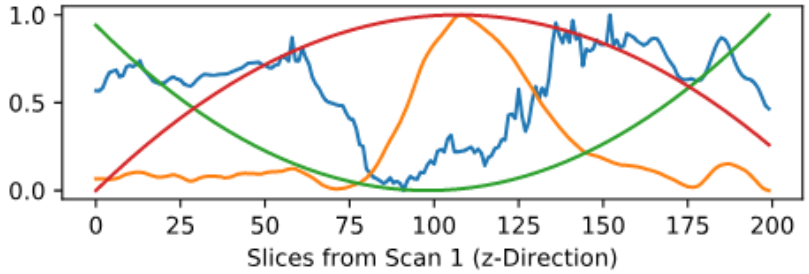


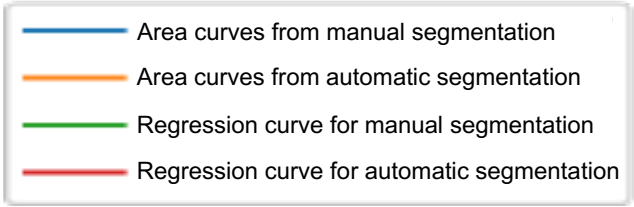


Result: 200 area values for each OCT scan

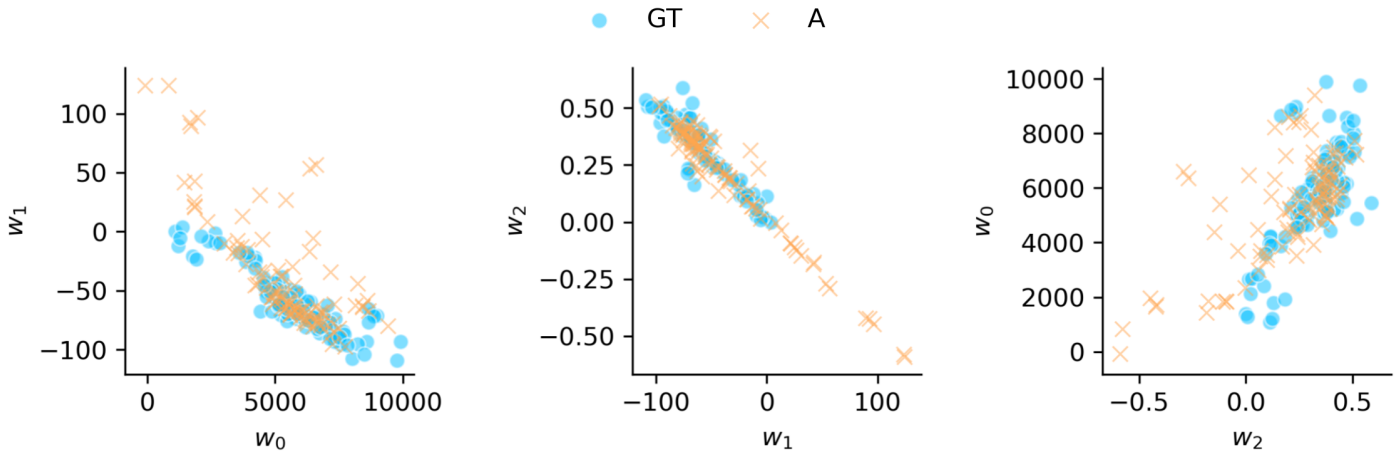
- Describing area curves with second order polynomials using Least Squares Regression
- $w_0 + w_1x + w_2x^2$ → Three values for each OCT scan







- w_2 describing the bending of the area curves → cluster of negative w_2 values
- Investigating the data in 3D → points almost lay in a plane



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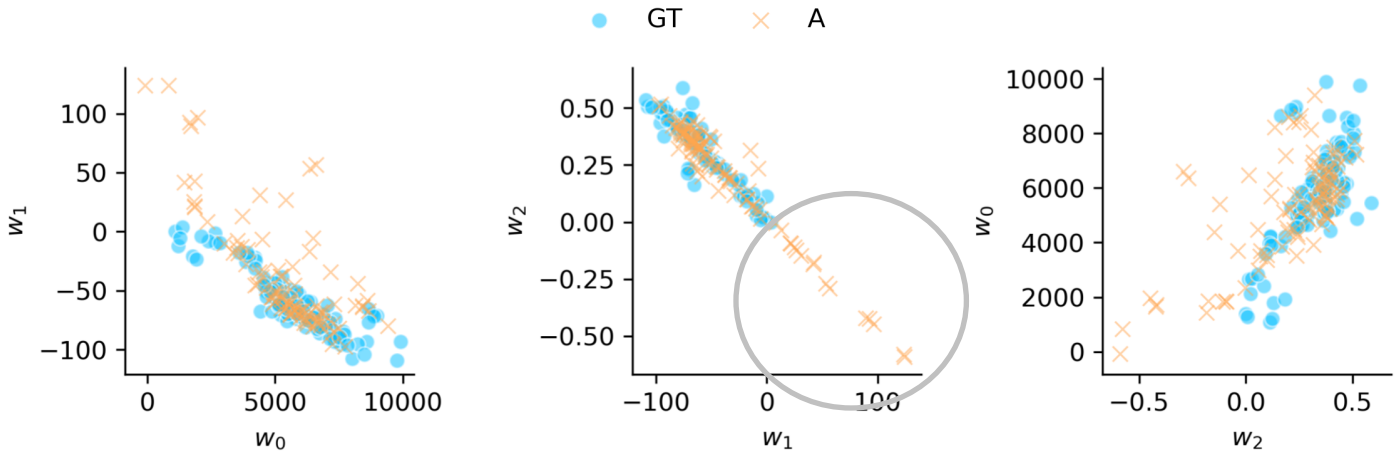
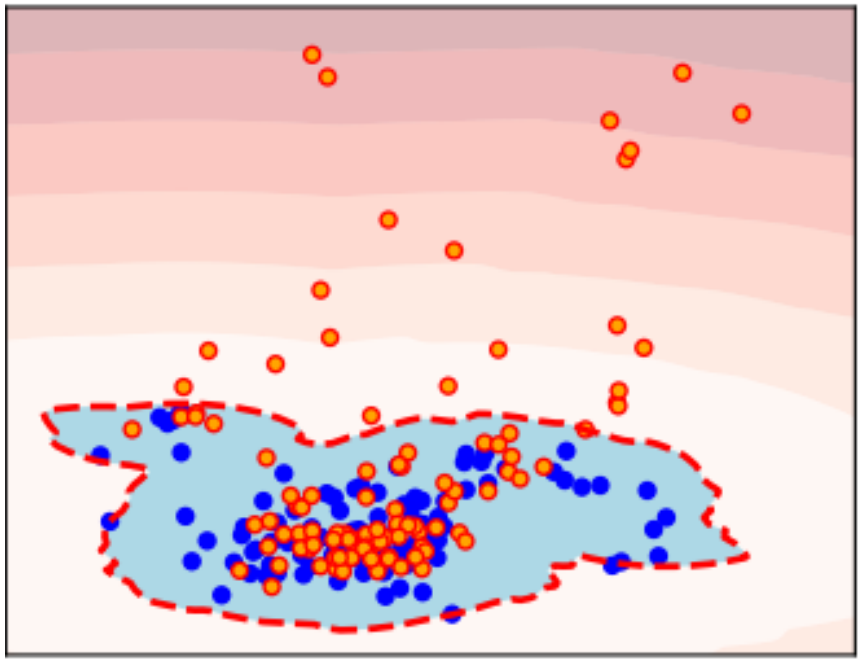
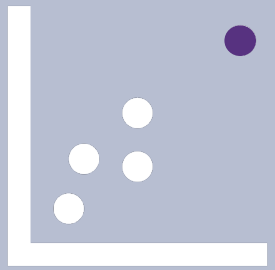


Projection into 2D with Principal Component Analysis



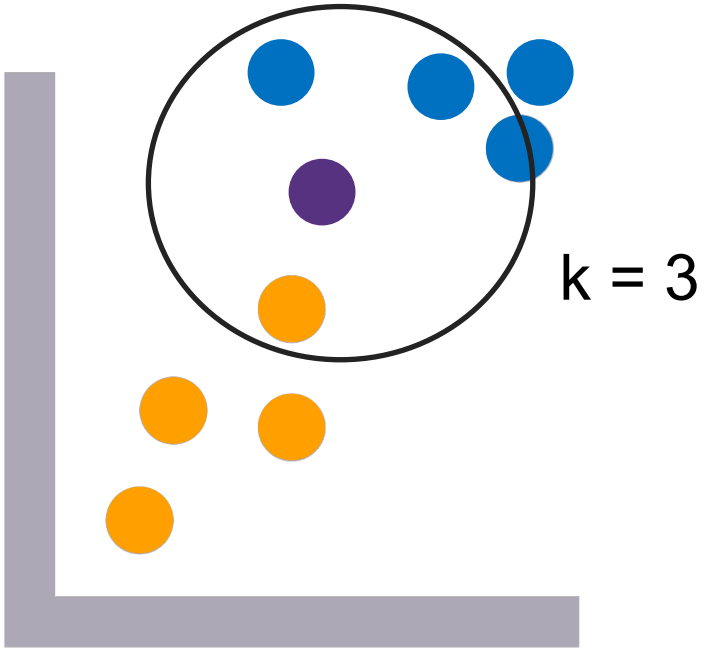
Result: **200** area values for each OCT scan

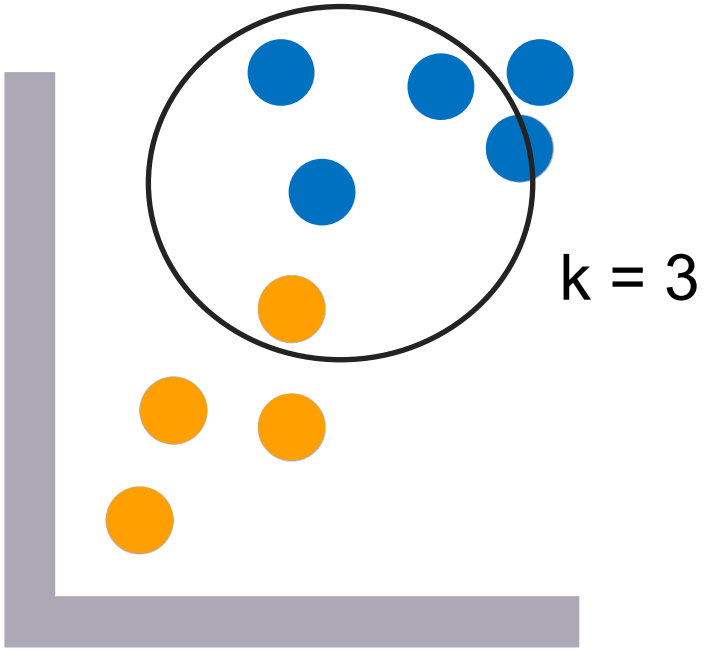
Result: **2** values for each OCT scan



- Fit models with the manually segmented data to represent correct behaviour (= correctly segmented)
- For each model we evaluate for all automatically segmented data if it is an outlier (= incorrectly segmented) or not
- The best model for our evaluated algorithm: K-Nearest-Neighbours

Outlier Detection


k = 3

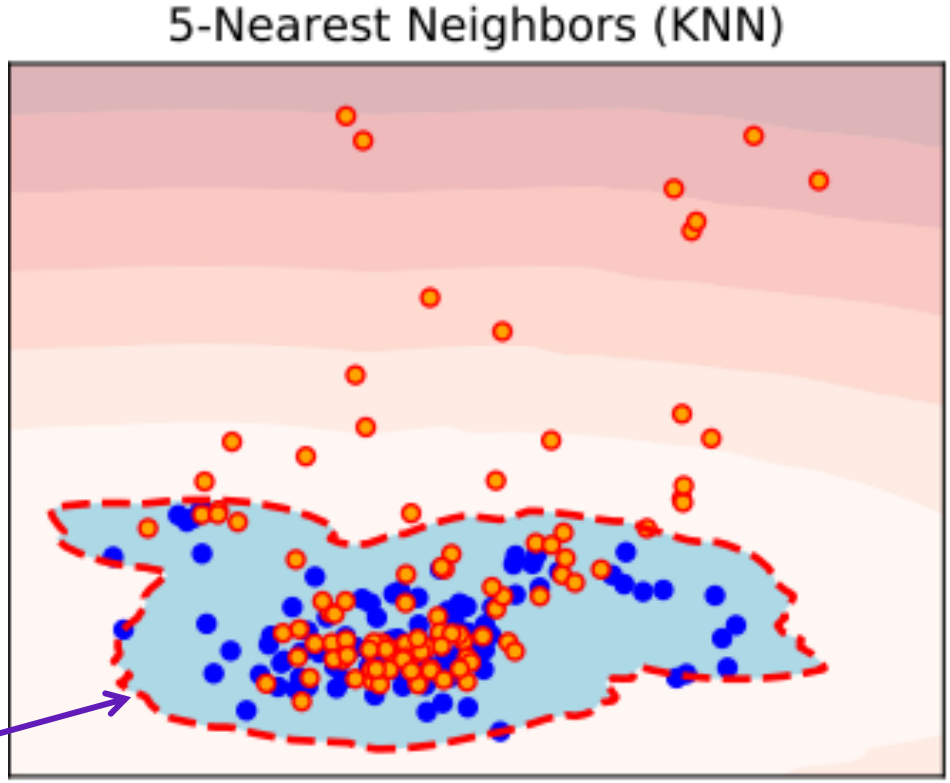

k = 3

Result: **200** area values for each OCT scan

Result: **2** values for each OCT scan

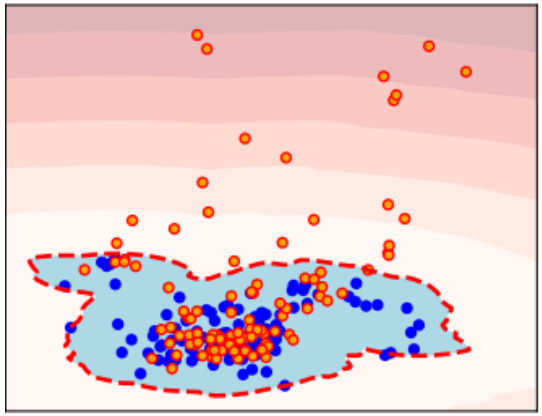
Result: **Incorrectly segmented** OCT scans

Results

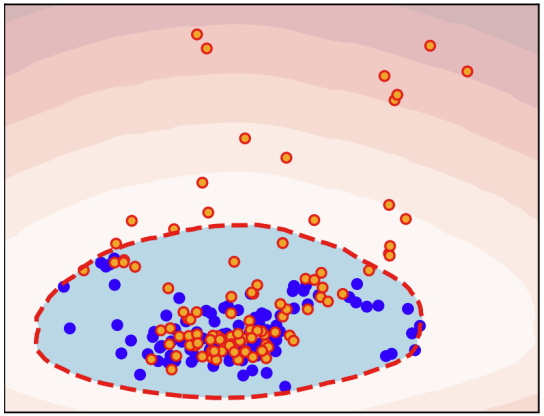


Decision Boundary

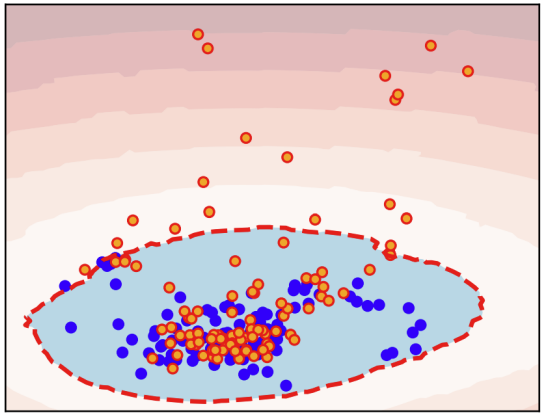
5-Nearest Neighbors (KNN)



Feature Bagging (FB)



Local Outlier Factor (LOF)



For more details

Renner V. and Hladůvka J. (2020), *"Towards Identification of Incorrectly Segmented OCT Scans"*, In Joint Austrian Computer Vision and Robotics Workshop. , pp. 159-165.

Proceedings of the Joint Austrian Computer Vision and Robotics Workshop 2020 DOI: 10.3217/978-3-85125-752-6-36

Towards Identification of Incorrectly Segmented OCT Scans

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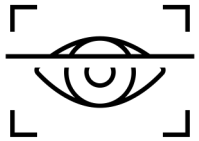
Abstract. *Precise thickness measurements of retinal layers are crucial to decide whether the subject requires subsequent treatment. As optical coherence tomography (OCT) is becoming a standard imaging method in hospitals, the amount of retinal scans increases rapidly, automated segmentation algorithms are getting deployed, and methods to assess their performance are in demand.*

scans is based on the work [5]. While accurate in most of cases, the method occasionally exhibits imperfections. An improvement is desirable, as the correct segmentation is essential for further automatic evaluation of OCT scans. This is because the thickness of the retinal layers is highly related to the presence of diseases, like AMD or DME [5]. They are caused by intraretinal and subretinal fluids, leading

Thank you all for joining!



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Slide 3:
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2 https://idf.org/our-activities/care-prevention/eye-health.html
3 https://www.meduniwien.ac.at/web/en/about-us/news/detailsite/2017/news-in-august-2017/line-field-oct-developed-at-meduni-vienna/

Slide 4:
1 M. K. Garvin, M. D. Abramoff, X. Wu, S. R. Russell, T. L. Burns, and M. Sonka. Automated 3-d intraretinal layer segmentation of macular spectral-domain optical coherence tomography images. IEEE Transactions on Medical Imaging, 28(9):1436–1447, Sep. 2009