Glaucoma Diagnosis

NVIDIA AI CONFERENCE
SINGAPORE 23-24 OCTOBER 2017

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Optical Coherence Tomography & Artificial Intelligence for Glaucomatous Optic Neuropathy
In Singapore, 75% of glaucoma patients are unaware they have glaucoma.
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- 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
Low Visibility of Deep Tissues

Standard OCT Technology
Compensation Technology

- Signal Restoration
- Based on physics of light propagation (no DL)
Deep Learning
Data Collection and Collaborators
Glaucoma Prediction

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

Standard Convolutional Network
Standard Data-Augmentation

- Very low dimensional group of transformations available
- Limited gain in predictive power
Leverage networks trained on millions of images (e.g. 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

- 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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