What’s next in AI for glaucoma screening?

The REFUGE challenge outcomes

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Opportunities for AI in glaucoma

Screening

Follow up / prognosis

Treatment planning

Disease understanding

Opportunities for AI in glaucoma

Screening

Follow up / prognosis

Treatment planning

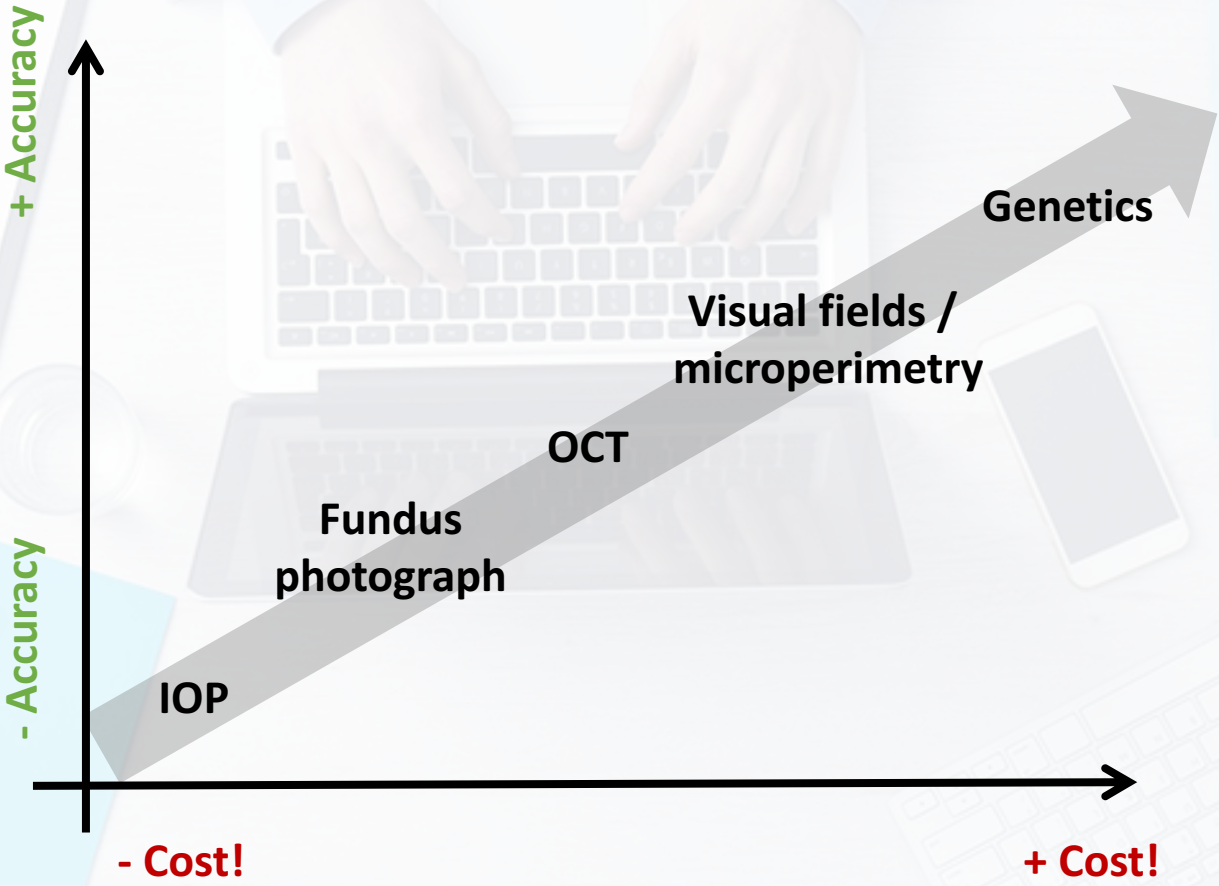
Disease understanding

Types of screening

Population based (universal)

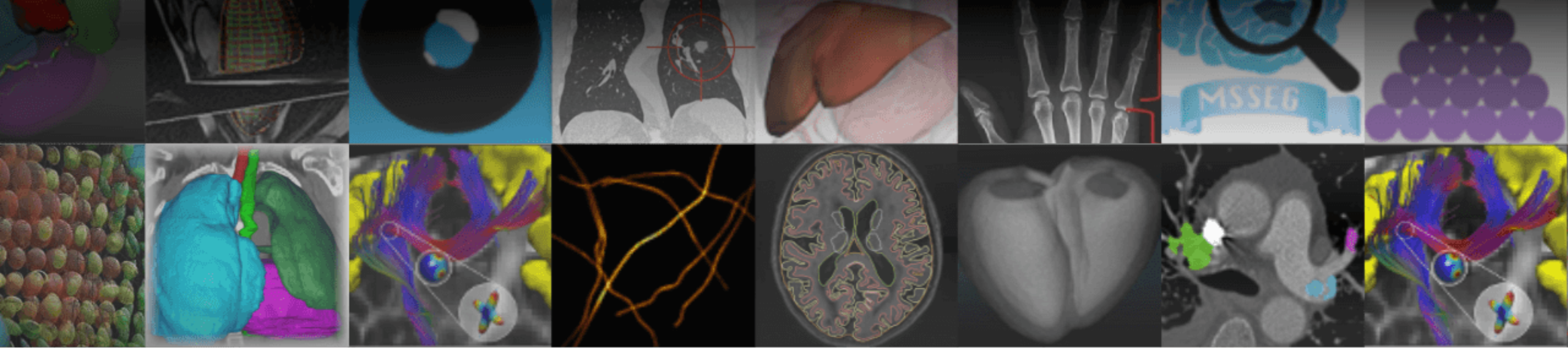
Case detection (opportunistic)

COST EFFECTIVENESS!

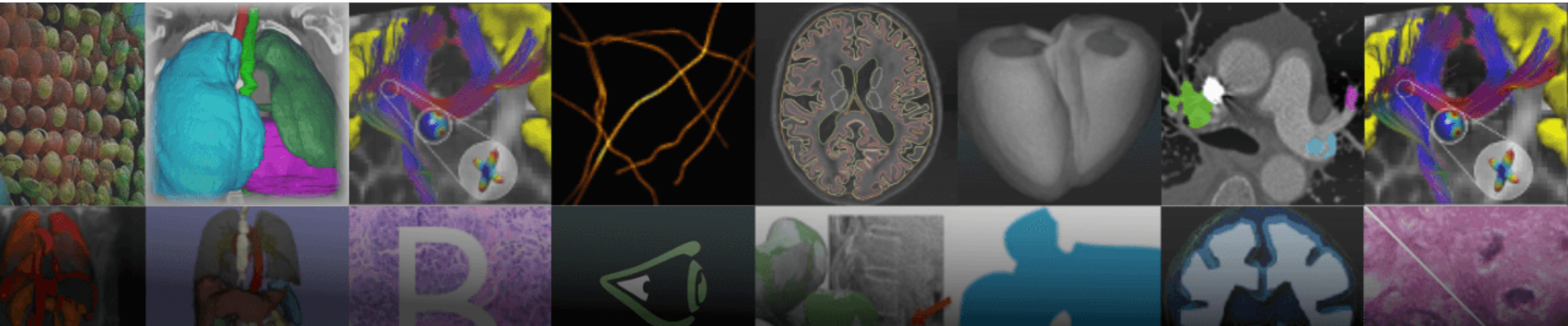

+ Accuracy
- Accuracy
Genetics
Visual fields /
microperimetry
OCT
Fundus
photograph
IOP
- Cost!
+ Cost!

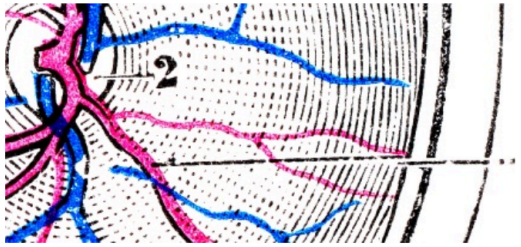
How to reduce the cost of glaucoma screening using AI?

The Diabetic Retinopathy experience



Grand challenges





Diabetic Retinopathy Detection

Identify signs of diabetic retinopathy in eye images

$100,000 · 661 teams · 4 years ago

kaggle

Overview

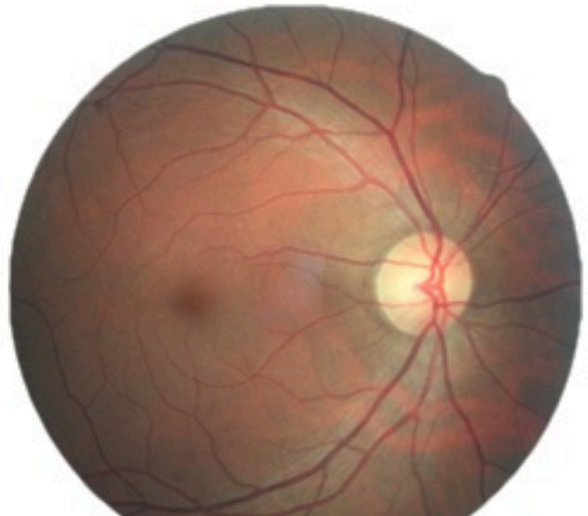
Description

Evaluation

Prizes

Timeline

Diabetic retinopathy is the leading cause of blindness in the working-age population of the developed world. It is estimated to affect over 93 million people.



The US Center for Disease Control and Prevention estimates that 29.1 million people in the US have diabetes and the World Health Organization estimates that 347 million people have the disease worldwide. Diabetic Retinopathy (DR) is an eye disease associated with long-standing diabetes. Around 40% to 45% of Americans with diabetes have some stage of the disease. Progression to vision impairment can be slowed or averted if DR is detected in time, however this can be difficult as the disease often shows few symptoms until it is too late to provide effective treatment.

Original Investigation | Innovations in Health Care Delivery

FREE

December 13, 2016

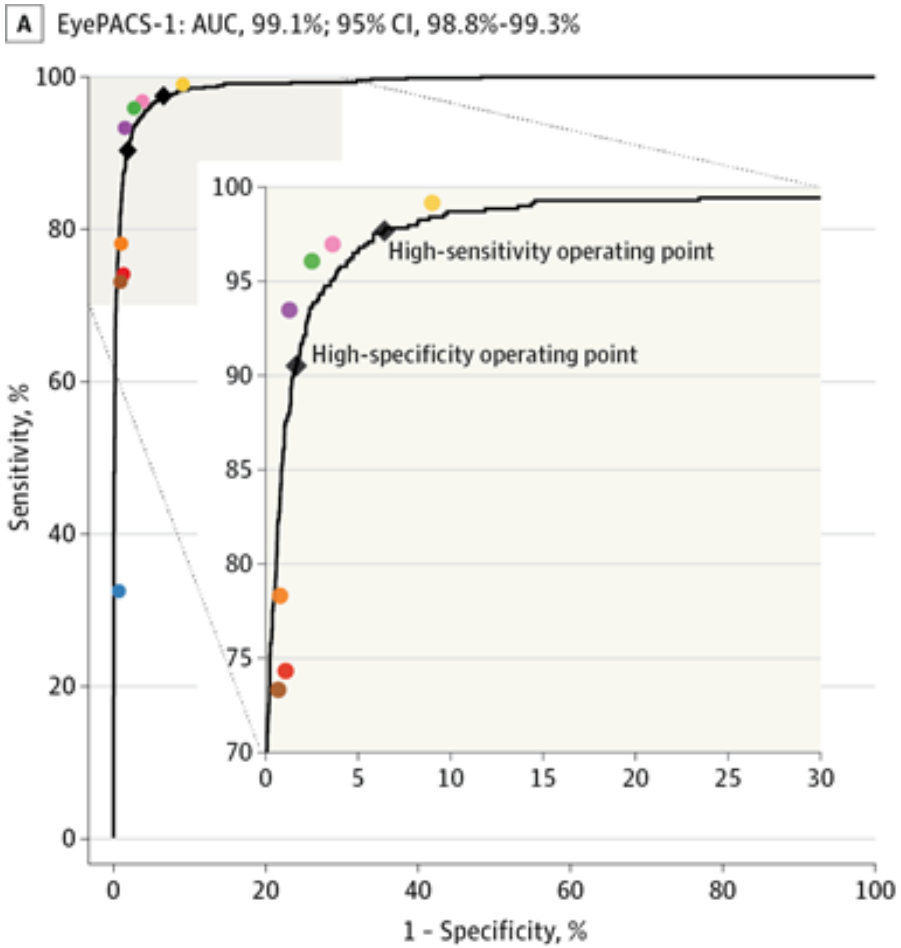
Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

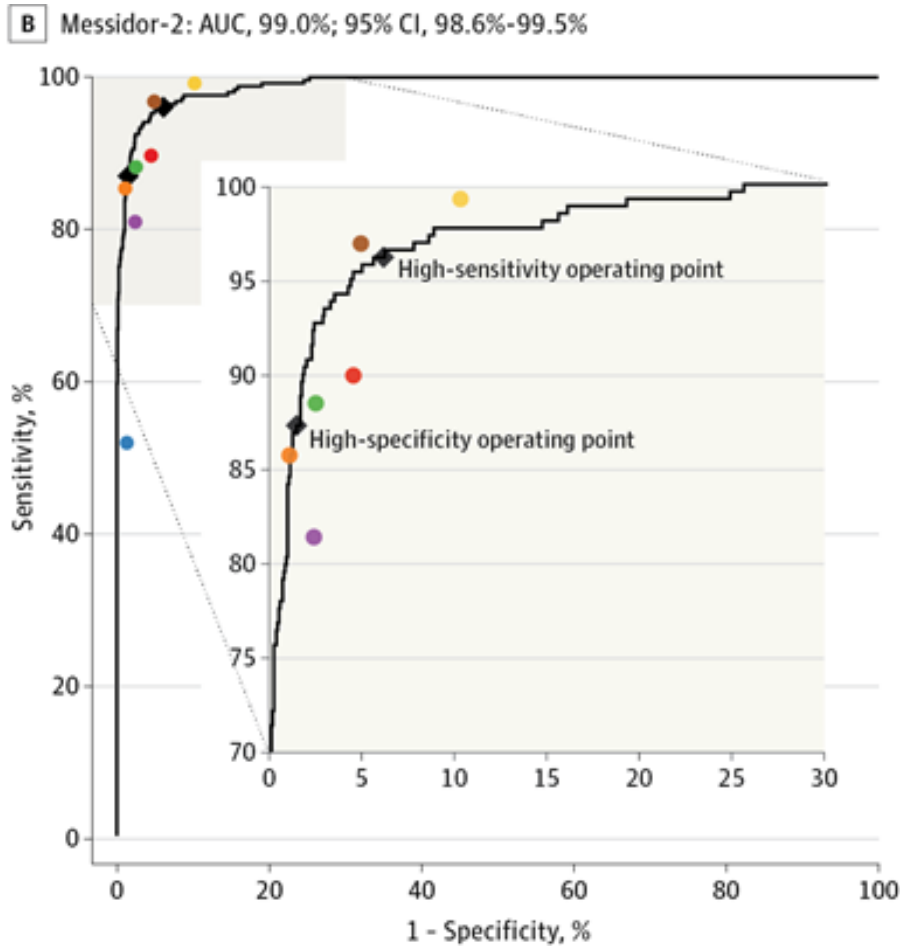
Varun Gulshan, PhD[1]; Lily Peng, MD, PhD[1]; Marc Coram, PhD[1]; et al

» Author Affiliations | Article Information

JAMA. 2016;316(22):2402-2410. doi:10.1001/jama.2016.17216

Gulshan et al., JAMA, 2016





Gulshan et al., JAMA, 2016

FDA NEWS RELEASE

FDA permits marketing of artificial intelligence-based device to detect certain diabetes-related eye problems

More Press Announcements

Press Announcements

For Immediate Release: April 11, 2018

Español

The U.S. Food and Drug Administration today permitted marketing of the first medical device to use artificial intelligence to detect greater than a mild level of the eye disease diabetic retinopathy in adults who have diabetes.

Diabetic retinopathy occurs when high levels of blood sugar lead to damage in the blood vessels of the retina, the light-sensitive tissue in the back of the eye. Diabetic retinopathy is the most common cause of vision loss among the more than 30 million Americans living with diabetes and the leading cause of vision impairment and blindness among working-age adults.

“Early detection of retinopathy is an important part of managing care for the millions of people with diabetes, yet many patients with diabetes are not adequately screened for diabetic retinopathy since about 50 percent of them do not see their eye doctor on a yearly basis,” said Malvina Eydelman, M.D., director of the Division of Ophthalmic and Ear,

Content current as of:
04/12/2018

Follow FDA
Follow @US_FDA
Follow FDA
Follow @FDAmedia

IDx

Autonomous AI that instantly detects disease

Increase patient access to early disease detection.

Learn More

https://www.eyediagnosis.co

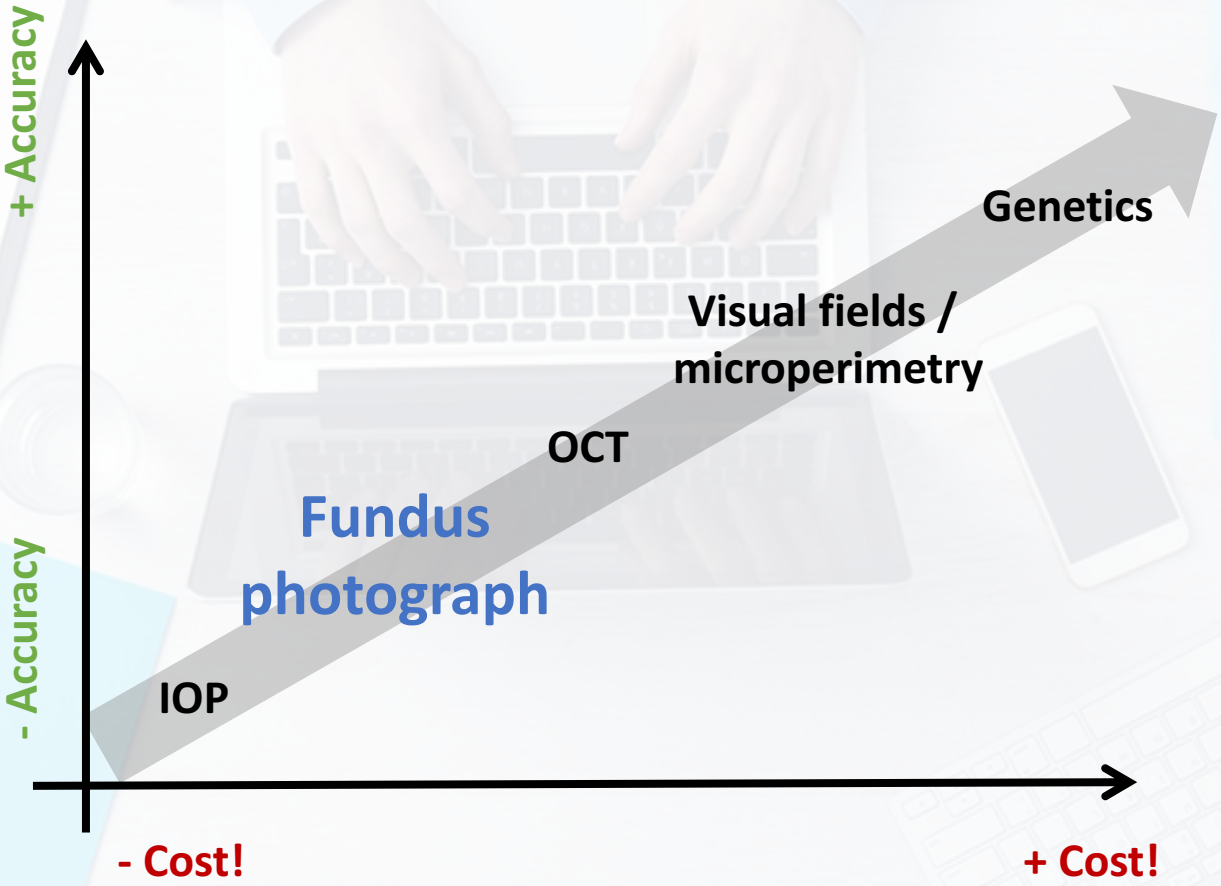
But...

Glaucoma features less evident in fundus images

Glaucoma as a multimodal disease

High cost of building (huge) reliable data sets

Clinical records based labels + Scrapping on clinical databases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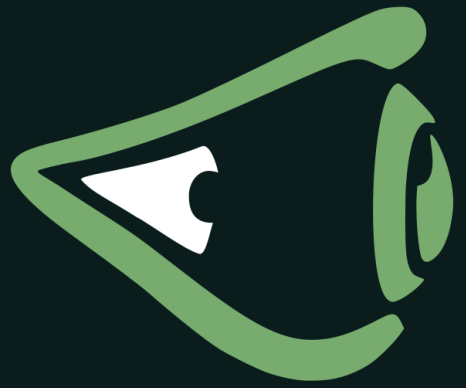
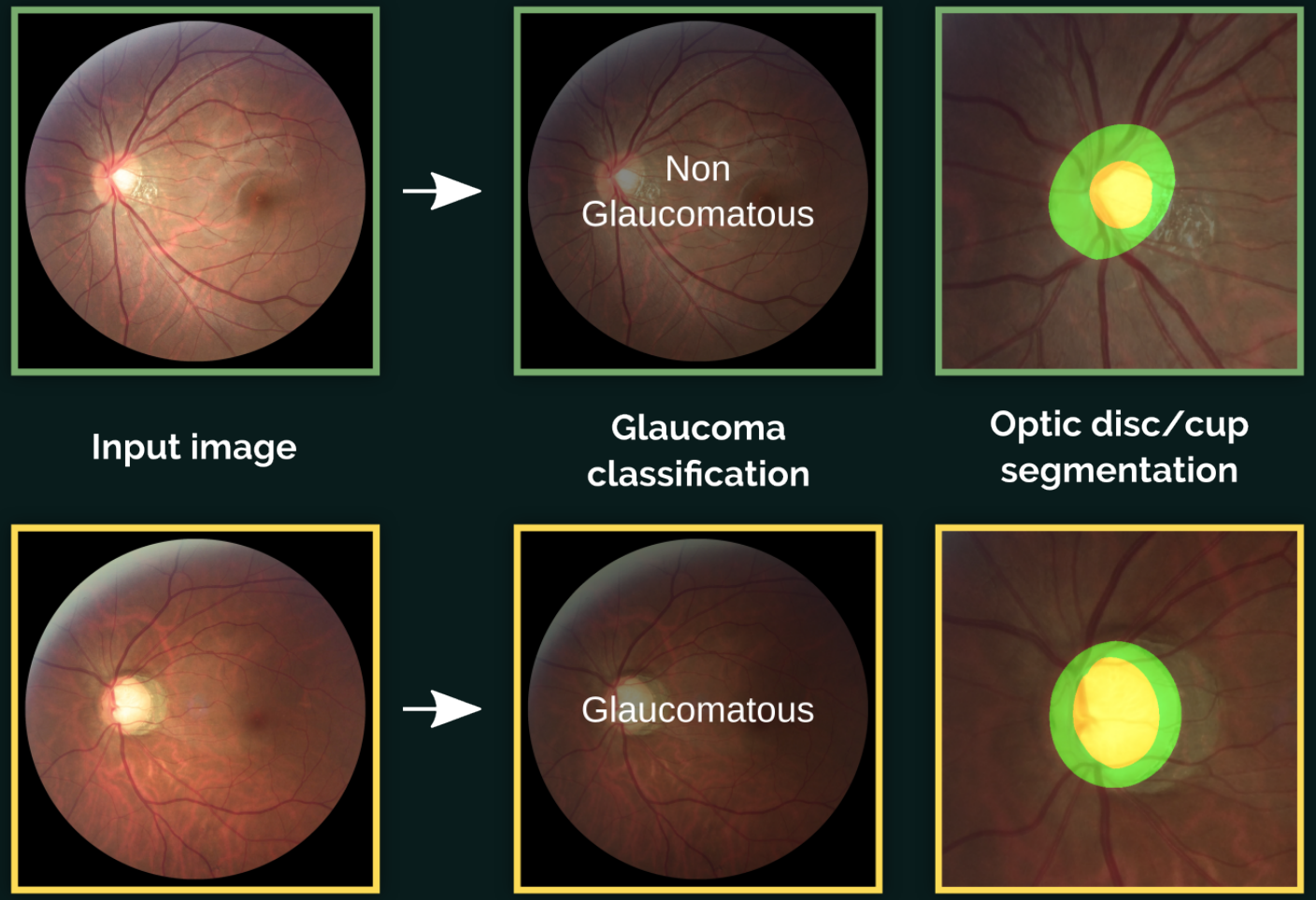


REFUGE

Retinal Fundus Glaucoma Challenge

20th September, Granada, Spain
OMIA Workshop, MICCAI 2018

Orlando et al., Medical Image Analysis, 2019



Orlando et al., Medical Image Analysis, 2019

The largest available data set of fundus pictures for glaucoma assessment

1200 images (10% glaucoma) divided in training, validation and test sets

Reliable annotations for glaucoma classification and optic disc/cup segmentation

Glaucoma labels retrieved from clinical records and optic disc/cup segmentations produced by +7 experts

A common evaluation framework to compare fundus image analysis methods for glaucoma

A test set with private labels + evaluation routines to report performance and prevent overfitting on test data

Orlando et al., Medical Image Analysis, 2019

Zeiss Visucam 500	Cannon CR-2	Cannon CR-2
400 images	400 images	400 images
Training	Offline evaluation (labels are now available)	On-site evaluation (private labels)

Orlando et al., Medical Image Analysis, 2019

12 participating teams

All the teams proposed deep learning based solutions!

Orlando et al., Medical Image Analysis, 2019

Medical Image Analysis
Volume 59, January 2020, 101570

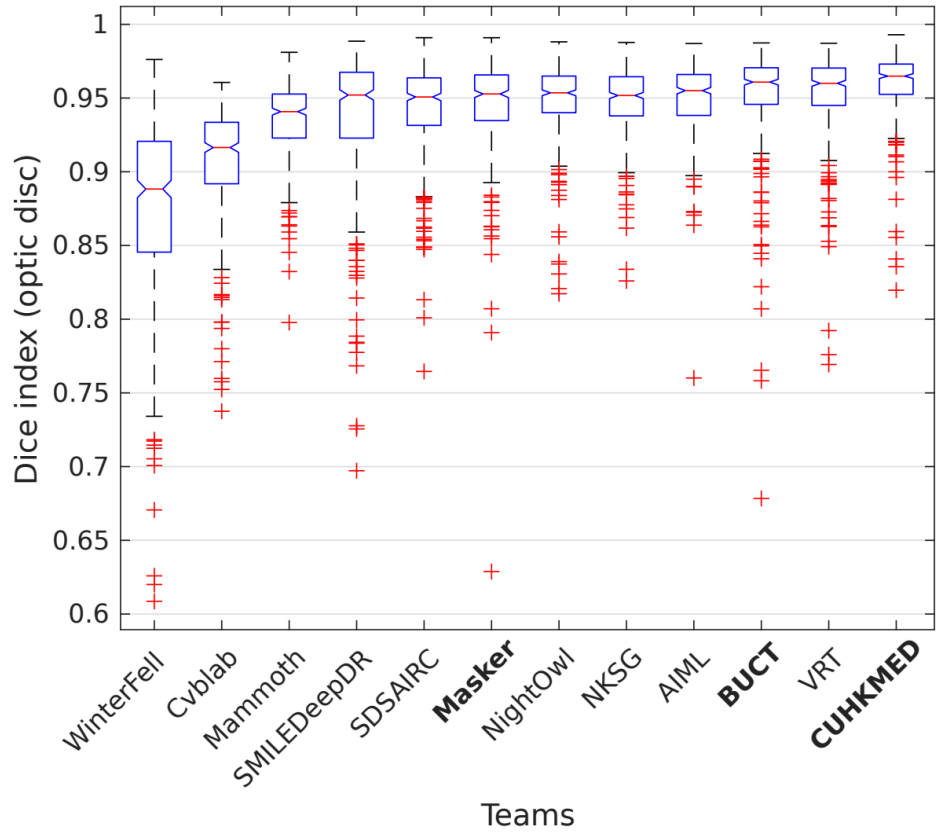
REFUGE Challenge: A unified framework for evaluating automated methods for glaucoma assessment from fundus photographs

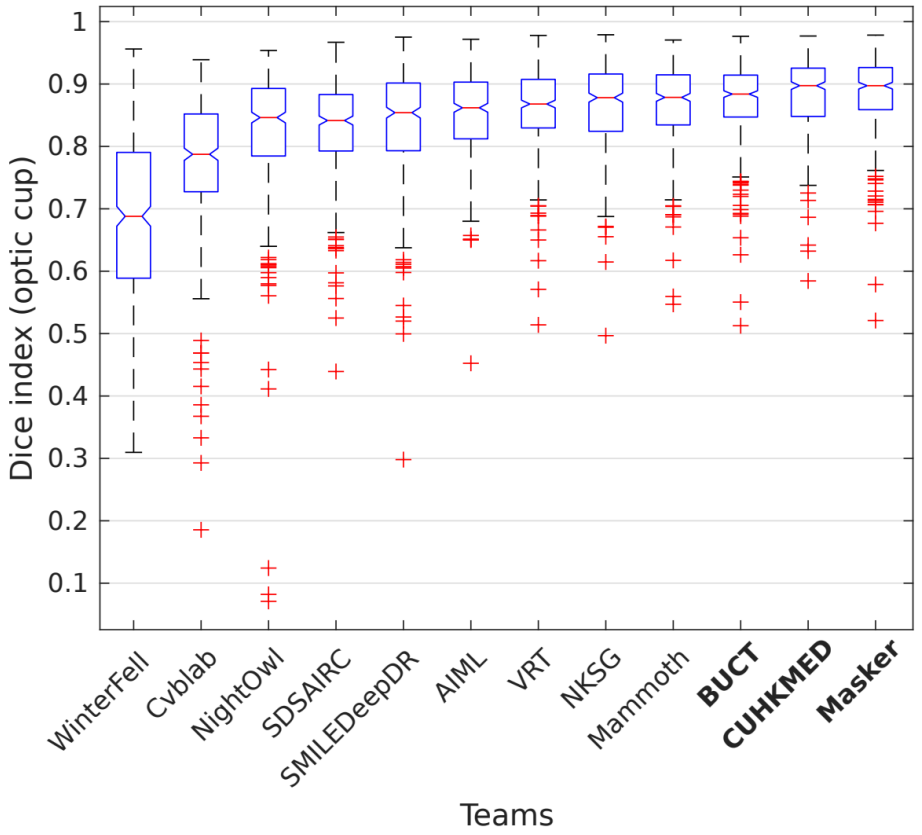
José Ignacio Orlando [a], Huazhu Fu [b], João Barbosa Breda [c, d], Karel van Keer [d], Deepti R. Bathula [e], Andrés Diaz-Pinto [f], Ruogu Fang [g], Pheng-Ann Heng [h], Jeyoung Kim [i], JoonHo Lee [j], Joonseok Lee [j], Xiaoxiao Li [k], Peng Liu [g], Shuai Lu [l], Balamurali Murugesan [m], Valery Naranjo [f], Sai Samarth R. Phaye [e], Sharath M. Shankaranarayana [n] ...
Hrvoje Bogunović [a]

⊞ Show more

https://doi.org/10.1016/j.media.2019.101570

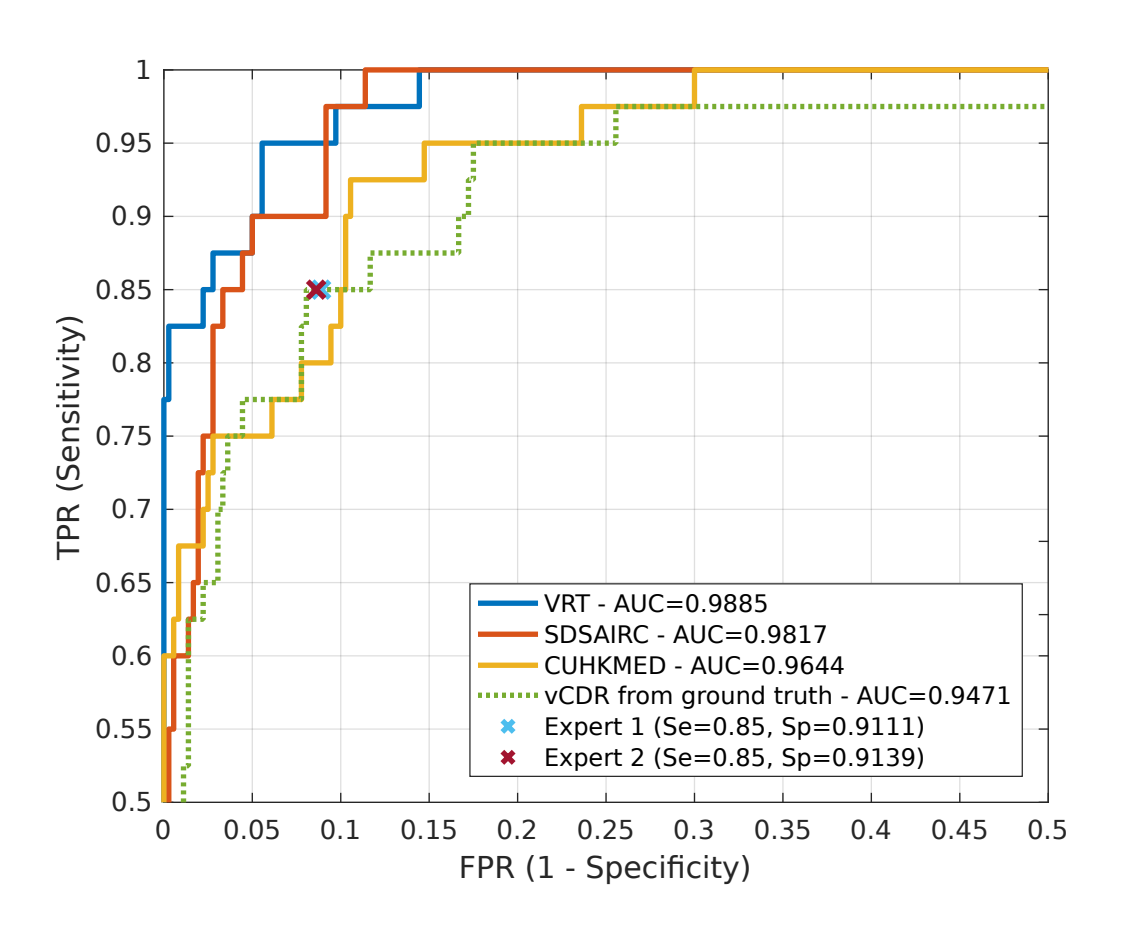
Optic disc/cup segmentation





Orlando et al., Medical Image Analysis, 2019

Glaucoma classification



Orlando et al., Medical Image Analysis, 2019

Still a long way to go to ensure that the problem is solved

Future initiatives must consider

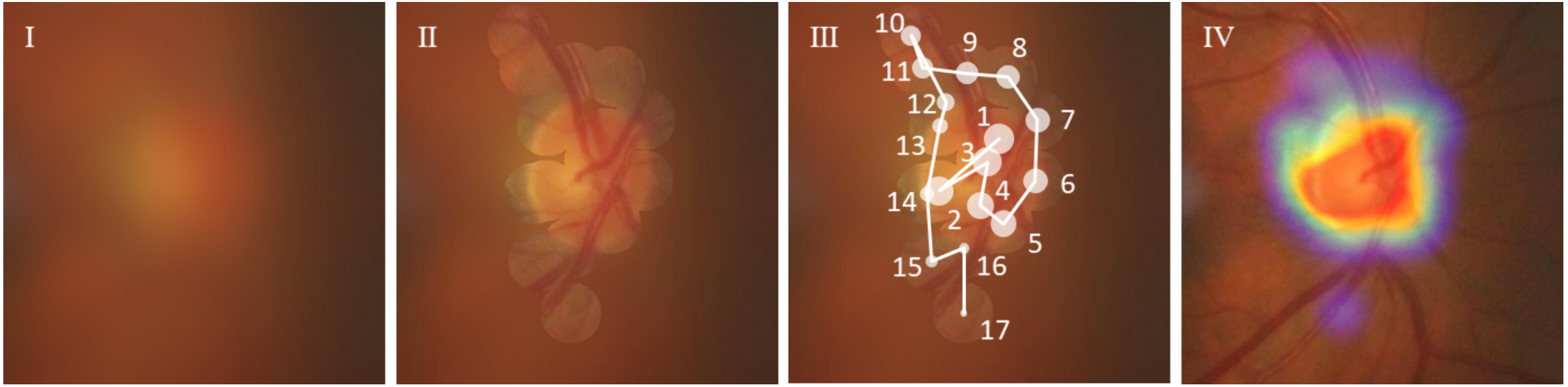
(I) Interpretability of the results → Class activation maps

Orlando et al., Medical Image Analysis, 2019

Interpretability of the results

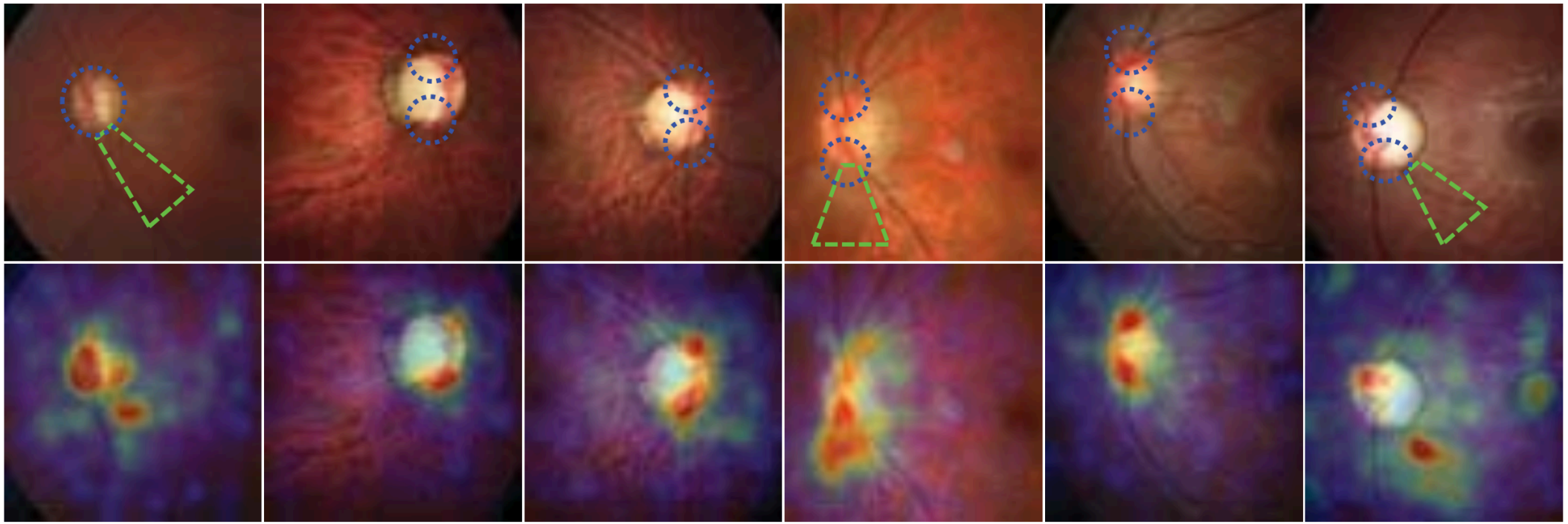
LAG database: 11.760 images + image level annotations + attention maps

(from "Attention Based Glaucoma Detection: A Large-Scale Database and CNN model")



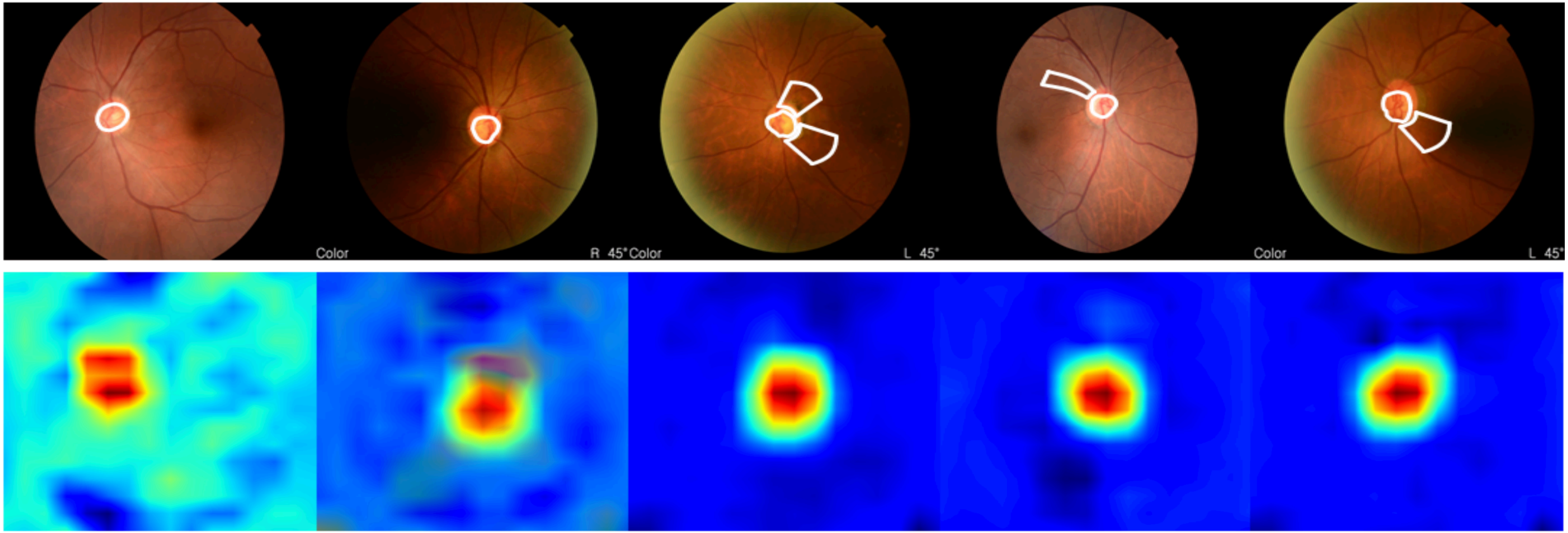
Li et al., CVPR, 2019

Interpretability of the results



Li et al., CVPR, 2019

Interpretability of the results



Jun et al., BMVC, 2018

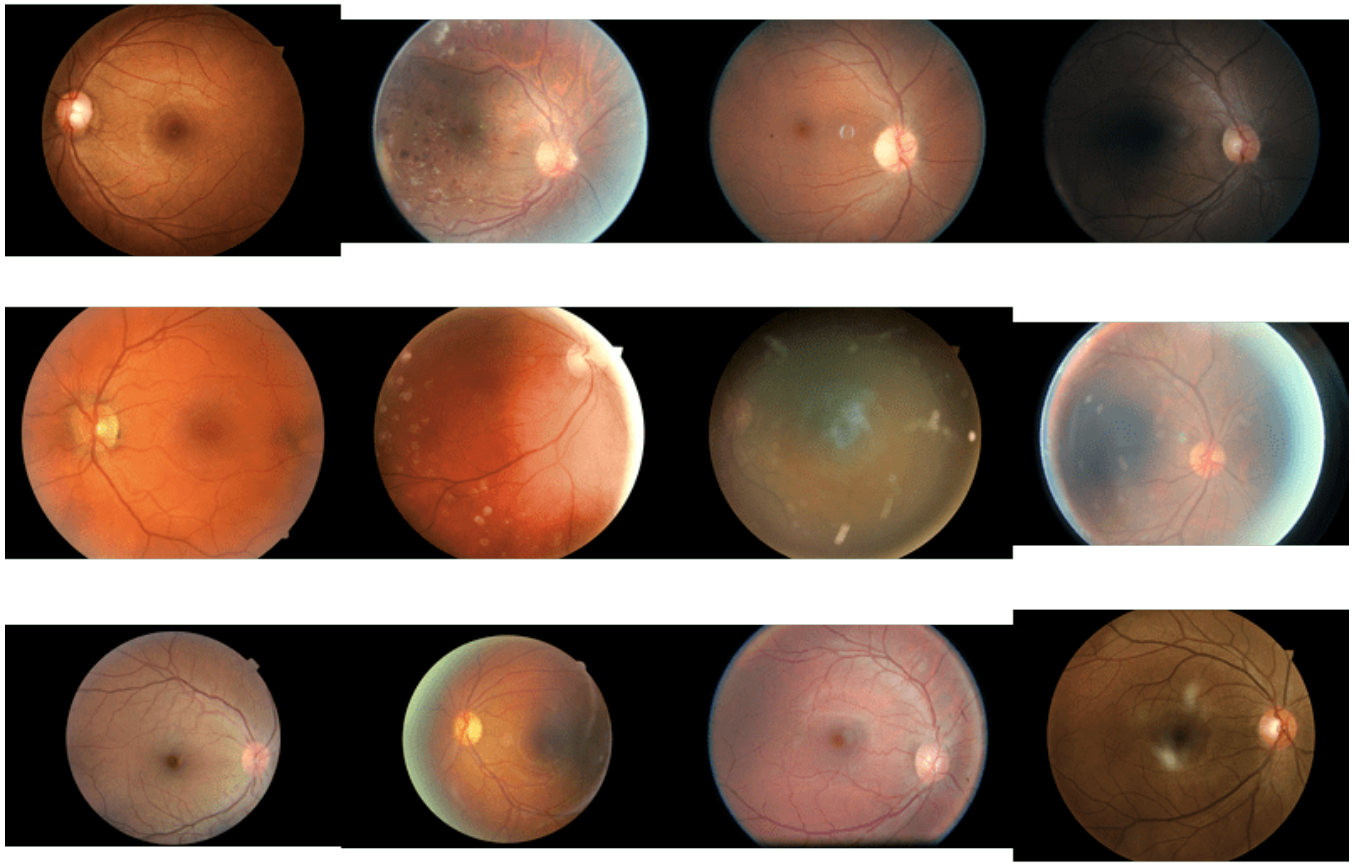
Future initiatives must consider

(I) Interpretability of the results → Class activation maps

(II) Larger / heterogeneous data sets (age, gender, ethnicities, acquisition quality, multiple devices, comorbidities, disease stages)

Orlando et al., Medical Image Analysis, 2019

Larger + more heterogeneous data sets



http://blog.kaggle.com/2015/08/10/detecting-diabetic-retinopathy-in-eye-images/

Future initiatives must consider

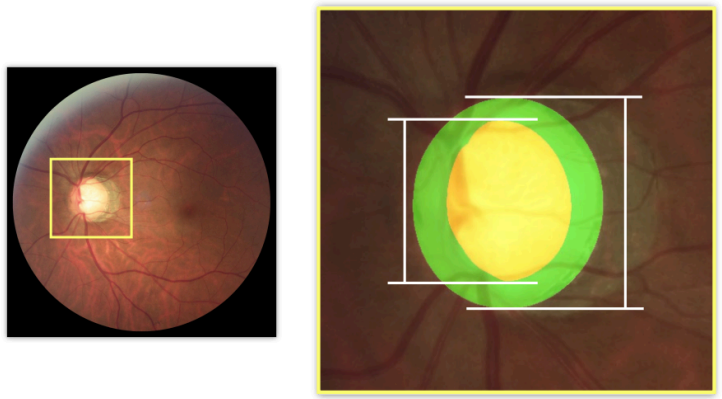
(I) Interpretability of the results → Class activation maps

(II) Larger / heterogeneous data sets (age, gender, ethnicities, acquisition quality, multiple devices, comorbidities, disease stages)

(III) Annotations for other relevant structures (OD hemorrhages, RNFL defects, PPA)

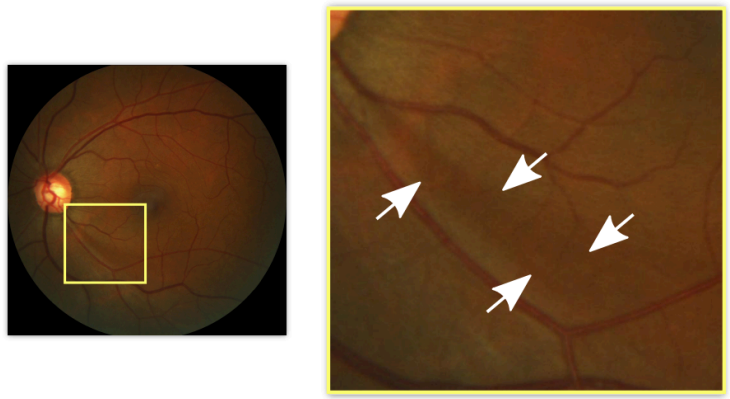
Orlando et al., Medical Image Analysis, 2019

Annotations for other clinical signs



(a) Cupping in the optic nerve head (ONH)

(b) Peripapillary hemorrhages



(c) Retinal nerve fiber layer (RNFL) defects

Lesions in images + Clinical parameters + Demographics + Why not clinical records?

Orlando et al., Medical Image Analysis, 2019

Conclusions

We need to go beyond just the optic disc

Target other features or even clinical parameters

AI is guided by data, so we need data!

Multicenter collaborations + Not just images

Advances in DR were boosted by open science

We need to (carefully, but still) release data and code!

Building a data set has to be the very first step

Invest time/money on preparing good data, then invest of developing the models!


That’s all!

REFUGE

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J. I. Orlando

H. Bogunović

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X. Zhang

F. Li

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Thanks for your attention!

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