

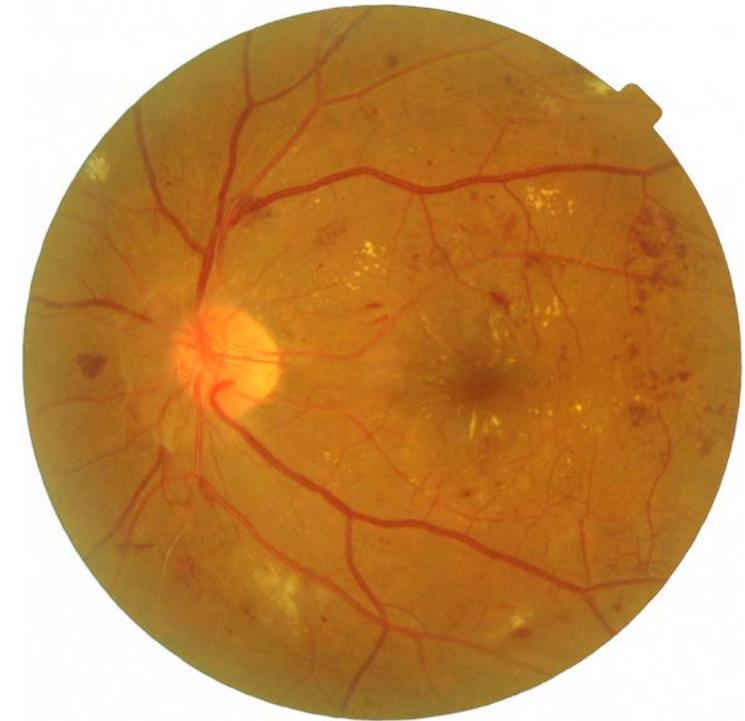
Artificial Intelligence for Diabetic Retinopathy Screening

A collaboration between:

- Polytechnique Montréal (**LIV4D**)
- Quebec Artificial Intelligence Institute (**Mila**)
- Maisonneuve-Rosemont Hospital (**HMR**)
- Retinal specialists:
 - Dr. Marie Carole BOUCHER MD FRCSC
 - Dr. Renaud DUVAL MD FRCSC
 - Dr. Michael H Brent MD FRCSC

Diabetic Retinopathy in (very) brief

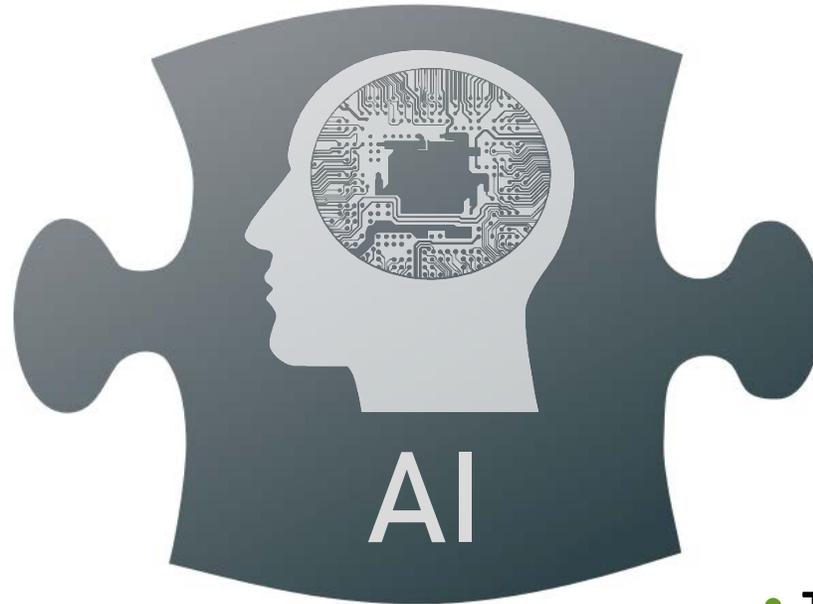
- Complication of **diabetes** (Type 1 or 2):
 - Causes damage to small blood vessels and neurons in the retina.
 - **3 million** Canadians living with diabetes:
 - Over **25%** suffer from Diabetic Retinopathy (DR).
 - Third-leading cause of **blindness** in Canada:
 - **First** leading cause in working-age adults.
- ⇒ **Early clinical intervention** (i.e. laser treatment) can reduce severe visual loss by 90%.



Fundus (retinal) image of an advanced case of diabetic retinopathy



Enabling DR early screening through AI



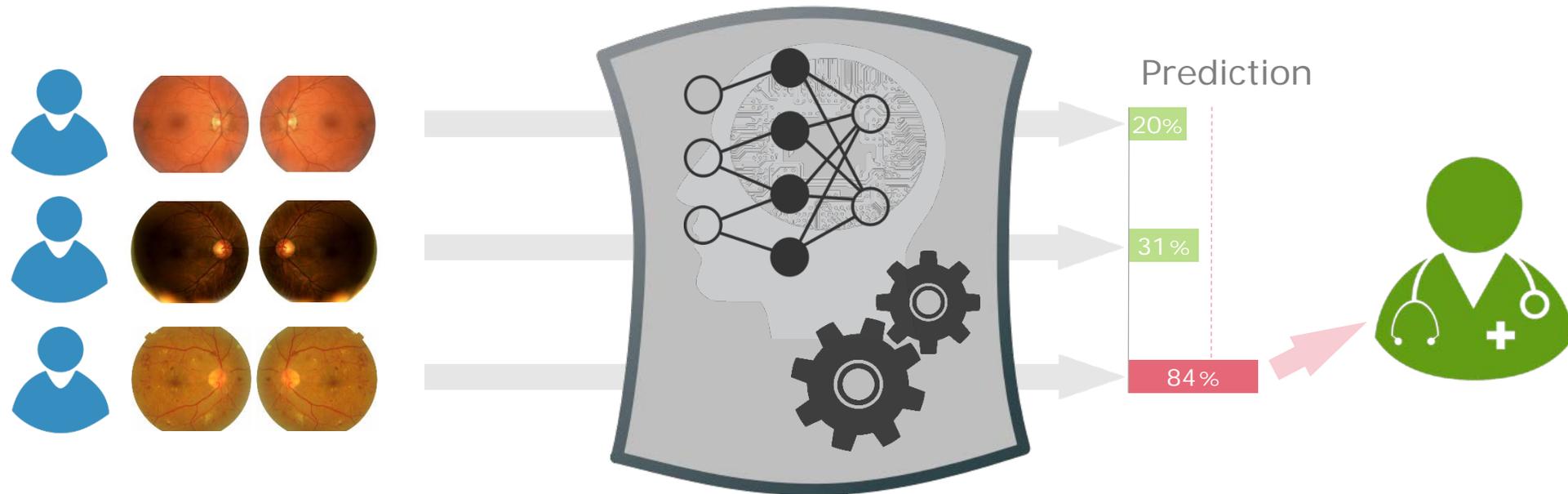
- **Up to 40% of Canadians with diabetes are not screened for DR.**
- The number of diabetic cases is continually increasing.

- **Telemedicine Networks** are emerging as a promising solution...
- ... but their capacity is limited by the number of trained readers.

⇒ **Artificial Intelligence (AI)** can facilitate early screening of DR cases and facilitate access to retinal specialists to patients who need care.



Enabling DR early screening through AI



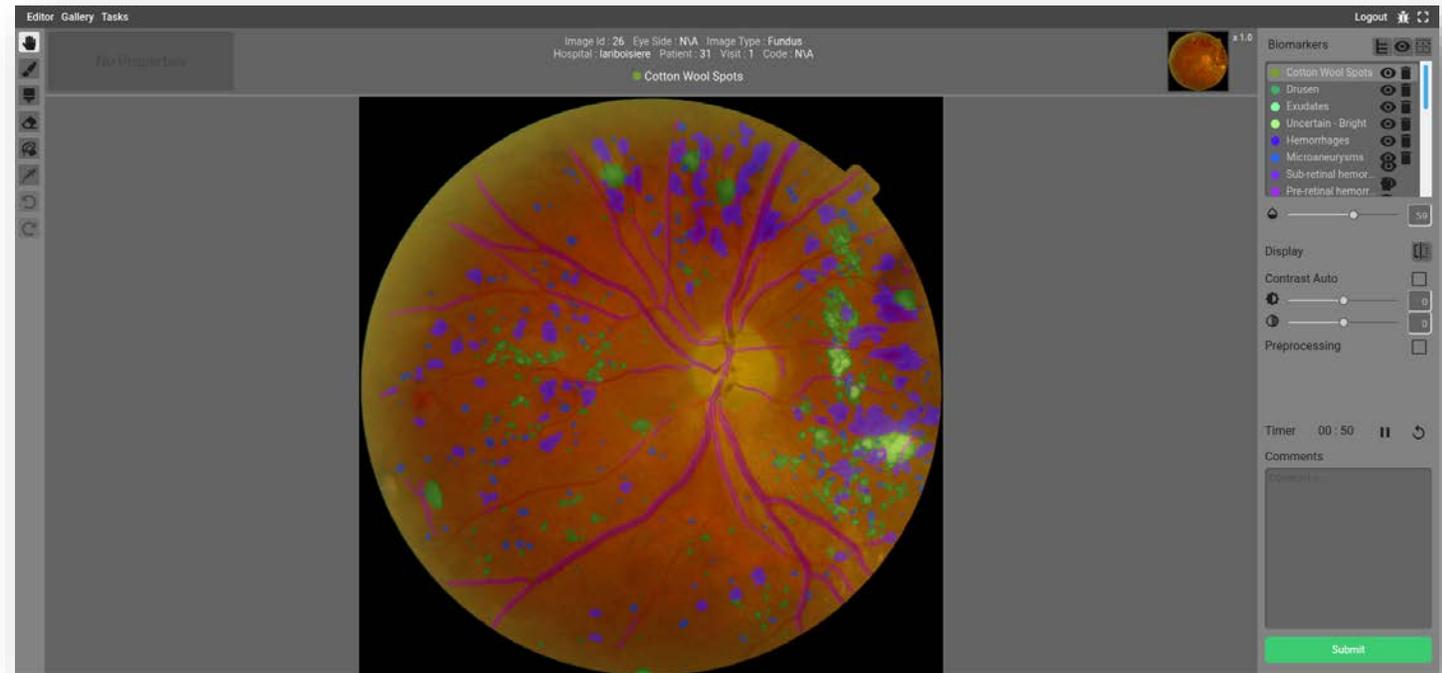
- ⇒ **Our goal:** investigate deep-learning based solutions to facilitate screening of early DR onset and increase the capacity of telemedicine programs.
- ⇒ **In practice:** overcome ⚠ **technical challenges** preventing state of the art screening models from being successfully applied in this context.



Building a Canadian dataset of annotated fundus images

⚠ No public Canadian DR dataset exists yet to train and validate a screening algorithm.

- **Online platform developed to collect and annotate retinal images:**
 - Web-based application
 - Retinal images anonymized and stored securely on an institutional server
 - Labelling of biomarkers & disease grading.
- **Building a Canadian dataset of fully-annotated fundus images:**
 - 8 retinal specialists involved so far in annotating fundus images
 - DR and Macular Edema graded according to Canadian ophthalmological guidelines
 - 12 anatomical markers manually labelled.

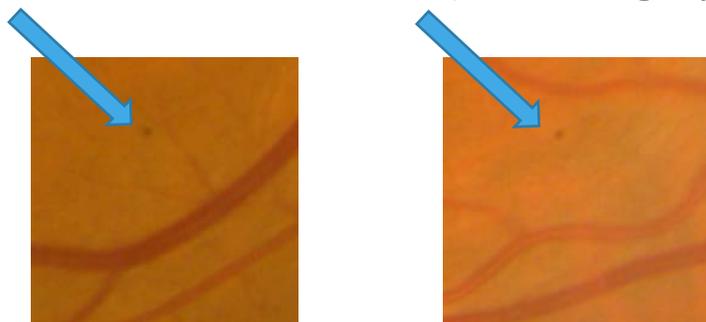


Web-based retinal image annotation platform



Inter-annotator variability study

- **200 images were independently graded by three retinal specialists:**
 - When possible, a gold standard was obtained by majority voting.
 - If not, the experts had to reach consensus through discussion.
- Planned release of this fully annotated dataset for public research.
- **Analysis :**
 - ***central source of disagreement***: the presence of artefacts (e.g. dust specks on the camera lens) showing up in the images.



Same artefact in two images that could be misclassified as a microaneurysm

Inter-annotator agreement (Accuracy) on DR

	g1	g2	g3	algo	gt
g1		0.84	0.81	0.86	0.95
g2			0.75	0.82	0.88
g3				0.77	0.86
algo					0.86
gt					

Inter-annotator agreement (Accuracy) on ME

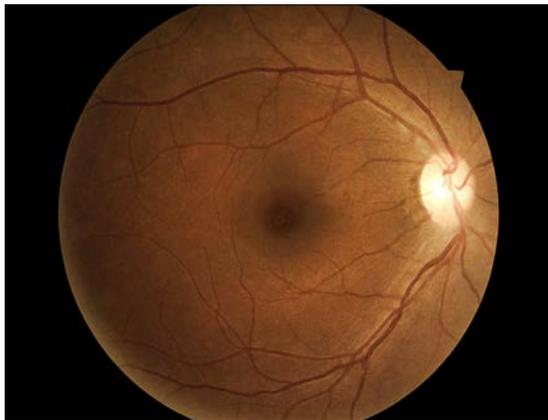
	g1	g2	g3	algo	gt
g1		0.71	0.7	0.64	0.83
g2			0.72	0.6	0.84
g3				0.64	0.86
algo					0.64
gt					



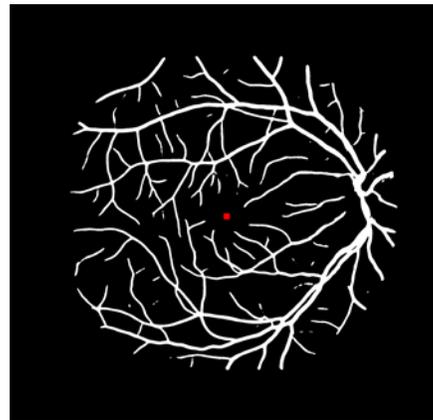
Quality assessment for fundus images

⚠ In real medical situations, algorithms must deal with poor quality images.

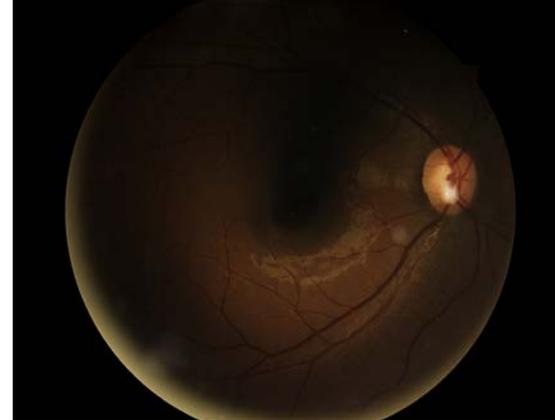
- We designed a model to **evaluate the quality of a fundus image**. This model achieved 97% accuracy on a test set of 88 fundus images.
- The quality score is inspired by the Scottish Diabetic Retinopathy Grading System.
- A screening algorithm obtains a kappa of 0.781 on poor images and 0.806 on good images. This shows the importance of evaluating image quality to improve the reliability of screening models.



Good quality image



Score : 2900



Poor quality image

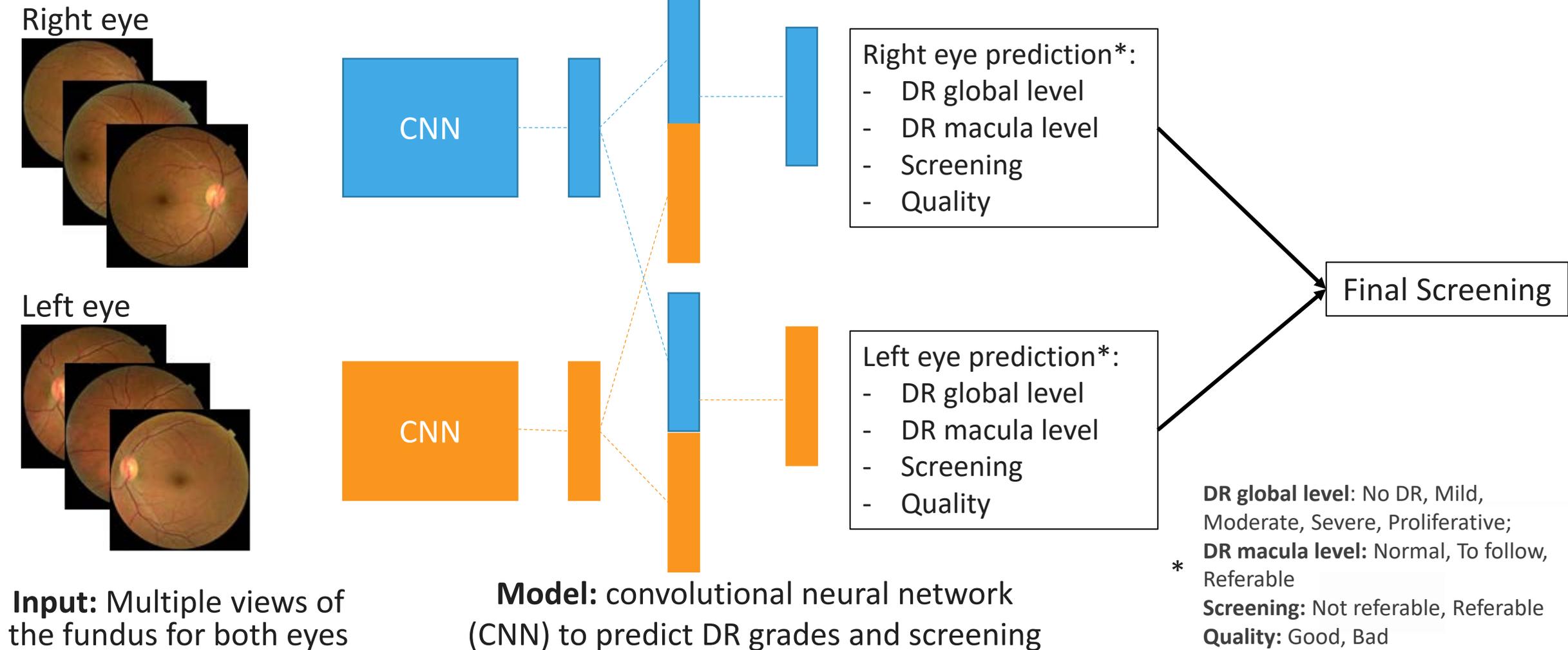


Score : 924



Taking advantage of multiview input data

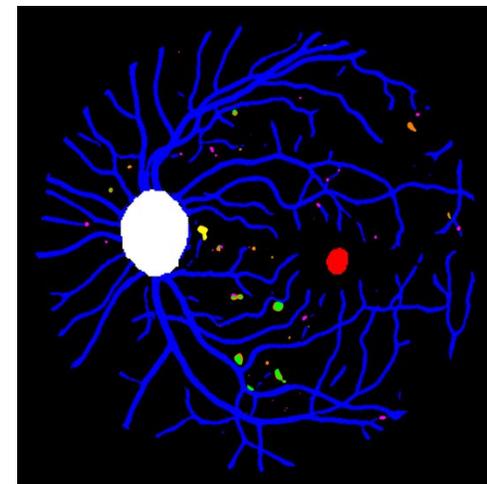
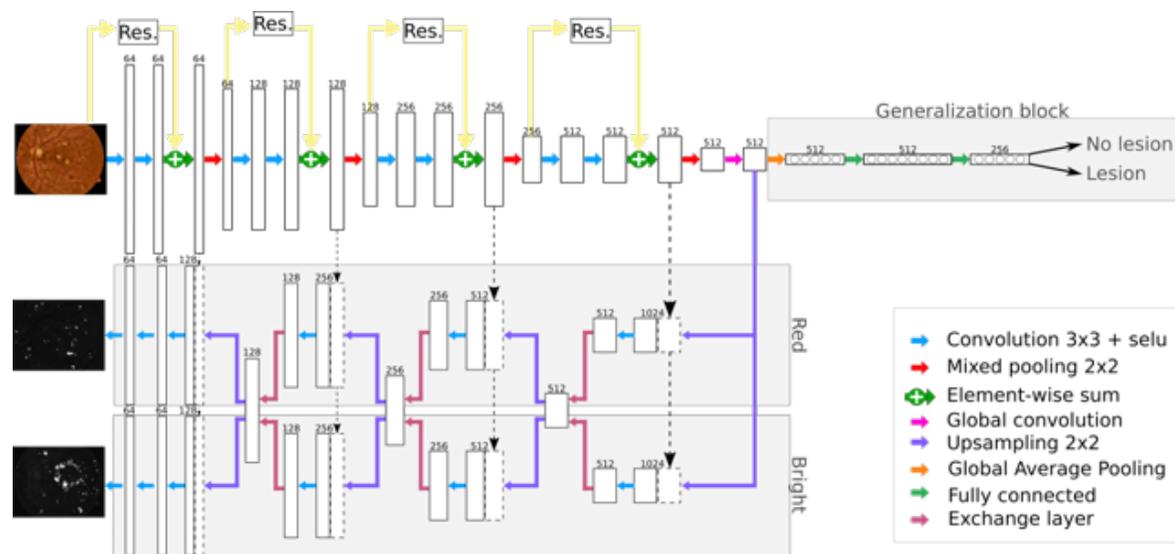
⚠ State of the art DR diagnostic models don't capitalize on multiple views.



Lesion segmentation

⚠ State of the art DR diagnostic models don't provide interpretable diagnoses.

- Neural networks can also be used for **segmentation** (recognizing elements in an image).
- The architecture below identifies many retinal structures.
- This is an important step toward **explainable AI**.



To summarize...

- **State of the art DR screening algorithms underperform on Canadian datasets:**
 - Rules for DR grading and image quality rating vary between specialists and medical centers.
 - Public datasets are not always reliable and have license restrictions limiting their usage.
 - Generalization of learned models to new datasets is not a simple problem.
 - **We are exploring technical solutions to overcome these challenges:**
 - Building our own training and testing datasets, analysing data bias.
 - Enhancing algorithm reliability by using quality scores and multi-view prediction.
 - Investigating interpretable models and explainable AI.
- ⇒ **Collaboration between AI researchers and retinal specialists is essential to identify, understand and overcome these challenges!**



Acknowledgments

Thank you for your interest!

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