Glaucoma Diagnosis

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OCTAGON

Optical Coherence Tomography & Artificial Intelligence for Glaucomatous Optic Neuropathy

SINGAPORE EYE RESEARCH INSTITUTE

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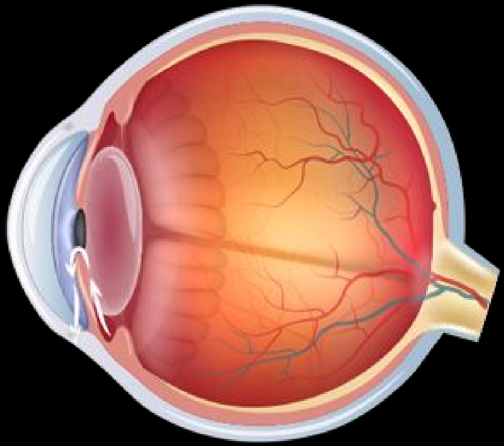
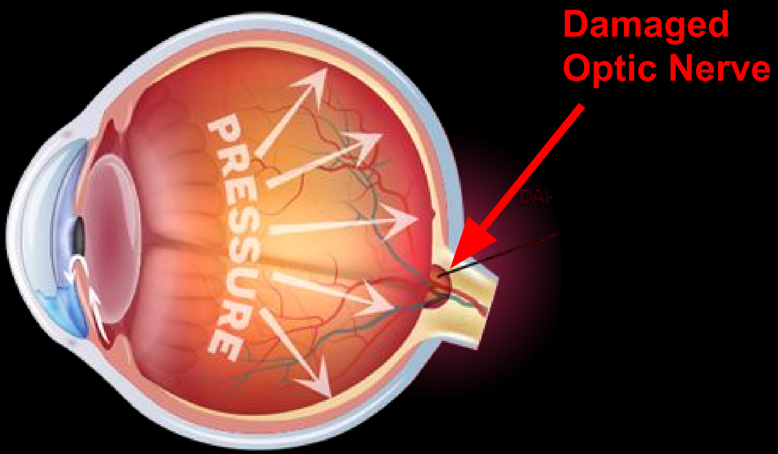
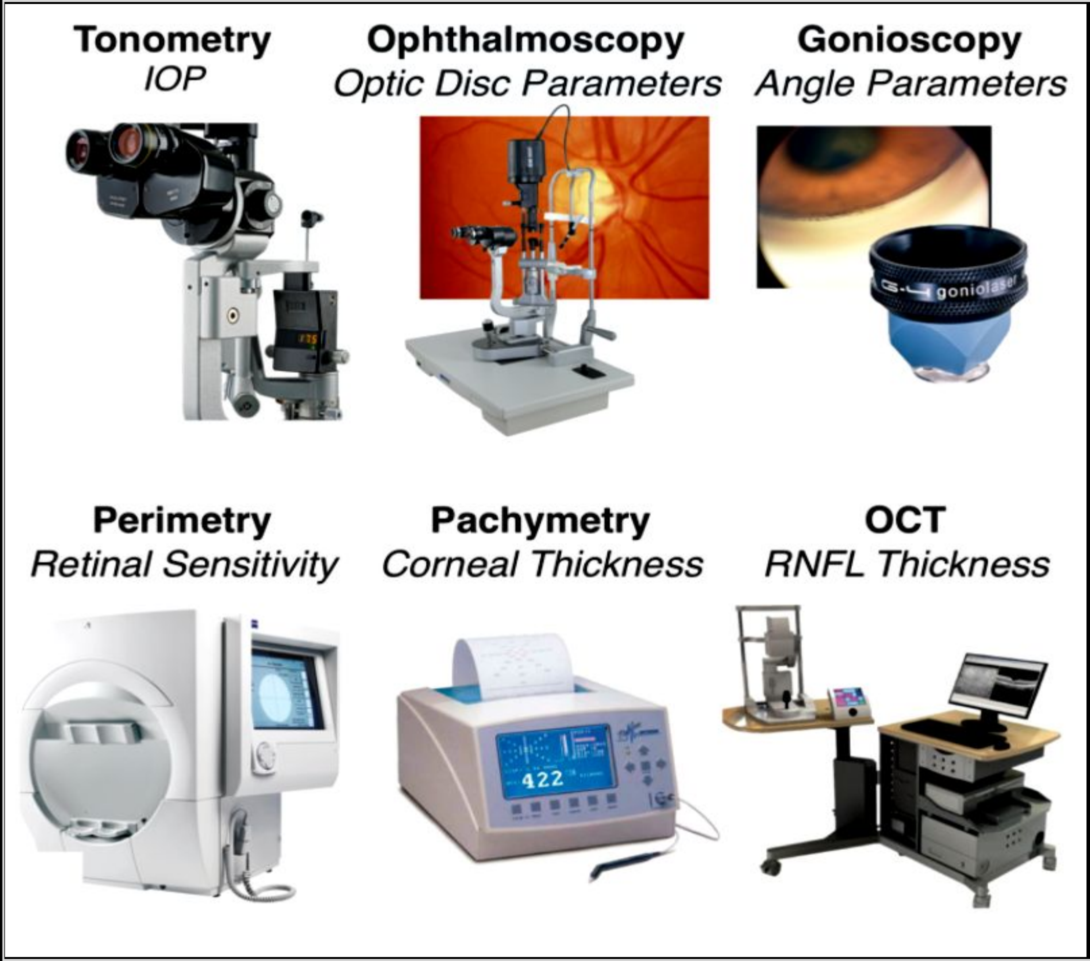
Normal eye



Glaucoma



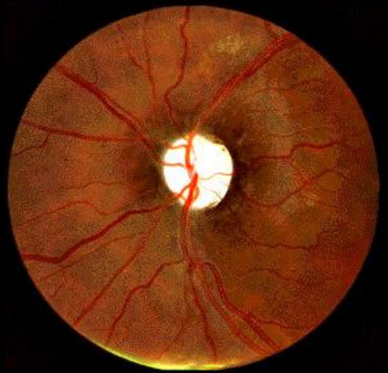
- Intraocular pressure (IOP) is the major risk factor for glaucoma
- … but glaucoma can also occur at normal levels of IOP (normal tension glaucoma)

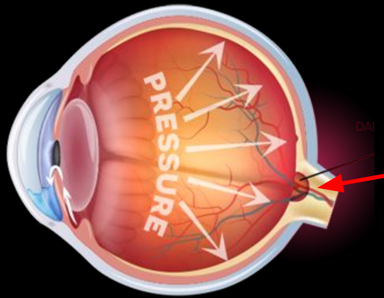


Current Glaucoma Diagnosis:

- Lengthy process
- Expensive
- Not automated + Subjective
- Not scalable

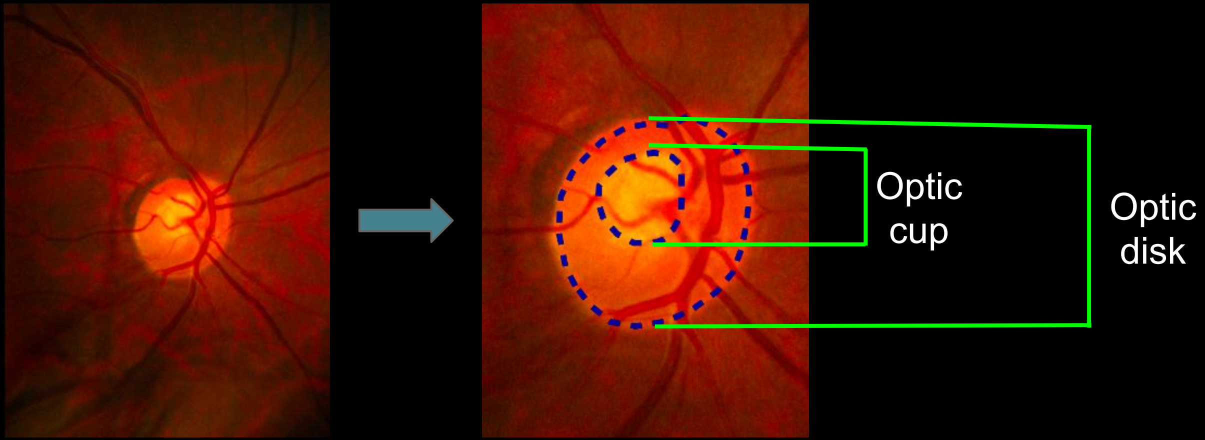
Fundus images are
easy and cheap to collect





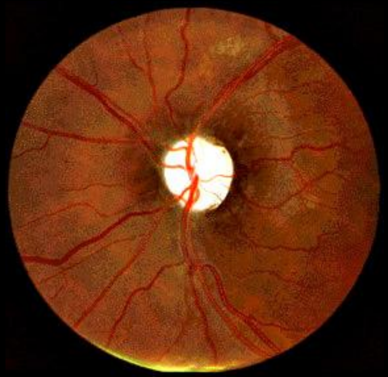
Damaged
Optic Nerve

Vertical Cup/Disk Ratio (VCDR)



- Vertical Cup/Disk Ratio: straightforward automated diagnosis
- **Very low diagnosis power** for glaucoma

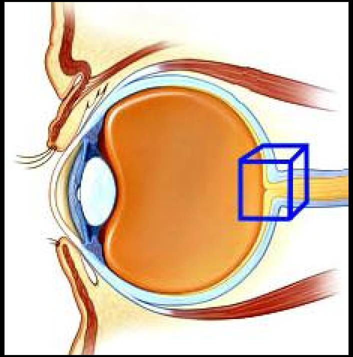
Deep Learning for Fundus Images Analysis



- Deep-Learning approaches: better than Vertical Cup/Disk Ratio
- … **but** fundus images are intrinsically of limited use: **low diagnosis power**
- … a robust glaucoma diagnosis needs to exploit 3D imaging modalities

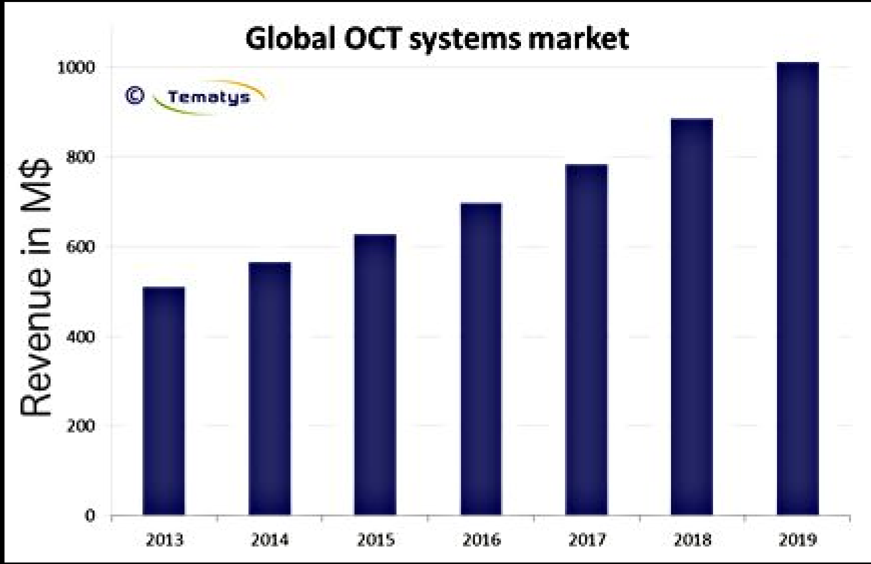
Optical Coherence Tomography (OCT)

Few seconds scan

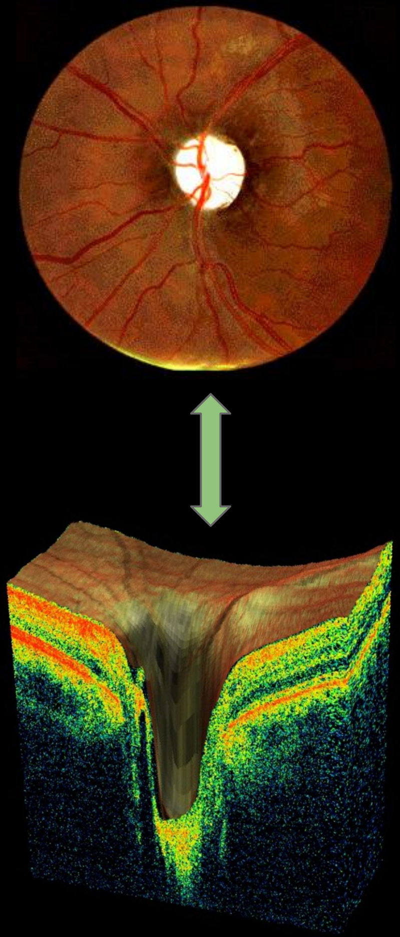


Imaging of the
Optic Nerve Head

Optical Coherence Tomography (OCT)

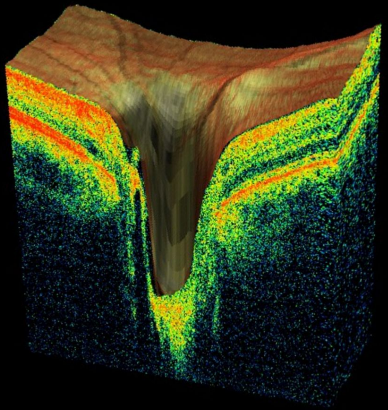


- Exponential growth of OCT market
- Democratization of the use of OCT

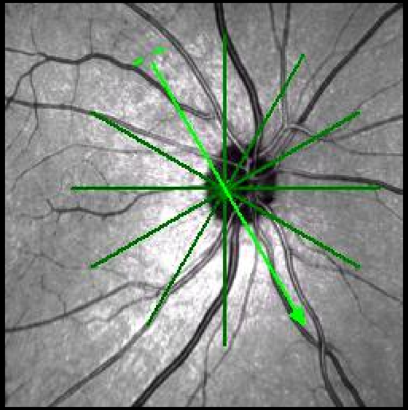


2D Fundus image

3D OCT volume

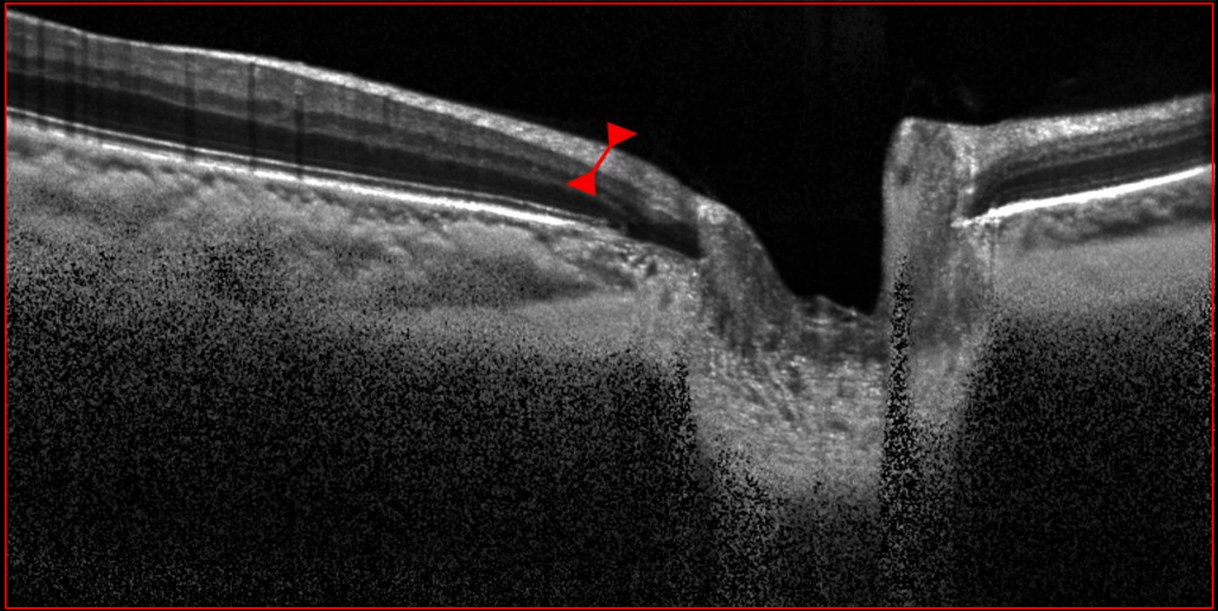


Full 3D volume



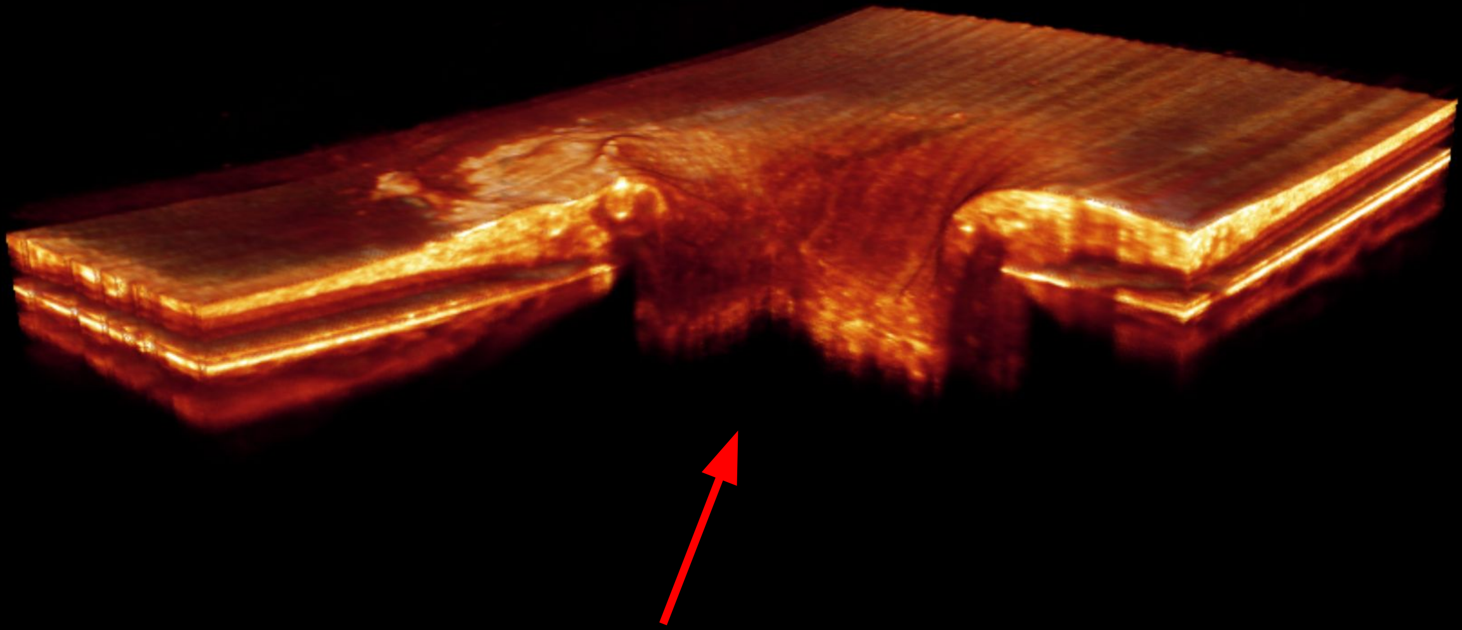
Diagonal Scans
(view from above)

1 slice



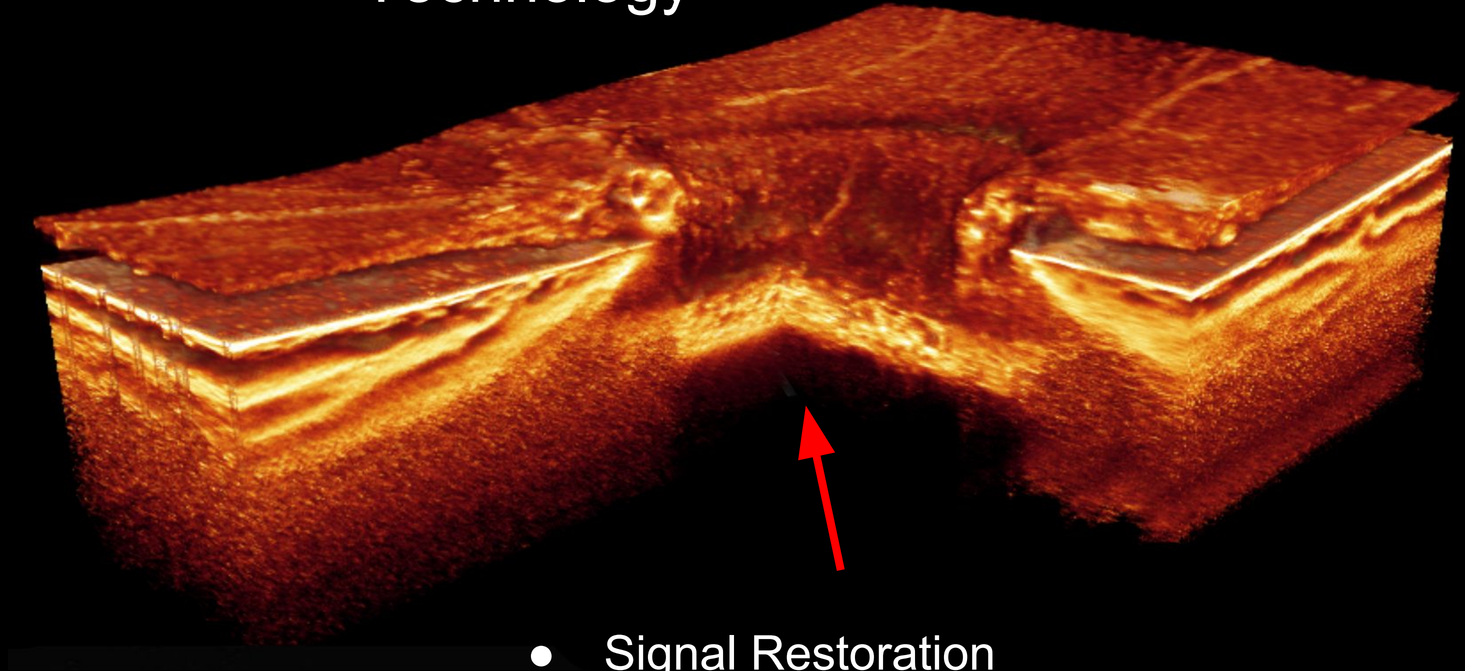
- Retinal Fiber Neural Layer (RNFL) Thickness: current gold standard
- Very limited information exploited
- Low predictive power

Standard OCT Technology



Low Visibility of Deep Tissues

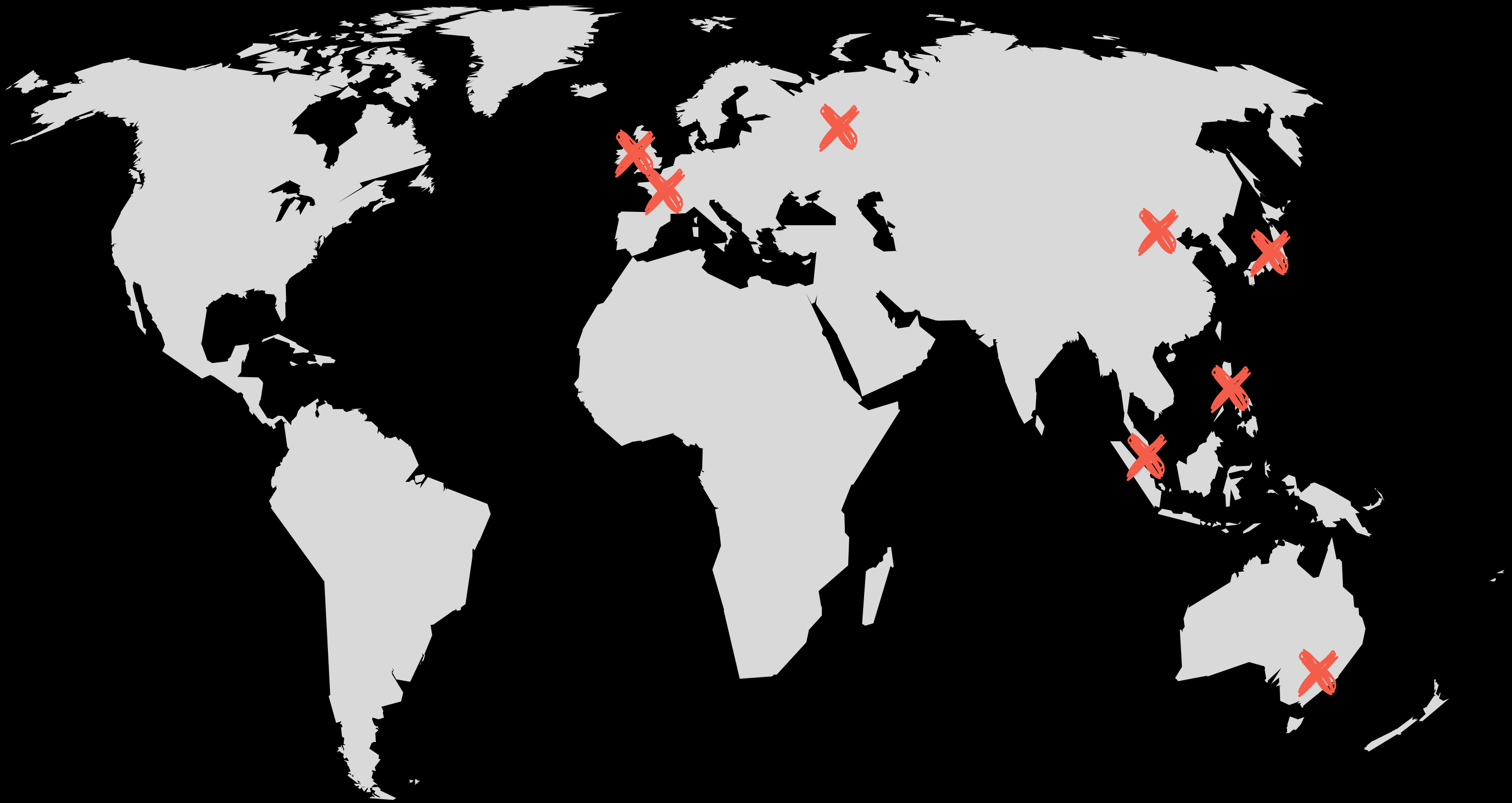
Compensation Technology



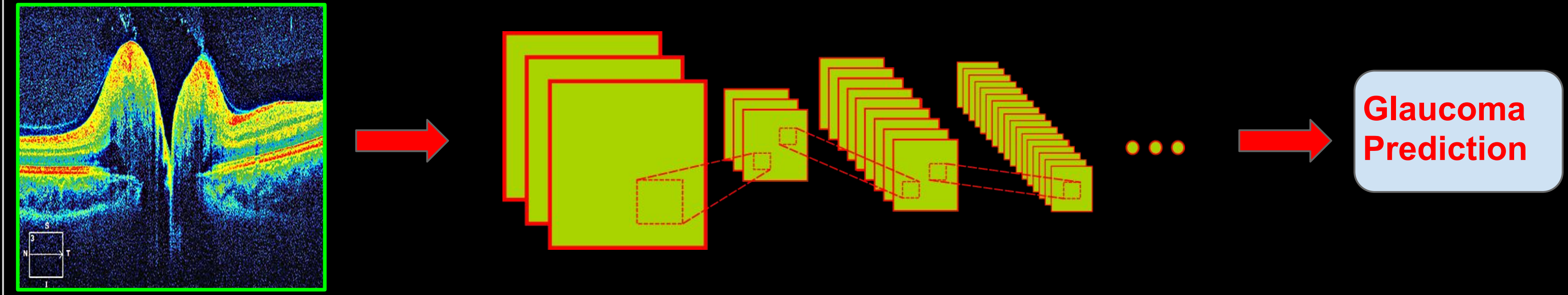
- Signal Restoration
- Based on physics of light propagation (no DL)

Deep Learning

Data Collection and Collaborators

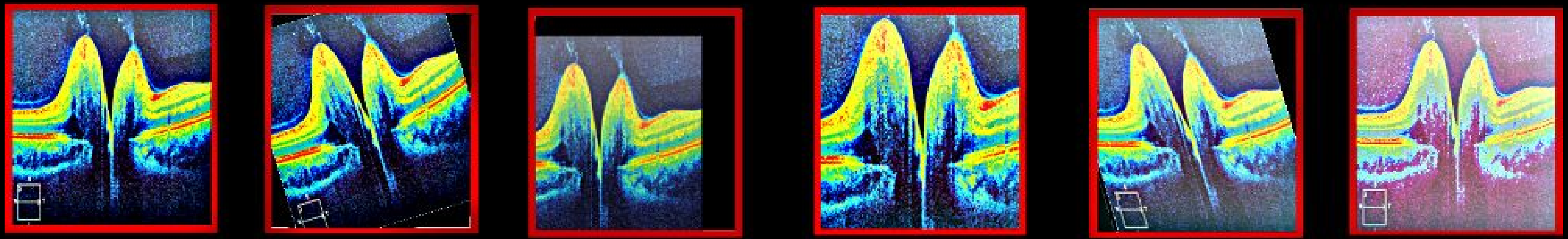


Standard Convolutional Network



- Only a few thousands training examples available
- Complex structure (more than MNIST!)
- CNN trained from scratch: very **poor generalization abilities**

Standard Data-Augmentation



Rotation

Translation

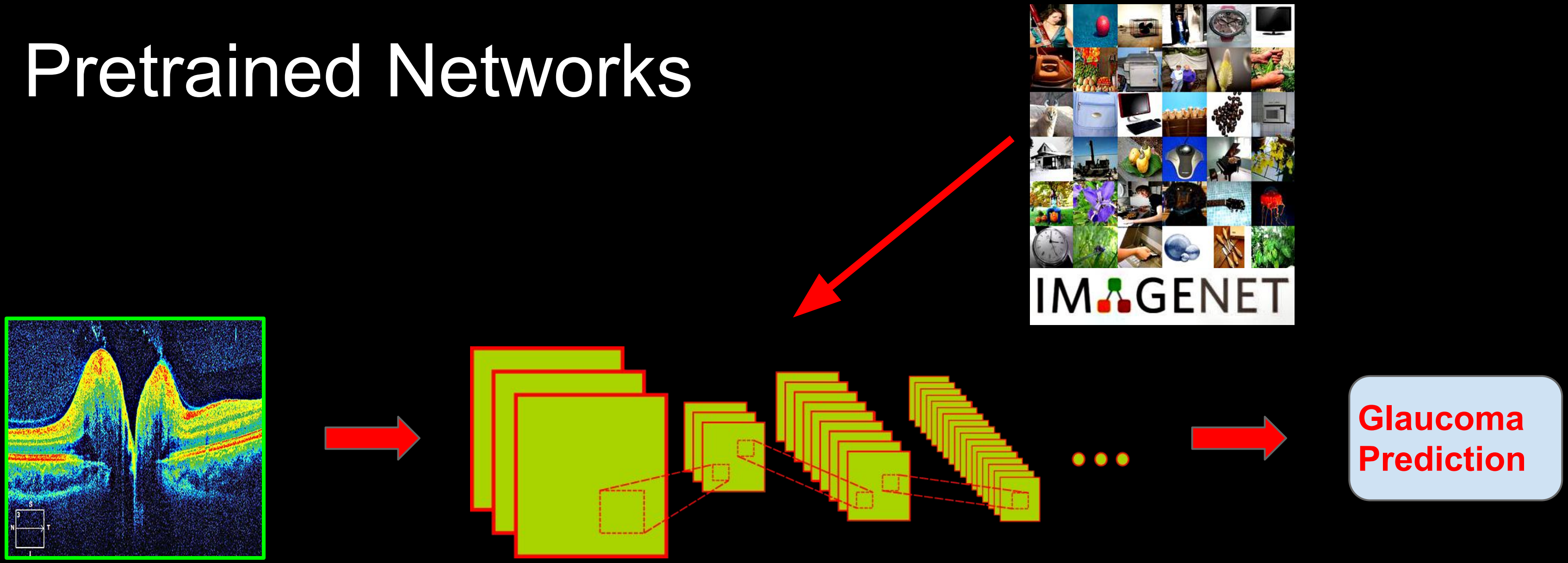
~~Zoom~~

~~Deformation~~

~~Pixel Intensity Change~~

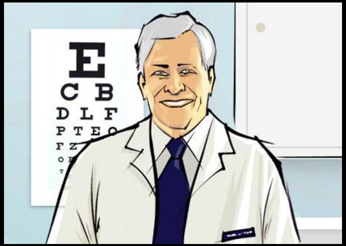
- Very low dimensional group of transformations available
- Limited gain in predictive power

Pretrained Networks

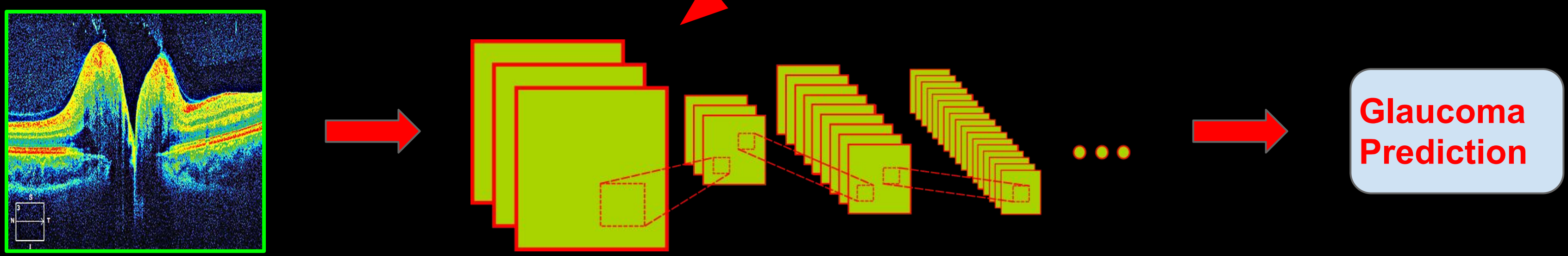


- Leverage networks trained on millions of images (eg. Imagenet)
- Very low level filters (e.g. edge detectors) are somehow useful
- ... but non-medical images are ultimately not very relevant for glaucoma diagnosis

Leveraging Prior Expert Knowledge is crucial

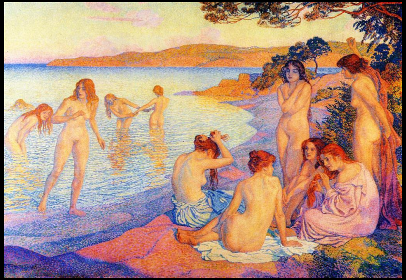


Incorporate
Human Expert
Knowledge
In the network



- Bayesian Regularization
- Helps mitigate overfitting
- Data efficiency: crucial in data-scarce settings






- How would you teach a 4th grader about art?
- Would you show him a few thousands paintings and let him figure it all out?

Deep Residual Unet (DRUnet)

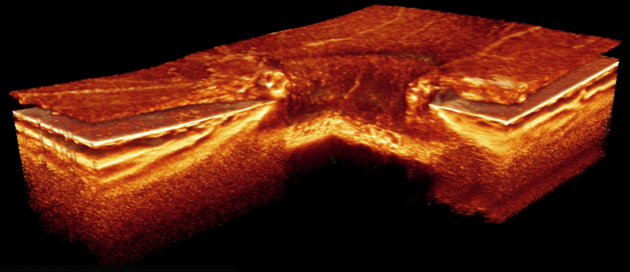
Recurrent DRUnet

Teach the network how to locate landmark points

Dimension Reduction: Variational Autoencoder

Conclusion:

- Deep-Learning in data-scarce (eg. medical) settings:
  - Many challenges and a few solutions
  - Incorporating prior expert knowledge is crucial
  - Intrinsic dimensionality is often not very high
  - Finding good representations is (as always) crucial
- What about Glaucoma diagnosis:
  - Current automated diagnosis have low predictive power
  - Deep Learning is a potential game-changer



Thanks!

Any questions?

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ABYSS PROCESSING