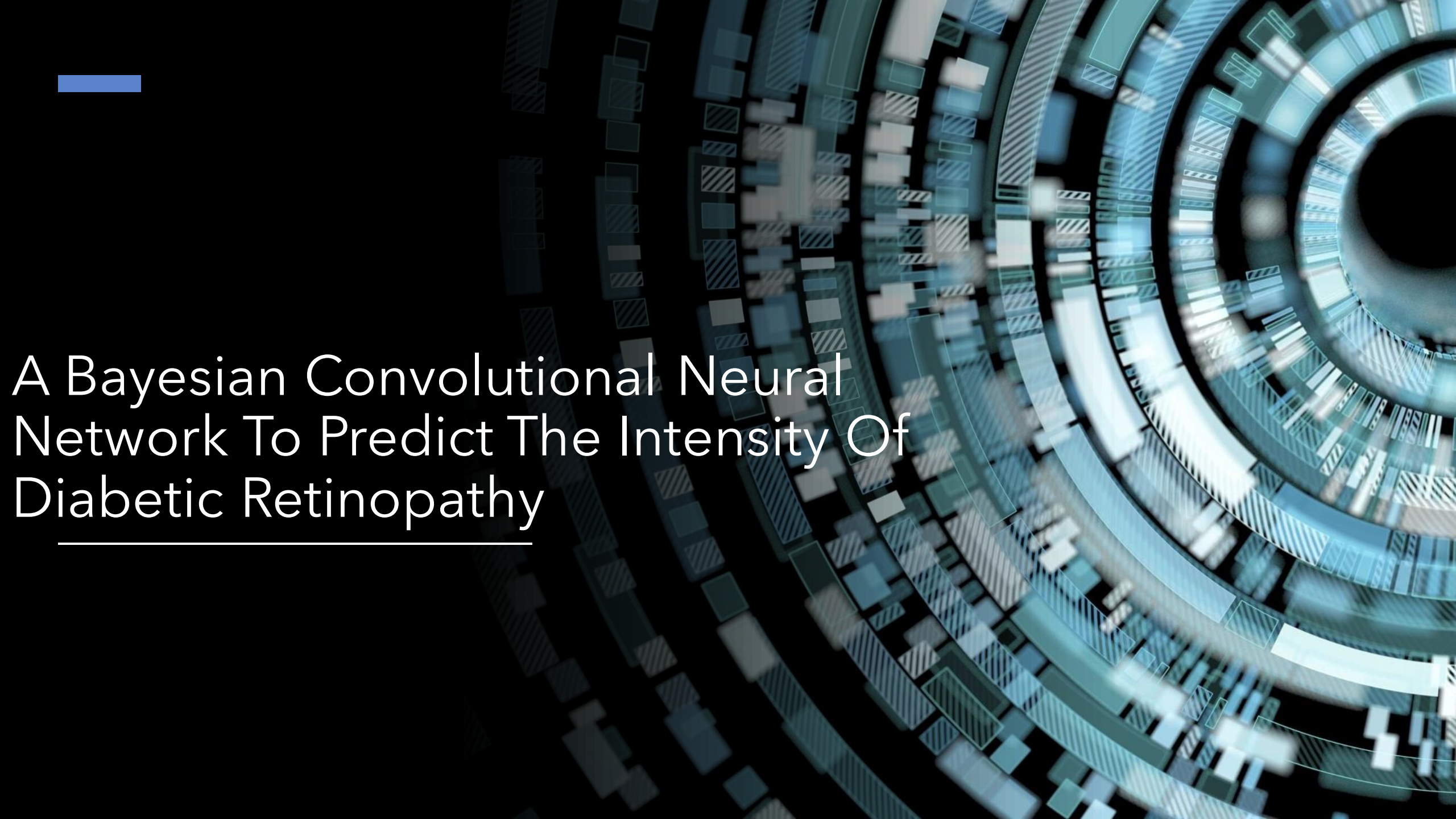
A Bayesian Convolutional Neural Network To Predict The Intensity Of Diabetic Retinopathy



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Abstract

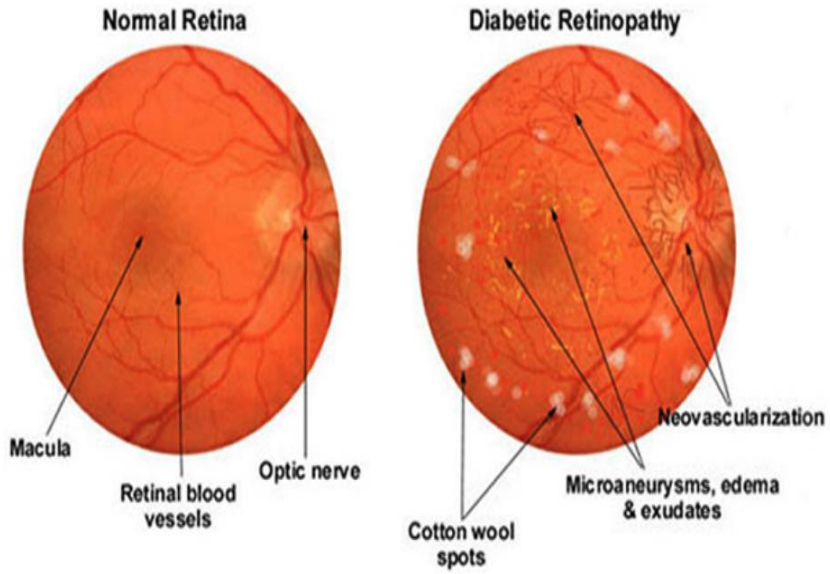
Diabetic Retinopathy is one of the major risks of losing vision among the people who have diabetes. If found early, there is a higher chance of treating the disease otherwise it might cause irrecoverable blindness in people. Although we have many deep learning models to identify the risk of DR from eye images, we do lack the uncertainty of prediction in those models. In other words, in connectionist models, the network uses point estimates as weights and it performs well with large datasets, but they fail to express uncertainty in regions with little or no data. The proposed model will try to achieve the accuracy rate as high as the frequentist inference models. In addition to that, it handles uncertainty and avoids overfitting the data. Research has shown that it also eliminates the use of dropouts in the model.

Introduction

What is Diabetic Retinopathy?

Diabetic retinopathy (DR), also known as diabetic eye disease, is a medical condition in which damage occurs to the retina due to diabetes mellitus. It occurs when the damaged blood vessels leak blood and other fluids into your retina, causing swelling and blurry vision. The blood vessels can become blocked, scar tissue can develop, and retinal detachment can eventually occur. The condition is easiest to treat in the early stages, which is why it is important to undergo routine eye exams.

Retinal (fundus) photography with manual interpretation is a widely accepted screening tool for diabetic retinopathy. Millions of people are suffering from DR around the world. Detecting DR is time consuming and the process is quite long. Instead we train our deep learning neural networks model to identify the early signs of blindess given an eye image of a person and rate it among 5 different class.



Approach

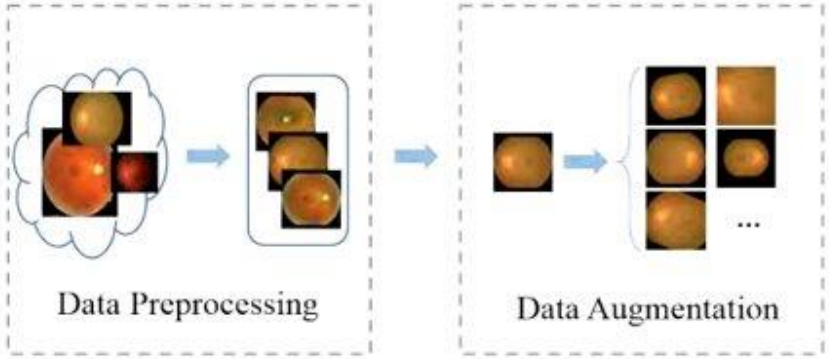
- Transfer Learning

The Eye Image data is trained using the concept of 'Transfer Learning', to make training faster comparatively as well to improve accuracy.

- Models Used
  - Resnet 50
  - VGG 16
  - Inception v3

Eye Image Data Collection

- We collected the data from Kaggle APTOS 2019 Blindness Detection. It is a large set of retina images taken using fundus photography under a variety of imaging conditions.
- We encountered lot of noise in both images and labels.
- Many images are out of focus, underexposed, or overexposed. The images were gathered from multiple clinics using a variety of cameras over an extended period, which will introduce further variation.
- The size of the image data is over 10 GB.



Data Labels

A clinician has rated the presence of diabetic retinopathy in each image on a scale of 0 to 4, according to the following scale:

0 - No DR,

1 – Mild,

2 – Moderate,

3 – Severe,

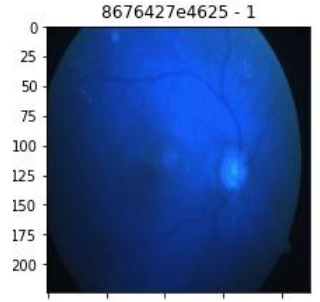
4 - Proliferative DR

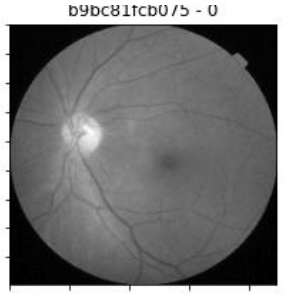
Technology Stack

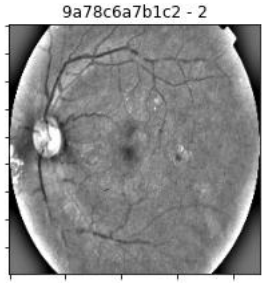
- Colab- For Development
- Deployment – Webapp
- Tensorboard Integration
- Libraries used
  - Keras
  - OpenCV
  - `Tensorflow_probability`

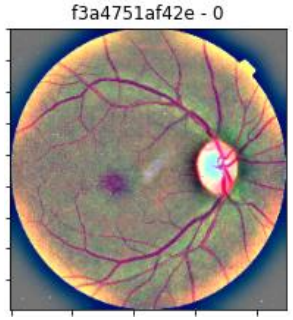
Image Transformation

- The original image is improper in shape and has lot of noise. Few of them have high resolution images and some have poorly oriented images.
- We used a library named OpenCv to read images and applied some transformation on top of the images. So our model will be able to learn precisely from the data and the accuracy is increased.
- For our model, We have converted image from BGR2RGB and removed noise by cropping the image, then we resized every image to same pixel size (224*224*3) and at last we applied a technique called Gaussian Blur, in order to highlight the places in eye image that are affected.









State-of-the-art Models

A common and highly effective approach to deep learning on small image datasets is to leverage a pre-trained network. A pre-trained network is simply a saved network previously trained on a large dataset, typically on a large-scale image classification task.

- ResNet50
- VGG16
- InceptionV3

There are two ways to leverage a pre-trained network: *feature extraction* and *fine-tuning*.

Key points

- Data Augmentation enables us to create valid perturbations of relatively small datasets to great effect
- Pre-Trained models provide an excellent starting point for acquiring completely distinct domain knowledge
- Dropout helps prevent overfitting
- Activation Function provides non-linear property to the NN.

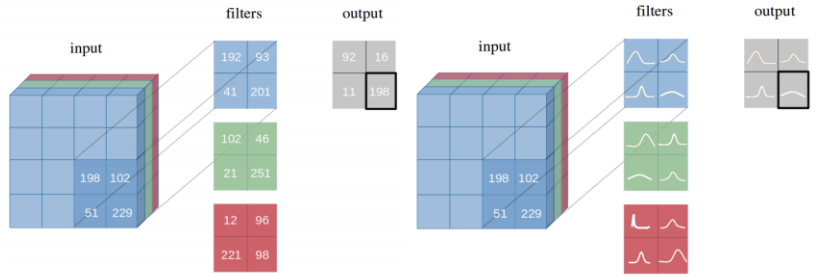
Fine Tuning Model: Another widely used technique for model reuse, complementary to feature extraction, is *fine-tuning*. Fine-tuning consists in unfreezing a few of the top layers of a frozen model base used for feature extraction, and jointly training both the newly added part of the model (in our case, the fully-connected classifier) and these top layers. This is called "fine-tuning" because it slightly adjusts the more abstract representations of the model being reused, in order to make them more relevant for the problem at hand.

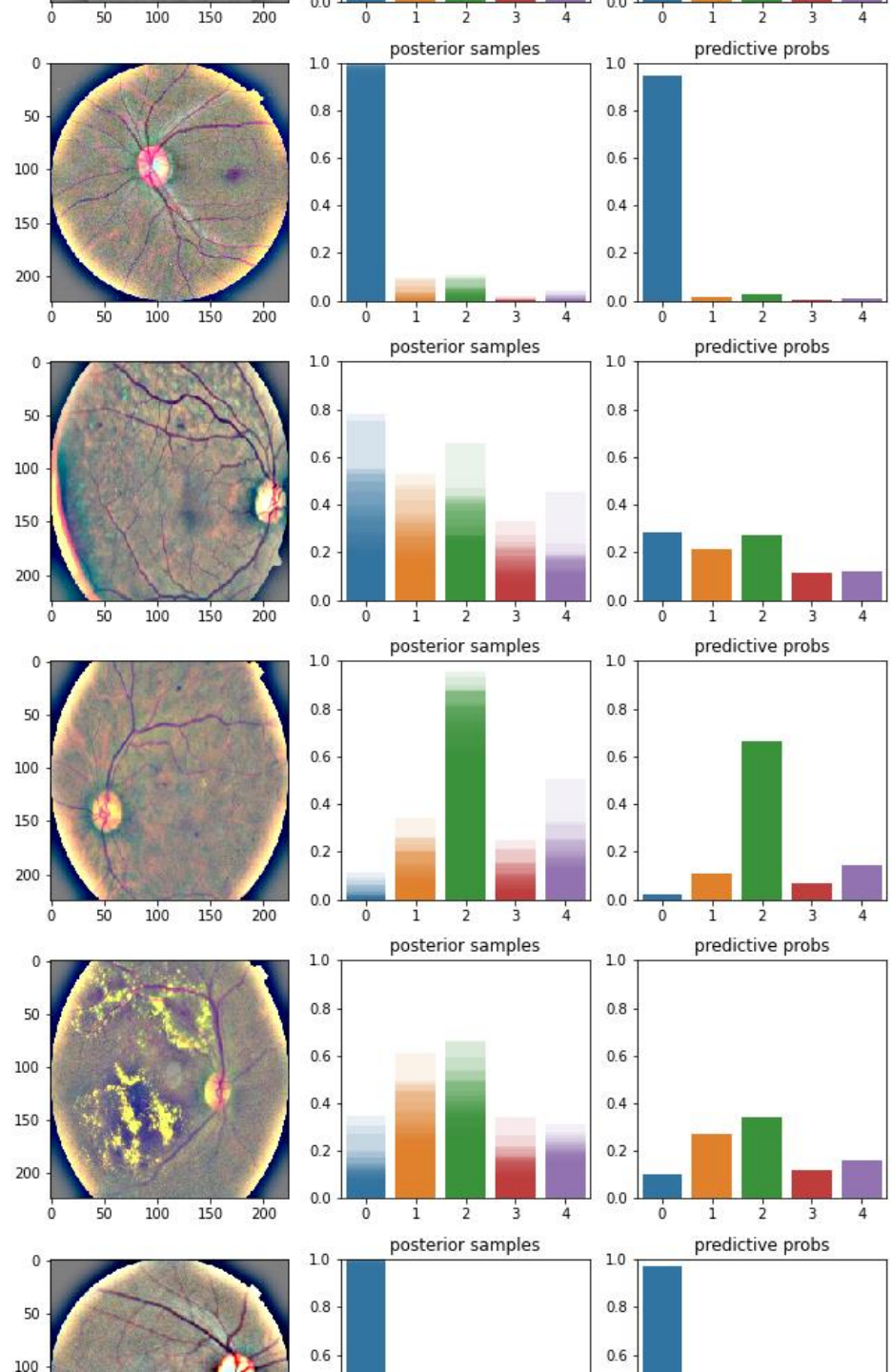
Model Comparison

Model	Test Accuracy	Train Accuracy
Resnet 50	70%	90%
VGG 16	65%	77%
Inception V3	64%	89%

Probabilistic Machine Learning

- Variational Inference : We define a function y = f(x) that estimates the given inputs {x1, . . . , xN } and their corresponding outputs {y1, . . . , yN } and produces an predictive output. Using Bayesian inference, a prior distribution is used over the space of functions p(f). This distribution represents our prior belief as to which functions are likely to have generated our data.
- Uncertainties in Bayesian Learning : Uncertainties in a network is a measure of how certain the model is with its prediction. In Bayesian modelling, there are two main types of uncertainty one can model : Aleatoric uncertainty and Epistemic uncertainty.





Bayesian Model

- Bayesian Model
- Accuracy – 70%

Reference

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- https://www.kaggle.com/c/aptos2019-blindness-detection/data
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- https://docs.opencv.org/2.4/modules/imgproc/doc/filtering.html#
- https://arxiv.org/pdf/1901.02731.pdf

Thank You