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%.
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.
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

- 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.

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

![Web-based retinal image annotation platform](image-url)
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
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.

Taking advantage of multiview input data

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

Input: Multiple views of the fundus for both eyes

Model: convolutional neural network (CNN) to predict DR grades and screening

Right eye prediction*:
- DR global level
- DR macula level
- Screening
- Quality

Left eye prediction*:
- DR global level
- DR macula level
- Screening
- Quality

Final Screening

DR global level: No DR, Mild, Moderate, Severe, Proliferative;
DR macula level: Normal, To follow, Referable
Screening: Not referable, Referable
Quality: Good, Bad
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!

This work was financed by the following institutions:

- Diabetes Action Canada
- IRSC CIHR
- Université de Montréal