B. TECH. PROJECT REPORT

On

Development of Intelligent Drowsiness Detection System

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Development of Intelligent Drowsiness Detection System Using Artificial Intelligence

A PROJECT REPORT

Submitted in partial fulfillment of the
requirements for the award of the degree

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in

ELECTRONICS & INSTRUMENTATION ENGINEERING

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CANDIDATE’S DECLARATION

We hereby declare that the project entitled **“Development of Drowsiness Detection System using Artificial Intelligence”** submitted in partial fulfillment for the award of the degree of Bachelor of Technology under the supervision of **Dr. Sudarsan Sahoo, Assistant Professor** in the Department of Electronics & Instrumentation Engineering, NIT Silchar is an authentic work.

Further, I/we declare that I/we have not submitted this work for the award of any other degree elsewhere.

Signature and name of the student(s) with date

Kaustubh Mishra(28th Dec, 2021)

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CERTIFICATE by BTP Guide

It is certified that the above statement made by the students is correct to the best of my/our knowledge.

Signature of BTP Guide with dates and their designation
Dr. Sudarsan Sahoo
Assistant Professor

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We would also like to thank our parents, friends, and classmates for their encouragement throughout our project period. At last but not the least, we thank everyone for supporting us in completing this project successfully.

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Abstract

Nowadays, more and more professions require long-term concentration. Drivers must keep a close eye on the road, so they can react to sudden events immediately. Driver fatigue often becomes a direct cause of many traffic accidents. Therefore, there is a need to develop the systems that will detect and notify a driver of her/him bad psychophysical condition, which could significantly reduce the number of fatigue-related car accidents. However, the development of such systems encounters many difficulties related to fast and proper recognition of a driver's fatigue symptoms. One of the technical possibilities to implement driver drowsiness detection systems is to use the vision-based approach. This document is a semester end review report that details about the technical aspects as well as our motivation behind the development of this project.

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CHAPTER 1

INTRODUCTION

1.1 Necessity

1.1.1 Technology and Human Psychology

Human beings have always looked for ways to increase the efficiency and output of their work. In order to do so, humans have always come up with new and better forms of technology that can aid and assist in their work. As technology advanced, so did the society and civilizations, and slowly but steadily technology infused with society such that today, technology can be seen in every aspect of human life. One such aspect is travelling and with the advancement in technology many different modes of transportation are available and our dependency on these modes is increasing exponentially. These methods of transportation have deeply affected our lives as we can travel between places in a very short span of time. Today, almost everyone uses one or other forms of transportation. Some use their own vehicles while others depend on the public transport. However, there are some rules and codes of conduct that one needs to follow while driving these vehicles. One of the most basic codes of conduct is to stay vigilant and alert while driving.

Neglecting those rules for safer travelling has caused hundreds and thousands of accidents to occur on roads every year. The statistics show that such accidents and tragedies are increasing with each passing year. Therefore, It is evident that these rules and codes of conduct have been neglected by the society in general. It may seem trivial to many folks but these rules and regulations are of utmost importance While on the road, an automobile wields the most power and in irresponsible hands, it can be destructive and in some cases, that carelessness can cost the life of people on the road. One such carelessness is not admitting when we feel too sleepy and drowsy to drive. Thus, in order to monitor and prevent accidents or tragedies from occurring due to such negligence, many scientist and researchers from all over the world are working on devising various techniques and/or systems to detect drowsiness in a person while driving. But at times, some of the points and observations made are only limited to a specific scenario or not accurate enough. Thus, the aim of this project is to utilize the power of transfer learning and train a model to detect drowsiness in a person.

1.1.2 Facts and Statistics

According to the statistics from the WHO, distracted and fatigue driving is one of the main reasons behind road traffic accidents. Since road accidents are a major threat to human life, several reports put forwards by various national institutes like Central Road Research Institute(CRRI), Ministry of Road Transport and autonomous organizations like the SaveLife Foundation and Mahindra have revealed many interesting statistics regarding the road accidents due drowsiness. Some of these stats are listed below.

- The study by CRRI revealed that 40% of road accidents on the Agra-Lucknow Expressway occur due to exhausted drivers feeling sleepy while driving.
- A study by Mahindra and Savelife Foundation showed that the truck drivers in India drive 12 hours a day covering around 417 km, with almost 50% of them admitting that they feel sleepy or tired while driving.
- According to the study by Lancet, about 28 million Indians suffer from sleep apnoea, which clearly leads to many drowsy drovers on Indian roads.
- According to the Ministry of Road Transport and Highways (MoRTH) findings, the socio-economic costs of road crashes in India is at ₹147,114 crore, which is equivalent to about 1% of the country's GDP.

Several countries are actively making laws to reduce accidents due to drowsiness . For example, In India , the drivers are usually paired or sometimes, even in groups of 3-4 , for long travel journeys and each driver takes turns driving the vehicle . In Europe, the law requires that "Drivers should stop and rest for every 4.5 hours of continuous driving, and the rest period should be no less than 20 minutes". It is subjective to determine whether the driver is in fatigue state or not without sufficient quantified indexes and reliable data analysis. Thus, our project relies on a trained model to analyze the images and/or frames and determine whether the person is drowsy or not in real-time.

The figure below shows the fatality vs year plot and can be seen clearly that no. of deaths are increasing with each passing year. These deaths are primarily due to accidents involving fatigue or exhausted drivers.

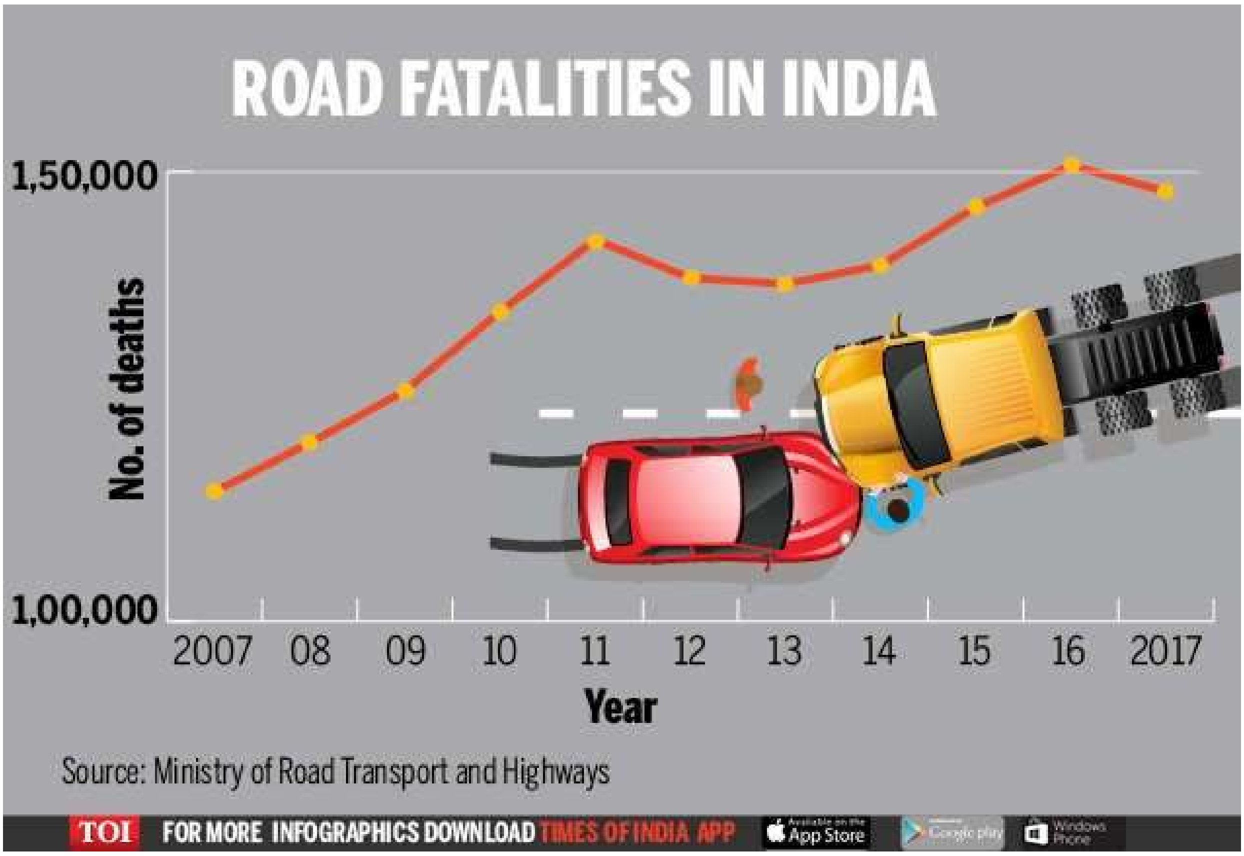


Fig 1.1: No. of Deaths Vs Year (courtesy : TOI)

1.2 Background Study

Upon reading the research papers listed in the reference section, the study and development of driver drowsiness systems can be broadly divided into categories :

1. *Sensor based techniques* : These techniques as the name suggest employ the use of various sensors and equipments and can further be divided into two sub-categories :
   a. Techniques that record Mechanical motions like vibrations, wheel movement and Lane positions
   b. The techniques that record and analyze heart rate, muscle contraction, temperature, blood-flow, etc of the driver/subject/participant.

2. *Vision Based Techniques* : These techniques primarily utilize the camera to analyse the person and perform operations in real-time. These techniques try to understand the changes in the facial region of the person as frames change. In our project, we are developing a vision based technique using deep learning architecture.

The gaps mentioned in the table below signify the difference between our approach and the approach used by the researchers in those papers. The following Table 1.0 summarises the research papers mentioned in the reference section :

Table 1.1 :

S.No	**Paper title**	**Outcome**	**Gaps**
1.	Detecting Driver Drowsiness Based on Sensors. Arun Sahayadhas, Kenneth Sundaraj, Murugappan Murugappan, Sensors (Basel) 2012 Dec; 12(12): 16937– 16953. Published online 2012 Dec 7. doi: 10.3390/s121216937	Three measures for monitoring Drowsiness(Sensor Based)	Described only about the sensor techniques, no description about vision techniques.
2.	A Context-Aware EEG Headset System for Early Detection of Driver Drowsiness. Gang Li, Wan-Young Chung, Sensors (Basel) 2015 Aug; 15(8): 20873–20893. Published online 2015 Aug 21. doi: 10.3390/s150820873.	1. Successful Implementation of Drowsiness Detection System using EEG, gyroscope and mobile application. 2. EEG results of drowsiness, defined slightly drowsy events.	Only employed supervised machine learning model: SVM classifier, during classification(final) stage. The model was pretrained.
3.	Feng You, Yunbo Gong, Haiqing Tu, Jianzhong Liang, Haiwei Wang, "A Fatigue Driving Detection Algorithm Based on Facial Motion Information Entropy", Journal of Advanced Transportation, vol. 2020, Article ID 8851485, 17 pages, 2020. https://doi.org/10.1155/2020/8851485.	1. Developed Face Feature Vector and Face Feature Triangle 2. Developed a prototype of the final model.	Used tiny YOLO-v3 deep learning model. This model utilises convolutional layers but is different from CNN as whole image is read at once unlike in strides as in CNNs.

4.	Charlotte Jacobé de Naurois, Christophe Bourdin, Anca Stratulat, Emmanuelle Diaz, Jean-Louis Vercher, Detection and prediction of driver drowsiness using artificial neural network models, Accident Analysis & Prevention,Volume 126, 2019,Pages 95-104,ISSN 0001-4575, https://doi.org/10.1016/j.aap.2017.11.038.	Employed different ANN models for the prediction/detection of drowsiness and summarized about the features like eyelid closure, gaze, head movement and driving time, most useful and used by the best prediction models.	Didn't study the models on continuum of images and/or real-time video input.

1.3 Intended Audience

The intended audience for this project are the development team, the project evaluation panel, and the tech-savvy enthusiasts who wish to learn from the project and/or provide feedback on the project.

1.4 Problem Definition

Fatigue as a safety problem is yet to be deeply tackled by any country in the world mainly because of its nature. Though several countries have started addressing this issue and some have even established certain laws and codes of conduct to be followed but the success rate is limited as often people are either unaware of such laws or at times are able to circumvent through these rules. Also fatigue, in general, is very difficult to measure or observe unlike other issues which have clear tests and key indicators available easily. This is mainly due to the subjective nature of Fatigue. Probably, the best solutions available now are the awareness about the fatigue-related accidents and promoting amongst drivers the notion to admit fatigue when needed. The latter solution is dependent on the success of the former whereas the success of the former is quite limited. Thus, this necessitates the development of a detection system that can alert the user in-case the user is found drowsy or sleepy while driving in real-time.

CHAPTER 2:

Literature Survey

This survey gives a brief information of the technology used so that any interested individual can understand the prerequisites required to understand the project as certain terms are specific to the technology used.

2.1 Technology Used

a. PYTHON : Python is a interpreted, high-level, general-purpose programming language. Python's design philosophy emphasizes code readability with its notable use of indentation. The language constructs and object oriented approach aids the programmers in writing clear, clean and meaningful codes for small or large-scale projects. Python is dynamically typed and supports multiple programming paradigms, including procedural, object-oriented, and functional programming.

b. JUPYTER LAB: Project Jupyter is a non-profit organization created to develop open-source software, open-standards, and services for interactive computing across dozens of programming language.

c. IMAGE PROCESSING : In computing, digital image processing is the use of computer algorithm to perform image processing on digital images.

d. MACHINE LEARNING : Machine Learning is the scientific study of algorithms and statistical models that computer systems use to perform a specific task effectively without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence. Machine Learning algorithms build a mathematical model based on sample data, known as "training data" in order to make predictions or decisions without being explicitly told.

e. TENSORFLOW : TensorFlow is a free and open-source software library for machine learning and artificial intelligence. It can be used across a range of tasks but has a particular focus on training and inference of deep neural networks. TensorFlow can be used in a wide variety of programming languages, most notably Python, as well as Javascript, C++, and Java.

f. Kaggle : Kaggle is an online community of machine learning enthusiasts and provides its users with free Tensor Processing Units(TPU) and GPU capabilities.

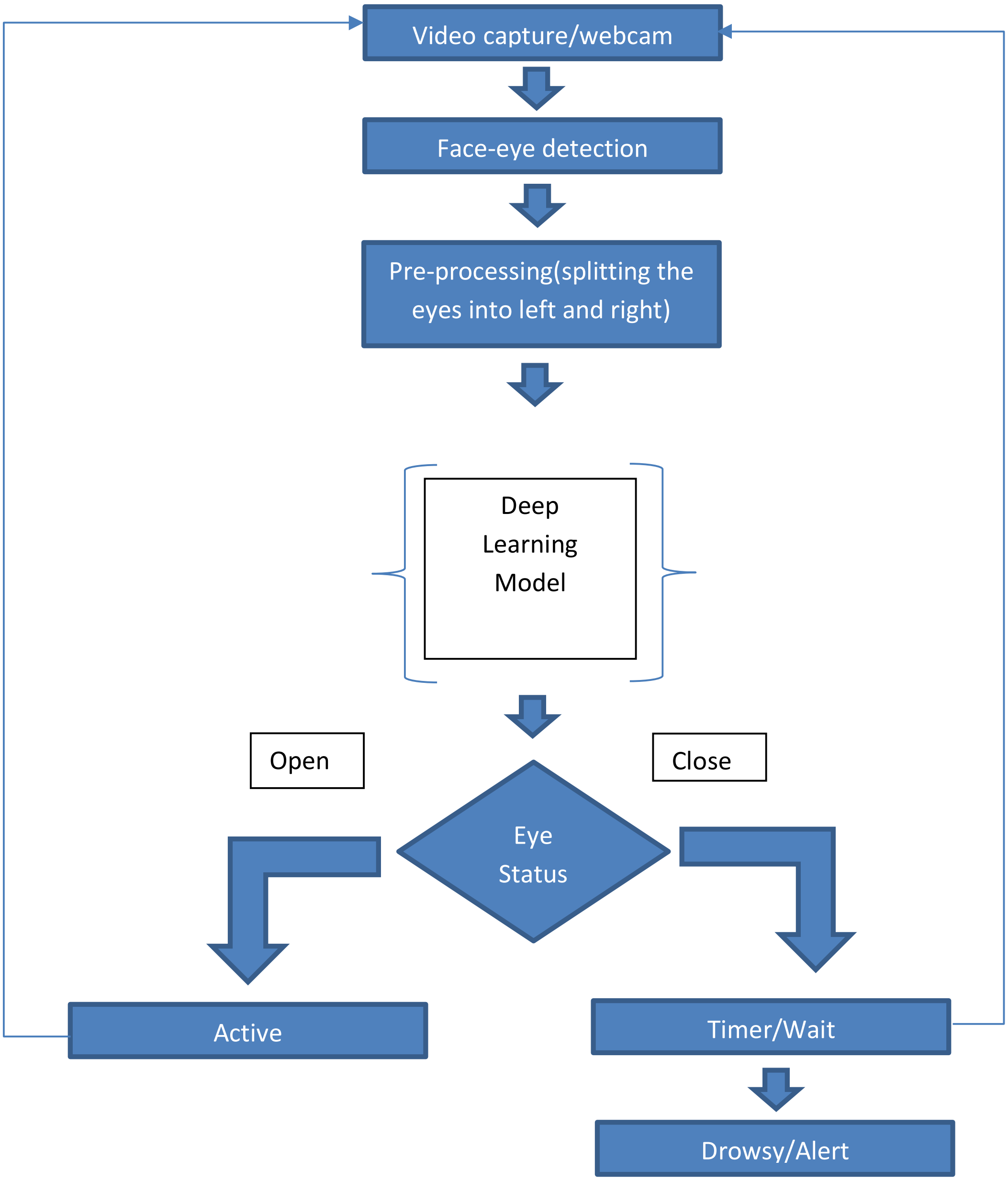
CHAPTER 3

CONCEPT DESIGN

3.1 Objective

The objective for this project was to determine whether a person in real-time is drowsy or not depending upon whether his eyes are open or not and to play an alarm if the EAR(eye aspect ratio) falls below a threshold and MAR(mouth aspect ratio) above a threshold after a specific period of time.

3.2 Flowchart :



This project utilizes opencv Library(in Python) which is aimed at providing real time computer vision. The project will also utilize dlib toolkit to allow for face and eye detection as well as Imutils package to allow for simple image manipulation functions to be available in our code. We will also create notebooks on kaggle as they provide online GPU & TPU capabilities.

Thus, the overall process is as follows :

Using opencv library to either capture faces in real-time or working on images/frames (during training). Then utlising dlib library or mediapipe library and Imutils package for image manipulation and preprocessing.

After preprocessing of the data, customize and train the MobileNet model on the data to detect whether the eyes were open .

Then using the input to the our customized CNN model to calculate EAR (eye-aspect ratio).

Then develop a set of conditions based on EAR, and classification result to determine whether the person is drowsy or not!

3.3 EAR CALCULATION

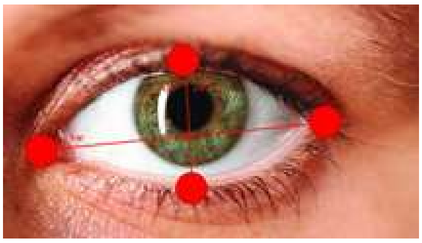


Fig 3.1 : EAR Calculation

EAR is a simple ratio between the distance from one end of the eye to other horizontally and vertically : See, Figure :

EAR = distance(eh)/distance(ew)..I

Where,

eh = vertical line

ew = horizontal line , Thus eyes closed have low EAR while open eyes have high EAR .

This method will be able to calculate the mathematical midpoint through these line equations, while detection can be used to locate the actual midpoint and the difference between these two points can also serve as a method for the alert system.

3.4 CNN

CNNs are feed forward neural network that are trained through backward propagation. In machine learning, CNNs have been successfully employed for analyzing visual imagery.

CNN use a variation of multilayer perceptrons designed to require minimal preprocessing. They have been sometimes also called as shift invariant or space invariant artificial neural networks (SIANN), based on their shared-weights architecture and translation invariance characteristics.

As described by Prof. Fei Fei Li (ex-Vice President Google and Chief Scientist of AI/Ml Google Cloud and Current Professor at Stanford and Co-director Stanford AI Lab) in her CS231 Convolutional Neural Networks Course at Stanford(in 2017) : A neural network is a black box in the sense that while it can approximate any function, studying its structure won't give you any insights on the structure of the function being approximated. But a basic understanding is required to understand the huge impact it has on Image Classification process since its inception.

CNN building Blocks :
Convolutional Layer
Activation Layer/Function
Pooling Layer
Batch Normalisation Layers
Fully Connected Layers
Loss layers

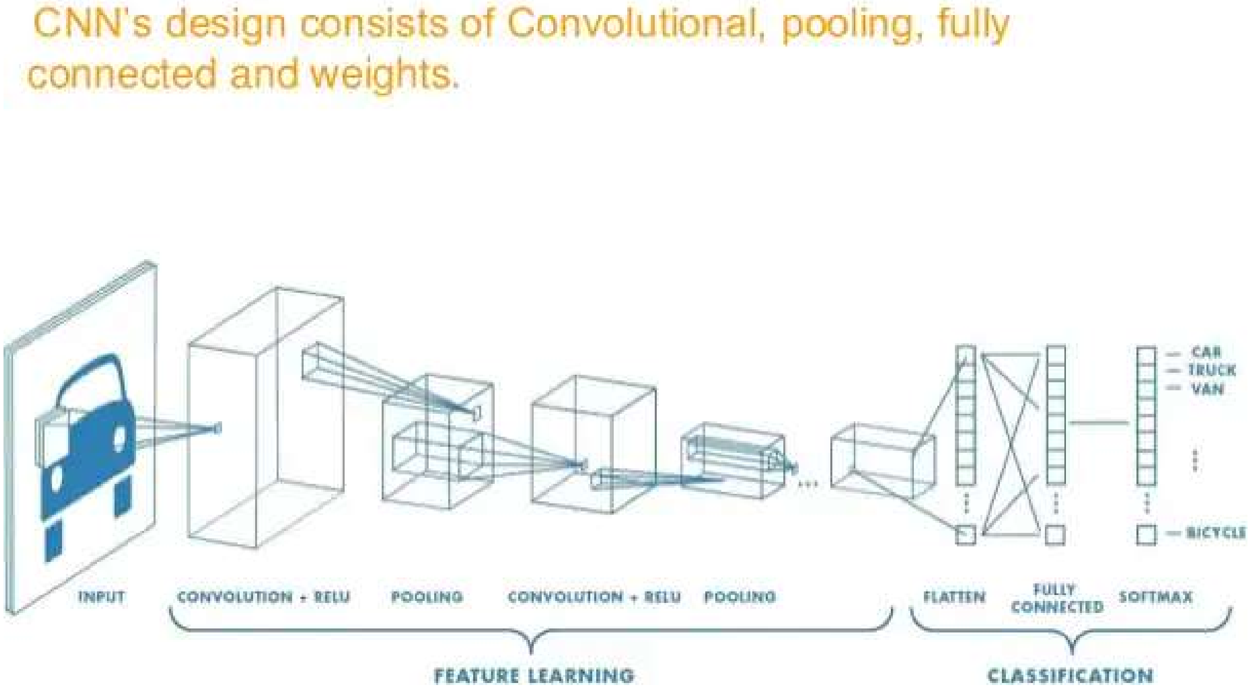

CNN's design consists of Convolutional, pooling, fully connected and weights.

Fig 3.2 : CNN Architecture (courtesy : Mathworks.com)

3.5 MobileNet Architecture

MobileNet is a type of CNN architecture designed for mobile and embedded vision applications. These type of architectures are streamlined to utilize depth-wise separable convolutions to build lightweight neural networks that can have low latency for mobile and embedded devices. They are designed to maximize accuracy and efficiency while being mindful about the restricted resources or data for an on-device or embedded application. A standard mobile Net has 28 layers with approximately 4.2 million parameters which can be reduced by tuning width multiplier hyperparameter efficiently. It is also dependent upon the dimensions of the image. We customize the model to suit our needs and then trained the model on training dataset.

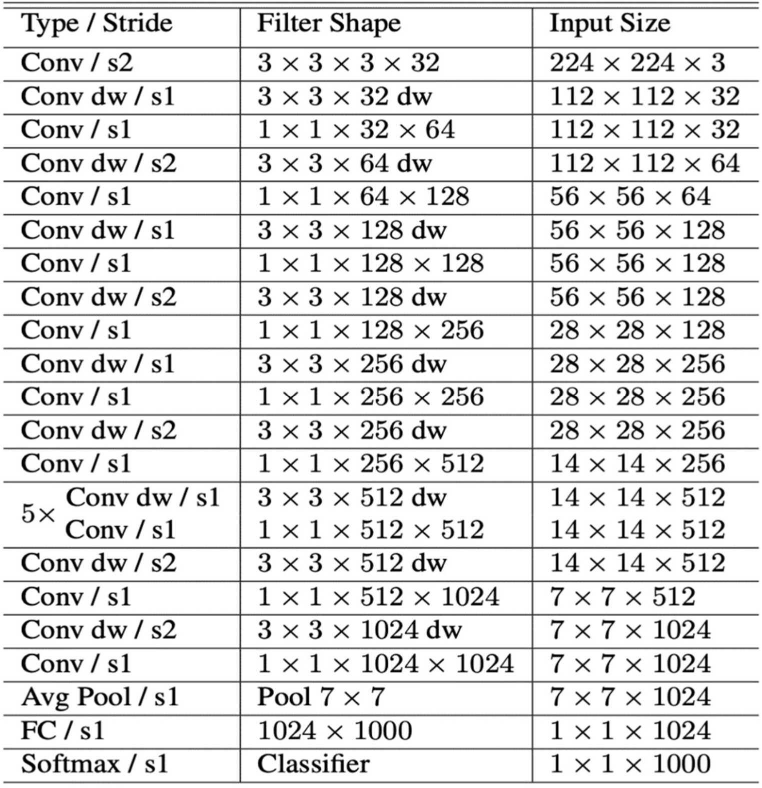
The reason for working with a pretrained model is that the model will not start with some random association of weights but will utilise a set of standard weights.

We preferred MobileNet because of the following reasons :

1. It can be used for mobile and embedded vision applications.
2. It is the smallest model available, and provides good accuracy and predictions. Thus, helps us conserve space-time complexity.

Look at the Table showing the MobileNet Architecture :

Table 3.1 : Mobile Net Architecture



Type / Stride	Filter Shape	Input Size
Conv / s2	3 × 3 × 3 × 32	224 × 224 × 3
Conv dw / s1	3 × 3 × 32 dw	112 × 112 × 32
Conv / s1	1 × 1 × 32 × 64	112 × 112 × 32
Conv dw / s2	3 × 3 × 64 dw	112 × 112 × 64
Conv / s1	1 × 1 × 64 × 128	56 × 56 × 64
Conv dw / s1	3 × 3 × 128 dw	56 × 56 × 128
Conv / s1	1 × 1 × 128 × 128	56 × 56 × 128
Conv dw / s2	3 × 3 × 128 dw	56 × 56 × 128
Conv / s1	1 × 1 × 128 × 256	28 × 28 × 128
Conv dw / s1	3 × 3 × 256 dw	28 × 28 × 256
Conv / s1	1 × 1 × 256 × 256	28 × 28 × 256
Conv dw / s2	3 × 3 × 256 dw	28 × 28 × 256
Conv / s1	1 × 1 × 256 × 512	14 × 14 × 256
5× Conv dw / s1 Conv / s1	3 × 3 × 512 dw 1 × 1 × 512 × 512	14 × 14 × 512 14 × 14 × 512
Conv dw / s2	3 × 3 × 512 dw	14 × 14 × 512
Conv / s1	1 × 1 × 512 × 1024	7 × 7 × 512
Conv dw / s2	3 × 3 × 1024 dw	7 × 7 × 1024
Conv / s1	1 × 1 × 1024 × 1024	7 × 7 × 1024
Avg Pool / s1	Pool 7 × 7	7 × 7 × 1024
FC / s1	1024 × 1000	1 × 1 × 1024
Softmax / s1	Classifier	1 × 1 × 1000

(courtesy : Research Team Cornell University)

3.6 Understanding the Likelihood Scenario

A bit of mathematics to understand the likelihood scenario. For simplicity, sigmoid function is used with single input feature and single parameter(weight). Let us consider a simple binary classification(or Logistic Regression) process.

$$h_\theta(x) = Sigmoid(\theta^T x) = \frac{1}{1+e^{-\theta^T x}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

$P(y = 1|x;\theta) = h_\theta(x)$ *as at present we are perf orming simple binary classif ication between* 0 & 1

and $0 \le h_\theta(x) \le 1$ *just like probability.*

$$So,\ P(y = 0|x;\theta) = 1 - P(y = 1|x;\theta) = 1 - h_\theta(x) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

Theref ore, Probability Function :

$$P(y|x;\theta) = \left(h_\theta(x)\right)^y \left(1 - h_\theta(x)\right)^{1-y} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (a)$$

So over m examples or dataset values, we have to maximize the probability on this dataset.

So, we need to f igure out the likelihood wrt θ's choosen.

$$L(\theta) = P(\vec{Y}|\vec{X};\vec{\theta}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (b)$$

So this is the probability that needs to be maximized, Theref ore, we can break this probability into product consisting of probability of each training example, assuming each probability as independent

$$L(\theta) = \prod_{i=1}^{m} P(y^i| x^i,\theta) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (c)$$

$$L(\theta) = \prod_{i=1}^{m} \left(h_\theta(x^i)\right)^{y^i} \left(1 - h_\theta(x^i)\right)^{1-y^i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (d)$$

$$\log(L(\theta)) = l(\theta) = \sum_{i=1}^{m} y^i \log\left(\left(h_\theta(x^i)\right)\right) + 1 - y^i \log\left(1 - \left(h_\theta(x^i)\right)\right) \ldots\ldots\ldots\ldots\ldots\ldots (e)$$

Continuing from the discussion of the livelihood, another important thing to notice is how will the likelihood reach maxima or minima, so in order to do that when we train our model we use “learning-rate” and “optimiser”.

Learning-rate is simply by how much the model should take in new information.

Optimisers are basically added so that when the model is far from a global or most stable state, the stride or jump to gather new information is fast or high and when it is close to the stable state it becomes slow and the strides become small. We will be utilising “adam” optimiser.

3.7 ADAM

Adaptive Moment Estimation is an algorithm for optimization technique for gradient descent. The method is really efficient when working with large problem involving a lot of data or parameters. It requires less memory and is efficient. Intuitively, it is a combination of the ‘gradient descent with momentum’ algorithm and the ‘RMSP’ algorithm.

Adam Optimizer inherits the strengths or the positive attributes of the above two methods and builds upon them to give a more optimized gradient descent.

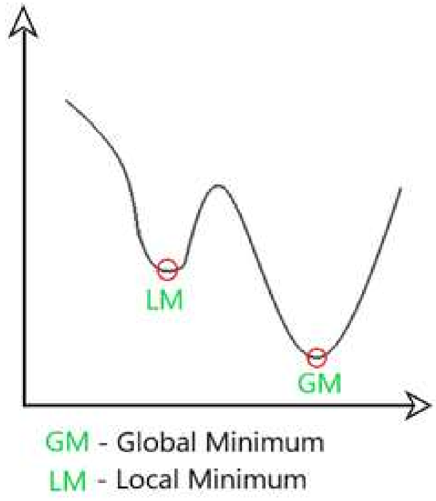


Fig 3.3 showing global minimum and local minimum

Here, we control the rate of gradient descent in such a way that there is minimum oscillation when it reaches the global minimum while taking big enough steps (step-size) so as to pass the local minima hurdles along the way. Hence, combining the features of the above methods to reach the global minimum efficiently.

Mathematical Caluclation :

```
Moment_1 = 0; moment_2 = 0;
For t in range(num_iterations):
        dx = compile_gradient(x)
        Moment_1 = beta1*moment_1 + (1-beta1)*dx
        Moment_2 = beta2*moment_2 + (1-beta2)*dx*dx
        Unbias_1 = Moment_1/(1-beta1**t)
        Unbias_2 = Moment_2/(1-beta2**t)
        X - = learning_rate*Unbias_1/(np.sqrt(Unbias_2)+ 1*e^(-7))
```

Finally, a good initial point as suggested after experimentation for calculation and fast culmination towards stable state is beta1 = 0.9 and learning rate = 1e^(-3).

CHAPTER 4

EXPERIMENT AND ANALYSIS

4.1 **Software Requirements Specification**

- Anaconda (distribution manager of Python and data science related software packages as well as virtual environment manager with GUI and CLI navigator)
- Python (3.7.2)
- IDE : Jupyter Notebook

Libraries/Packages Used :

- tensorflow(2.1)
- Keras API (open-source library providing Python Interface for neural networking) (2.4.2)
- opencv(4.3)
- Dlib
- Imutils
- Numpy(1.20.2)
- Sklearn
- Playsound, etc

Operating System :

- Windows or Ubuntu

Web Notebooks :

- Kaggle, Google Collaboratory

4.2 Data Collection

The project required a dataset that can offer close visualisation of human eye. Thus, upon research, we found MRL data set to compatible with the project. The MRL dataset was actually collected to work on training a model for eye disease classification. But we found this dataset to offer us close visualisation of various human eyes, thus we decided to work on this data.

From MRL dataset we differentiated the images into closed eyes and open eyes.

Since the data was very large about 358 mb with + 1,00,000 images, each with either 86x86 or 94x94 resolution so we used only some part of the data.

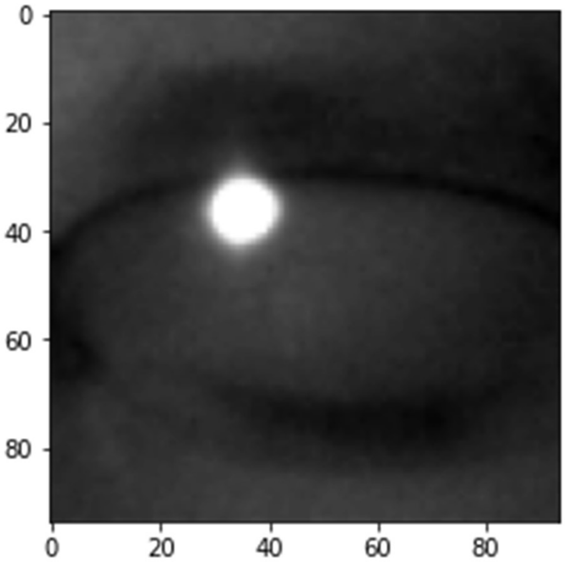


Fig 4.1 : Image in MRL Dataset

This is an image in the MRL dataset and as can be seen offers close visualisation of human eye.

4.3 Data Preprocessing

In this part, First we checked the data by looking at some of it's images in Grayscale.

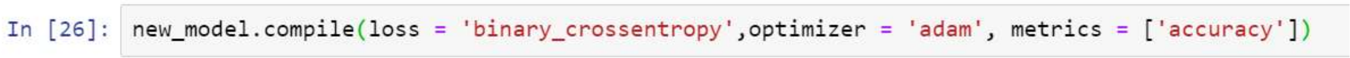
Then upon understanding the data, divided it into training and testing dataset. Next, added the Category tags i.e. Closed_Eye and Open_Eye tags to the images of the eyes depending on the folder, images belonged to as done in the data collection part.
Followed by resizing the images from 86x86 or 94x94 to a common size of 224x224. Since upon converting the images to the standard pixel size of 256x256 for deep learning purposes introduced garbage-pixel values in the image as well as images turned "lighter" we settled down to 224x224 pixel-size for images.
Then, converted the image from GrayScale to RGB(RED GREEN BLUE) format used for colored images so essentially transformed these images into color format!, followed by reading those images and transforming them into array and labels to be used as dataset.

Then divided the dataset into two lists X and Y. X stores the features and Y stores the label(i.e. whether the image is Closed_eye or Open_eye) for training the model. Finally, created the pickle file of both the X and Y lists to store the data in the serialized binary format or as a byte stream.

4.4 Model Training

First we imported the mobile net architecture through keras and tensorflow then customized the pre-trained model by removing its four layers and adding three layers of our own and finally adding the activation function (sigmoid) for binary classification (classifying as open eye or close eye).

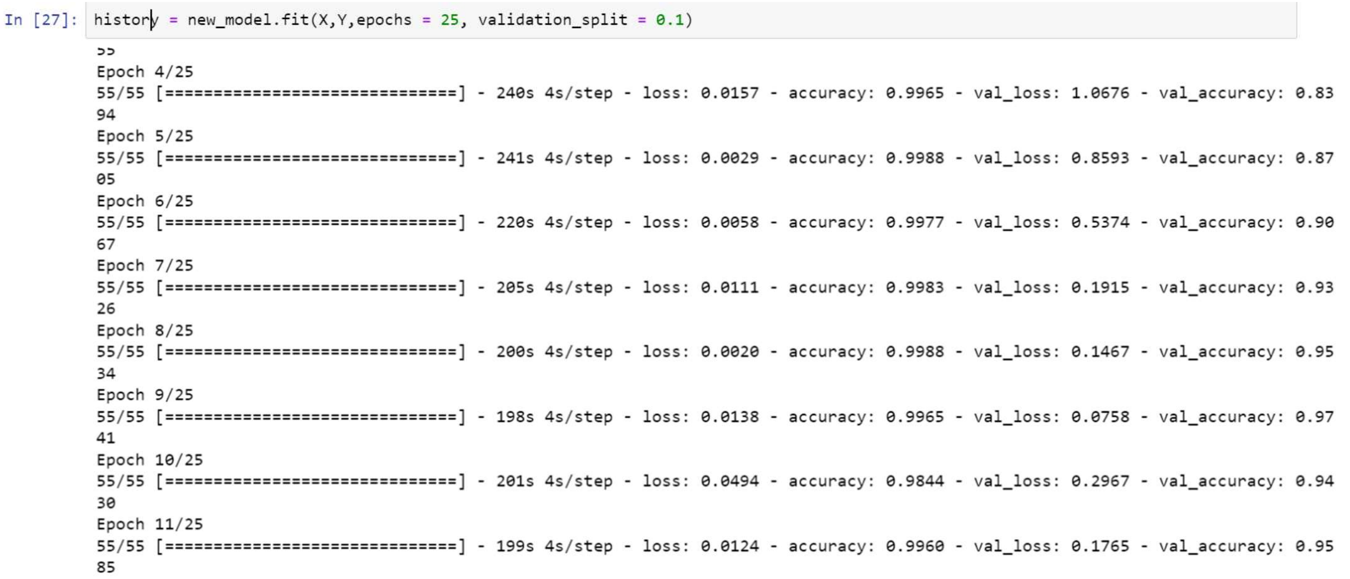
Then we performed model training. We trained the model for a total of 25 epochs and at the end of each epoch calculated its validation loss and accuracy.



```
In [26]: new_model.compile(loss = 'binary_crossentropy',optimizer = 'adam', metrics = ['accuracy'])
```

Fig 4.2 : showing the model compilation configuration

The above image shows that the model is compiled and the **loss** will be calculated as **binary cross entropy** with **optimizer** as **adam** and the **metric** to check for is **accuracy**.



```
In [27]: history = new_model.fit(X,Y,epochs = 25, validation_split = 0.1)

         55
         Epoch 4/25
         55/55 [==============================] - 240s 4s/step - loss: 0.0157 - accuracy: 0.9965 - val_loss: 1.0676 - val_accuracy: 0.83
         94
         Epoch 5/25
         55/55 [==============================] - 241s 4s/step - loss: 0.0029 - accuracy: 0.9988 - val_loss: 0.8593 - val_accuracy: 0.87
         05
         Epoch 6/25
         55/55 [==============================] - 220s 4s/step - loss: 0.0058 - accuracy: 0.9977 - val_loss: 0.5374 - val_accuracy: 0.90
         67
         Epoch 7/25
         55/55 [==============================] - 205s 4s/step - loss: 0.0111 - accuracy: 0.9983 - val_loss: 0.1915 - val_accuracy: 0.93
         26
         Epoch 8/25
         55/55 [==============================] - 200s 4s/step - loss: 0.0020 - accuracy: 0.9988 - val_loss: 0.1467 - val_accuracy: 0.95
         34
         Epoch 9/25
         55/55 [==============================] - 198s 4s/step - loss: 0.0138 - accuracy: 0.9965 - val_loss: 0.0758 - val_accuracy: 0.97
         41
         Epoch 10/25
         55/55 [==============================] - 201s 4s/step - loss: 0.0494 - accuracy: 0.9844 - val_loss: 0.2967 - val_accuracy: 0.94
         30
         Epoch 11/25
         55/55 [==============================] - 199s 4s/step - loss: 0.0124 - accuracy: 0.9960 - val_loss: 0.1765 - val_accuracy: 0.95
         85
```

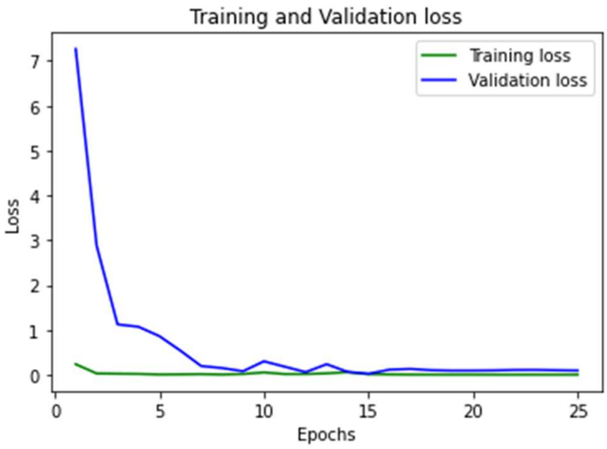
Fig 4.3 : model training

We can observe that the model is getting trained and despite our best efforts to minimize the training time it still took approximately *4 minutes each epoch* thus, the total training time of 25 epochs can be calculated as 25 * (~4) = *100 minutes or 1 hr and 40 minutes* . If we increase the number of epochs the accuracy will increase.

CHAPTER 5

RESULT AND DISCUSSION

After successful training of the model, we plotted the loss vs epochs and the accuracy vs epochs of both the training and the validation phase. The following figures, figure 5.1 shows loss vs epochs curve of training and validation data and figure 5.2 shows accuracy vs epochs curve of training and validation data.



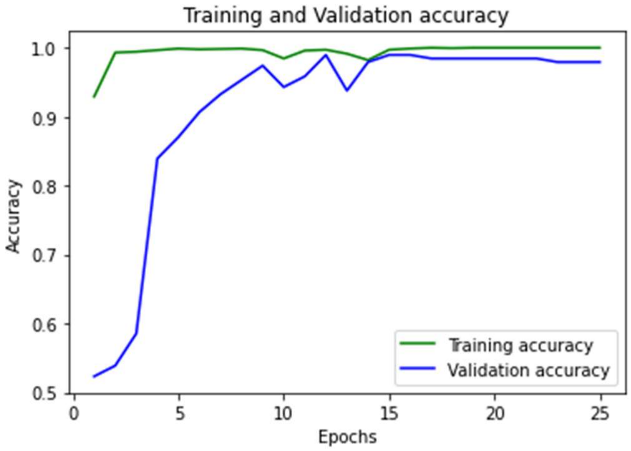


fig 5.1 : Loss Curves

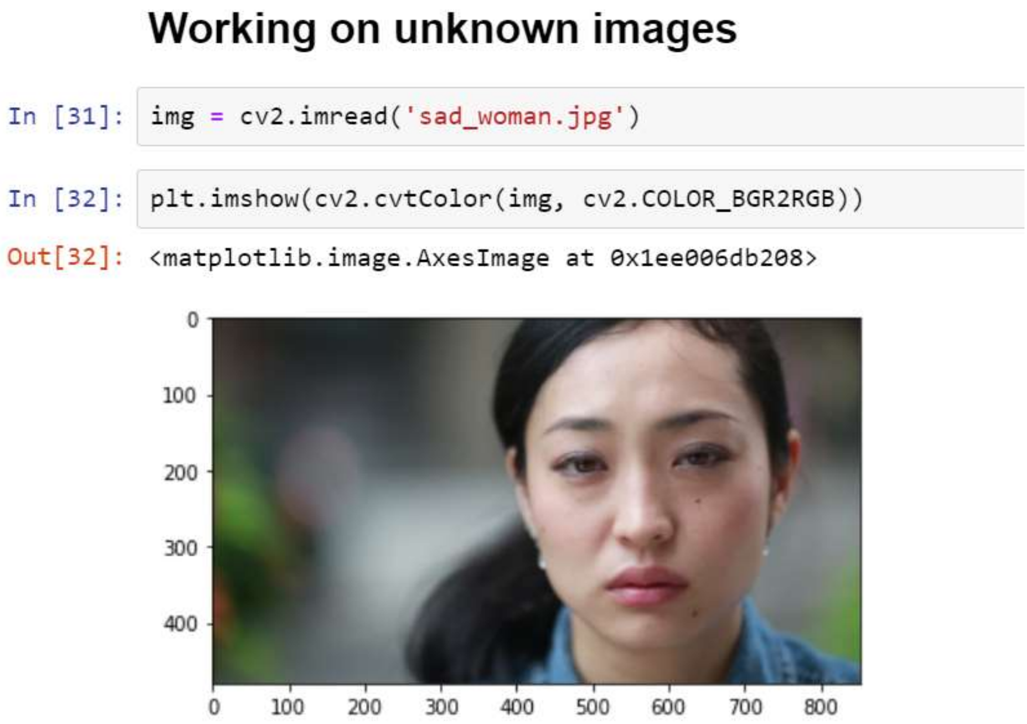
fig 5.2 : Accuracy curves

The training metrics (loss and accuracy) can be seen in green and the validation metrics (loss and accuracy) are shown in blue. As can be seen, the model starts with quite low training loss due to standardization of filter weights by using the pretrained model and thus has high training accuracy from the start but the validation loss is quite high initially as the filter weights of the model are not configured for this particular dataset and therefore do not extract any meaningful information initially. For the same reason the initial validation accuracy is low(but still better than any model created from the scratch) and thus, slowly at the end of each epoch they take the losses into consideration (both the training and validation loss) and through backward propagation(using adam optimizer) modify the weights to better predict the type of eyes(close eye or open eye) and hence slowly the losses continue to decrease and accuracy improves.

Notice, before 15 epochs both the validation curves(accuracy and loss) decrease rapidly, signifying that the adam optimizer is moving fast or gaining momentum and taking huge steps to reach a stable state.

Also notice that after 15 epochs both the validation curves(accuracy and loss) start to become stable indicating that the model is reaching its intended stable state and as it continues to move forward the difference between losses of each epoch decrease signifying that the adam optimizer is slowing down.

Finally, in order to check the working of the model, we picked a random free source image of a woman and fed it to the model .



Working on unknown images

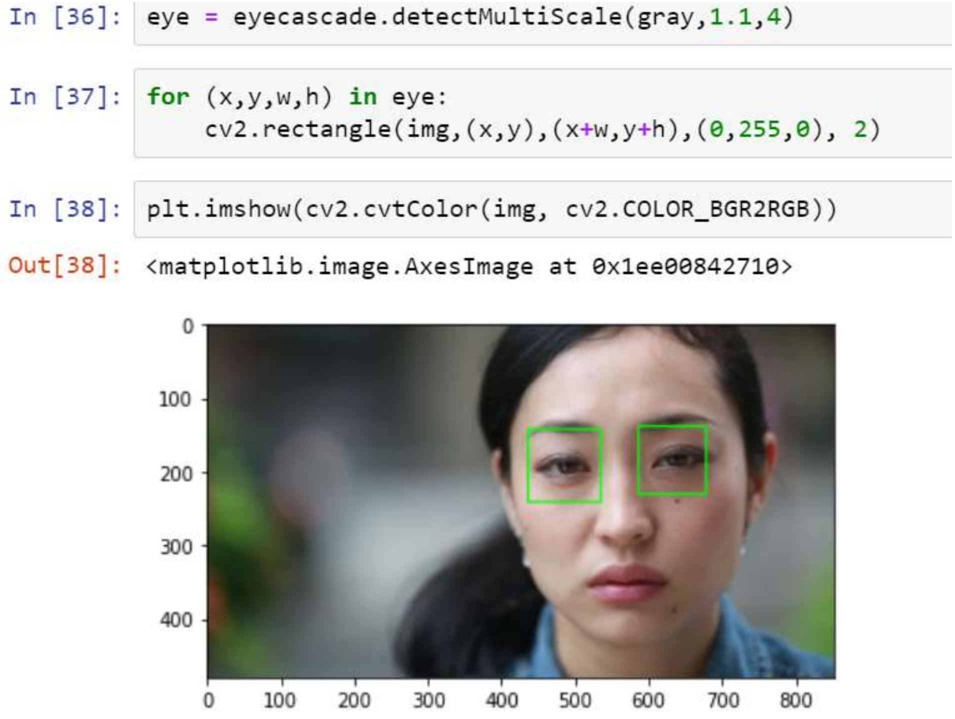
```
In [31]: img = cv2.imread('sad_woman.jpg')

In [32]: plt.imshow(cv2.cvtColor(img, cv2.COLOR_BGR2RGB))

Out[32]: <matplotlib.image.AxesImage at 0x1ee006db208>
```

Fig 5.3 : Working on Unknown Images

The model successfully detected the eye and classified it as open eye.



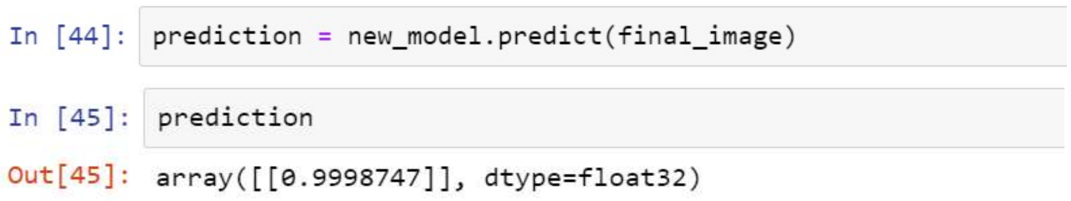
```
In [36]: eye = eyecascade.detectMultiScale(gray,1.1,4)

In [37]: for (x,y,w,h) in eye:
             cv2.rectangle(img,(x,y),(x+w,y+h),(0,255,0), 2)

In [38]: plt.imshow(cv2.cvtColor(img, cv2.COLOR_BGR2RGB))

Out[38]: <matplotlib.image.AxesImage at 0x1ee00842710>
```

Fig 5.4 : Successful Detection



```
In [44]: prediction = new_model.predict(final_image)

In [45]: prediction

Out[45]: array([[0.9998747]], dtype=float32)
```

Fig 5.5 : prediction

We can see that the output is positive and have a value very close to ~1 (0.9998747) showing that the eyes detected are open eyes.

CHAPTER 6

CONCLUSION AND SCOPE FOR FUTURE WORK

As seen in the previous chapter, the model successfully predicted whether the eyes as open and can now be used on unknown images for predictions. The accuracy is also good (around 95%), thus, the model is now ready to work on images.

However, the model is still not ready to be used for video capture or webcam purpose and cannot perform its operation in real-time. Thus, in the upcoming semester, we will work on modifying the model to work with videos and/or real-time. At the same time, we will also work on the alert system.

Finally, we will work on the front-end part. In front-end, we will use flutter framework to create a user interface. Then we will deploy the model on heroku server .

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