A review of 2-D fundus and 3-D OCT retinal images’ analysis using modern deep learning techniques for automated identification of retinal landmarks, pathology, and disease classification.

The proposed deep learning based algorithms are classified into two main classes i.e.

 (i) Supervised learning algorithms

(ii) Unsupervised learning algorithms.

However, these two main classes are further categorized into the following types:

1. Retinal vasculature classification/segmentation

Supervised method:

1. Method is presented to tackle the problem of retinal blood [vessel segmentation](https://www.sciencedirect.com/topics/computer-science/vessel-segmentation), which combines two superior classifiers: Convolutional [Neural Network](https://www.sciencedirect.com/topics/neuroscience/neural-networks) (CNN) and [Random Forest](https://www.sciencedirect.com/topics/computer-science/random-decision-forest) (RF). In this method, CNN performs as a trainable hierarchical feature extractor and ensemble RFs work as a trainable classifier.
2. Firstly, a deep learning technology is used to vessel segmentation to generate the probability map of the retinal image, which is more reliable for optimizing the feature detection in retinal image. Secondly, we detect the landmarks using the multi-scale Hessian response on the probability map of the retinal image.
3. Deep maxpooling convolutional neural networks with GPU implementation to segment blood vessels.
4. Method is based on two key ideas: (1) applying a multi-scale and multi-level Convolutional Neural Network (CNN) with a side-output layer to learn a rich hierarchical representation, and (2) utilizing a Conditional Random Field (CRF) to model the long-range interactions between pixels. We combine the CNN and CRF layers into an integrated deep network called DeepVessel.
5. Network contains three convolutional layers, three intermediate pooling layers, one fully connected layer and a terminating softmax classification layer.
6. Improved version of supervised structured prediction based multi label method for retinal vessel segmentation. Their CNN has 6 layers including a max pooling layer, an unsampling layer, and a final fully connected softmax layer.
7. Comparison of single pixel classification and structured prediction (SP) based segmentation of vessels. This extensive study is based on different network architectures and pre-processing techniques.
8. A robust deep learning based method for classification of arterioles and venules across the entire retinal image considering the vessels located at OD. Proposed network contained 6 layers including 3 convolutional layers and 3 fully connected layers.
9. A fully convolutional neural network inspired from U-net architecture for simultaneous segmentation of arterioles and venules from retinal image. Proposed network takes colored image as input and outputs arterioles and venules with colored labels.

Hybrid:

1. Their DNN has five layers with three hidden layers; initially weights of first layer are obtained by pre-training of a de-noising auto-encoder (DAE) while the rest of the weights are randomly initialized. This unsupervised technique is used for weight initialization because naïve learning of weights through backpropagation has high probability of erroneous convergence into local minima. After weight initialization, overall learning and fine tuning of weights is done using backpropagation algorithm.
2. Using an unsupervised training followed by supervised classifier training for retinal vessel segmentation. They have used two DAEs followed by an RF classifier for extraction of vessels. The unsupervised pre-training of stacked auto-encoder is used for learning weights of network.

Unsupervised Learning:

a)Presented a two level SDAE network for retinal vessel segmentation. CLAHE is employed to get rid of uneven illumination. A simple DAE has three layers with one hidden layer.

1. Microaneurysm Classification
2. Simultaneous segmentation of retinal anatomical structures
3. Simultaneous segmentation of retinal pathologies
4. DR Identification/ Classification
5. Retinopathy of Prematurity Identification
6. AMD Identification/Classification
7. Multiple Retinal Disease Classification.