Machine Learning Engineer Nanodegree

Retinal OCT Images (Optical Coherence Tomography) - Capstone Proposal

Gilles SING-CHEONG
May, 2019

Proposal

Domain Background

Retinal optical coherence tomography (OCT) is an imaging technique used to capture high-resolution cross sections of the retinas of living patients. OCT has revolutionized the diagnosis and management of common eye diseases such as glaucoma, macular degeneration, and diabetic retinopathy, as well as many other diseases of the retina, optic nerve, and anterior segment of the eye.

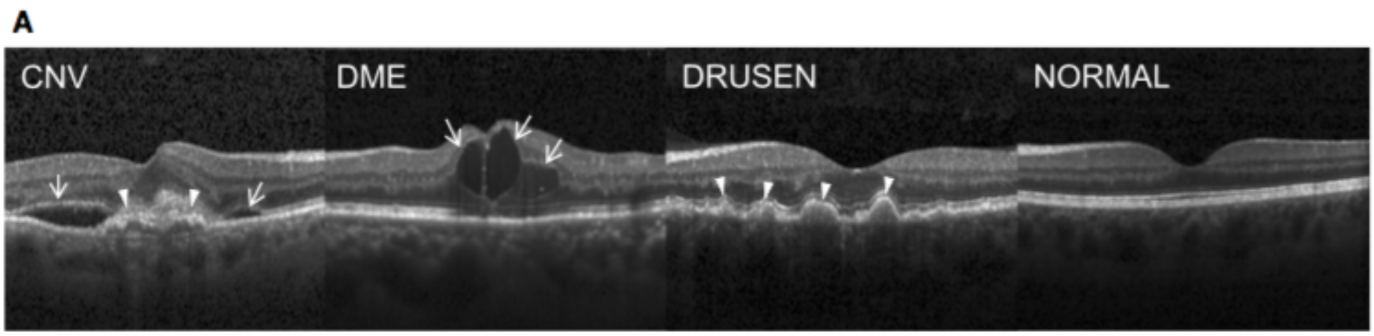
The technology was developed by James Fujimoto's laboratory at MIT in 1991. The first time a patient was imaged with OCT outside of the laboratory took place at NEEC at Tufts Medical Center in 1994. By 1996, the first commercially available device was developed by Carl Zeiss Meditec, Inc. Now a day, approximately 30 million OCT scans are performed each year, and the analysis and interpretation of these images takes up a significant amount of time (Swanson and Fujimoto, 2017).

Due to this amount of images, the risk of doing a wrong analysis or misenterpretation by an ophtalmologist is present, even if odds should be low. As a support for doctors, automatic diseases classification using Machine Learning (ML) technics are applied to healthcare domain. This is a growing area of research, since few years.

The main goal of this capstone project is to classify automaticaly 3 type of ocular diseases and healthy ocular from OCT images by using ML technics :

- Choroidal neovascularization (CNV) : Choroidal neovascularization is the creation of new blood vessels in the choroid layer of the eye. Choroidal neovascularization is a common cause of neovascular degenerative maculopathy (i.e. 'wet' macular degeneration)[1] commonly exacerbated by extreme myopia, malignant myopic degeneration, or age-related developments.

- Diabetic Macular Edema (DME) : DME is a complication of diabetes caused by fluid accumulation in the macula that can affect the fovea. The macula is the central portion in the retina which is in the back of the eye and where vision is the sharpest. Vision loss from DME can progress over a period of months and make it impossible to focus clearly.
- Drusen : Drusen are yellow deposits under the retina. Drusen are made up of lipids, a fatty protein. Drusen likely do not cause age-related macular degeneration (AMD). But having drusen increases a person's risk of developing AMD. Drusen are made up of protein and calcium salts and generally appear in both eyes.
- Normal : Normal vision occurs when light is focused directly on the retina rather than in front or behind it. A person with normal vision can see objects clearly near and faraway.



My motivation to deal with this kind of project are multiple. First, it is personal, because a member of my family had been faced to the situation of a wrong ocular diagnostic, fortunatly with no big consequences. At that time it would be helpfull if this technic was already used in clinics as an additional tool for diagnostics. Then, after 15 years in aerospace industry, it is an opportunity to work on other challeging topics, more linked to healthcare.

Links used :

[NEEC OCT History & Development (https://www.neec.com/research/oct-history-development/)](https://www.neec.com/research/oct-history-development/)

[OCT Wikipedia (https://en.wikipedia.org/wiki/Optical_coherence_tomography)](https://en.wikipedia.org/wiki/Optical_coherence_tomography)

[Cell - Identifying Medical Diagnoses and Treatable Diseases by Image-Based Deep Learning (https://www.cell.com/action/showPdf?pii=S0092-8674%2818%2930154-5)](https://www.cell.com/action/showPdf?pii=S0092-8674%2818%2930154-5)

[Kaggle (https://www.kaggle.com/paultimothymooney/kermany2018)](https://www.kaggle.com/paultimothymooney/kermany2018)

[Detecting Retina Damage from OCT-Retinal Images (https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938)](https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938)

Problem Statement

The main objective of this capstone project is to tell from an OCT scan if the patient has retina's disease or not. If yes, which disease is it between CNV, DME, DRUSEN. To have an OCT scan classification, ML technics will be used, like Convolutional Neural Network (CNN).

For this project, a recent CNN architecture called [SqueezeNet (https://arxiv.org/abs/1602.07360)](https://arxiv.org/abs/1602.07360) will be evaluated. It will be compare to pre-trained models and a custom CNN that [analysis are already done (https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938)](https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938). The choice of SqueezeNet architecture was done by the performance, shown in [Analysis of deep neural networks (https://medium.com/@culurciello/analysis-of-deep-neural-networks-dcf398e71aae)](https://medium.com/@culurciello/analysis-of-deep-neural-networks-dcf398e71aae).

The evaluation will be done by comparing models based on evaluation metrics described bellow.

Datasets and Inputs

For this project, the dataset used are coming from Kaggle. It is 84,495 X-Ray images (JPEG) classified in 4 categories (NORMAL,CNV,DME,DRUSEN). Images are labeled as (disease)-(randomized patient ID)-(image number by this patient). For sample : CNV-53018-2.jpeg.

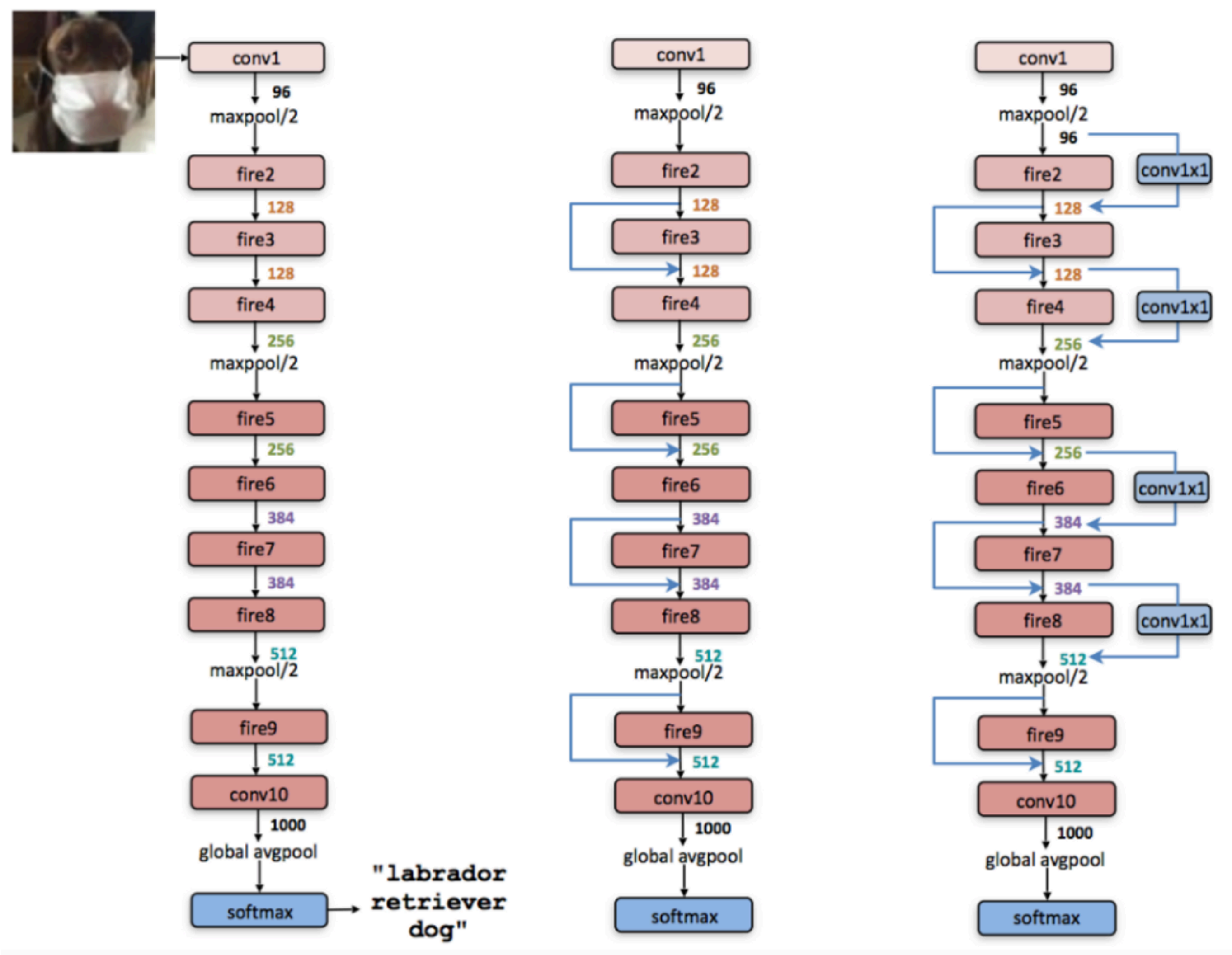
These OCT scans are splitted in 3 parts. One for the model training phase, one for the validation phase and the last one for the testing phase.

Links used :

[Kaggle - Retinal OCT Images (optical coherence tomography) (https://www.kaggle.com/paultimothymooney/kermany2018)](https://www.kaggle.com/paultimothymooney/kermany2018)

Solution Statement

A solution for OCT scan classification is to use CNN. Althought many models exist for this kind of topic, a recent model architecture called [SqueezeNet (https://arxiv.org/abs/1602.07360)](https://arxiv.org/abs/1602.07360) will be tested. The performance (cf Evaluation Metrics) of SqueezeNet architecture will be evaluated and compared to a [study comparing pre-trained model and a custom CNN (https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938)](https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938) using the same kaggle dataset. The same preprocessing of OCT scan will be used for the training and testing dataset by tranforming images. It consists in altering the original image by rescaling, rotating, shearing, flipping, etc. Then the models will be trained and tested by doing prediction for the ocular disease classification in order to see if the models overfit or underfit. Finally, prediction will be done on validation dataset to evaluate the performance of models on new dataset.



The Squeeze-Net Architecture

Benchmark Model

Some studies by comparing models had been done with [some benchmark (https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938)](https://towardsdatascience.com/detecting-retina-damage-from-oct-retinal-images-315b4af62938). Transfert learning using MobileNet, VGG16 pre-trained model give 71.2% accuracy after 8 epochs, 87.2% accuracy after 9 epochs and for a custom CNN 5 hidden layers gives 94.4% accuracy after 7 epochs.

Evaluation Metrics

The evaluation metric for this project is accuracy, loss, F1 score , confusion matrix, time computational, ROC curve.

Project Design

Data check

First, check the number of images for each diseases.

Pre-Processing data

For each folder (val, test, training), create variables X*(train/test/val) containing all images from each paths from each sub folder (NORMAL/DRUSEN/DME/CNV) and Y*(train/test/val) containing disease label associated to X_.

Image augmentation

OCT scans are pre-processed by altering image (scaling, rotating, shearing, flipping).

Model definition

Build SqueezeNet model with Keras

Model Training and validation

. Train SqueezeNet model with a small set of data for sanity check.

. Run a training with a full dataset using early stop function in order to get the number of epochs the model needs to reach the best accuracy and mainly saving time.

. Iterate by doing some fine tuning in order to try to improve results.

. Evaluate SqueezeNet model compared to benchmark with other pretrained model.

In [ ]:
```

```