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1st Canada-Italy Business Forum on AI

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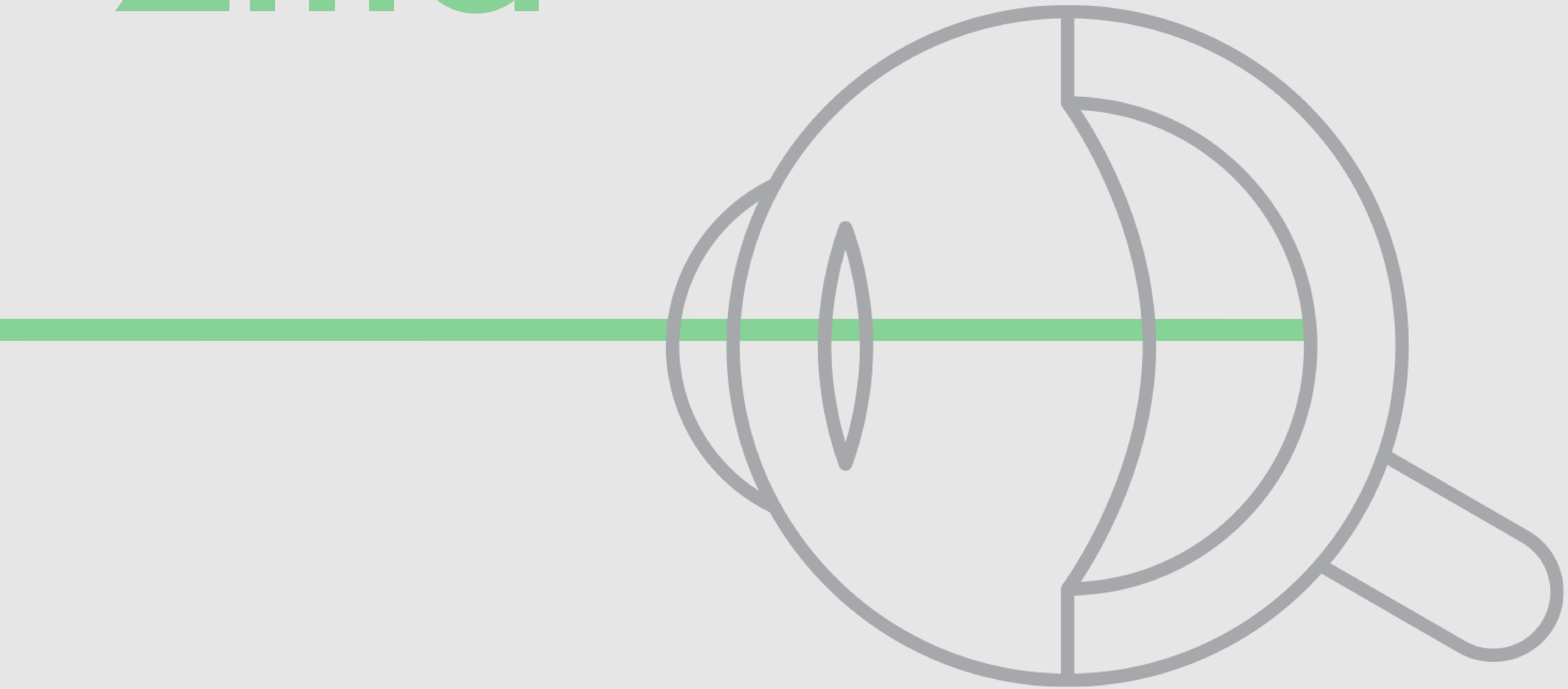
insight
through
light

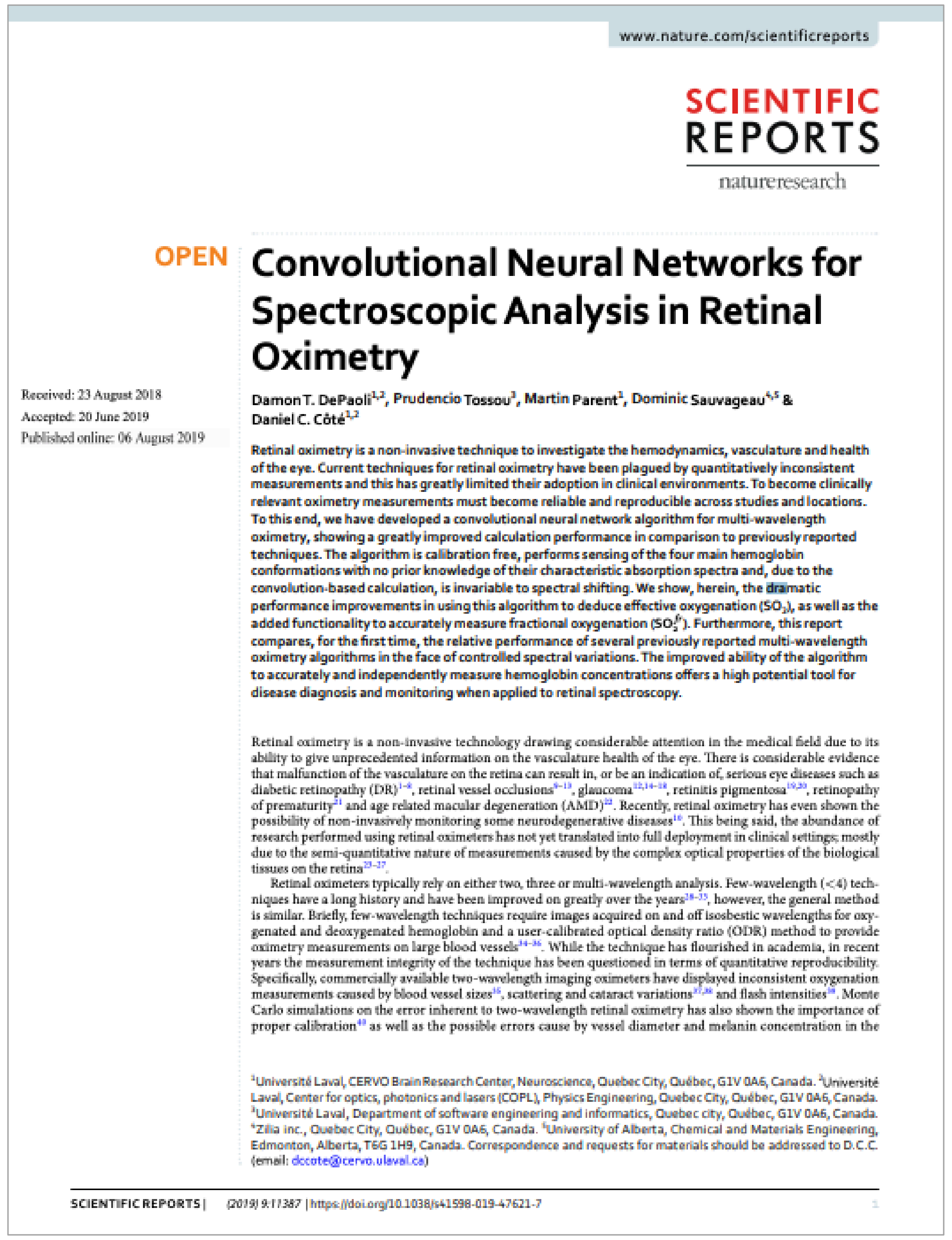


Challenge

Obtain accurate, reliable and reproducible measurements

New AI-based Approach

- Convolutional Neural Networks
- Full Spectrum Analysis
- Dramatic Performance Improvements



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Convolutional Neural Networks for Spectroscopic Analysis in Retinal Oximetry

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Retinal oximetry is a non-invasive technique to investigate the hemodynamics, vasculature and health of the eye. Current techniques for retinal oximetry have been plagued by quantitatively inconsistent measurements and this has greatly limited their adoption in clinical environments. To become clinically relevant oximetry measurements must become reliable and reproducible across studies and locations. To this end, we have developed a convolutional neural network algorithm for multi-wavelength oximetry, showing a greatly improved calculation performance in comparison to previously reported techniques. The algorithm is calibration free, performs sensing of the four main hemoglobin conformations with no prior knowledge of their characteristic absorption spectra and, due to the convolution-based calculation, is invariable to spectral shifting. We show, herein, the dramatic performance improvements in using this algorithm to deduce effective oxygenation (SO_2), as well as the added functionality to accurately measure fractional oxygenation (SO_2^{fr}). Furthermore, this report compares, for the first time, the relative performance of several previously reported multi-wavelength oximetry algorithms in the face of controlled spectral variations. The improved ability of the algorithm to accurately and independently measure hemoglobin concentrations offers a high potential tool for disease diagnosis and monitoring when applied to retinal spectroscopy.

Retinal oximetry is a non-invasive technology drawing considerable attention in the medical field due to its ability to give unprecedented information on the vasculature health of the eye. There is considerable evidence that malfunction of the vasculature on the retina can result in, or be an indication of, serious eye diseases such as diabetic retinopathy (DR)[1–8], retinal vessel occlusions[9–13], glaucoma[12,14–18], retinitis pigmentosa[19,20], retinopathy of prematurity[21] and age related macular degeneration (AMD)[22]. Recently, retinal oximetry has even shown the possibility of non-invasively monitoring some neurodegenerative diseases[16]. This being said, the abundance of research performed using retinal oximeters has not yet translated into full deployment in clinical settings; mostly due to the semi-quantitative nature of measurements caused by the complex optical properties of the biological tissues on the retina[23–27].

Retinal oximeters typically rely on either two, three or multi-wavelength analysis. Few-wavelength (<4) techniques have a long history and have been improved on greatly over the years[28–33], however, the general method is similar. Briefly, few-wavelength techniques require images acquired on and off isosbestic wavelengths for oxygenated and deoxygenated hemoglobin and a user-calibrated optical density ratio (ODR) method to provide oximetry measurements on large blood vessels[34–36]. While the technique has flourished in academia, in recent years the measurement integrity of the technique has been questioned in terms of quantitative reproducibility. Specifically, commercially available two-wavelength imaging oximeters have displayed inconsistent oxygenation measurements caused by blood vessel sizes[15], scattering and cataract variations[37,38] and flash intensities[39]. Monte Carlo simulations on the error inherent to two-wavelength retinal oximetry has also shown the importance of proper calibration[40] as well as the possible errors cause by vessel diameter and melanin concentration in the

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