EMBEDDED PROJECT ON FACIAL EMOTION RECOGNITION

THE PROJECT REPORT

Submitted By

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in partial fulfilment for the award of the diploma

in

COMPUTER SCIENCE AND TECHNOLOGY

TECHNIQUE POLYTECHNIC INSTITUTE

HOOGHLY – 712102

SESSION: 2021 - 2022

PROJECT REPORT
on

EMBEDDED PROJECT ON FACIAL EMOTION RECOGNITION

**Submitted in Partial Fulfillment of the Requirements
for the Award Of**

Diploma in Computer Science & Technology

From

**WEST BENGAL STATE COUNCIL OF TECHNICAL
& VOCATIONAL EDUCATION AND SKILL
DEVELOPMENT**

Under the Guidance of
(Mr. Shibdas Bhattacharaya, DCST)

Submitted By

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(Roll No. - 10)	(Roll No. - 18)	(Roll No. - 72)
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**Department of Computer Science & Technology
TECHNIQUE POLYTECHNIC INSTITUTE**
Panchrokhi, Sughandhya,
Hooghly – 712102

Department of Computer Science and Technology
Technique Polytechnic Institute

Certificate of Approval

The foregoing embedded project entitled **"EMBEDDED PROJECT ON FACIAL EMOTION RECOGNITION SYSTEM USING MACHINE LEARNING"** is approved as an embedded project to meet the need of WBSCTVESD curriculum**.** The project is quite interesting as now days Machine Learning has a huge demand in various fields. We had gone through the project requirements and specification, project progress plan, not only that but also we discussed a lot on the scope of the project. After all the discussion we satisfied on the project and we allow this group to perform this research-oriented case studies as their hardware & software based final year project.

……………………………………..
Signature of the H.O.D / In-Charge,
Computer Science & Technology

……………………………………….
Signature of the Project Guide,
Computer Science & Technology

DECLARATION

We hereby declare that the project work entitled as **"EMBEDDED PROJECT ON FACIAL EMOTION RECOGNITION SYSTEM USING MACHINE LEARNING"** is an authentic record of our own work carried out at Technique Polytechnic Institute, affiliated to the W.B.S.C.T.V.E.S.D. as required for the award of Diploma in **COMPUTER SCIENCE & TECHNOLOGY** under the guidance of **"Mr. Shibdas Bhattacharaya"** during the period 2021-2022 (5th to 6th Semester).

Team Members:

Sl. No.	Name of the Student	Section/Roll No.	Signature of Student
1.	Hillol Das	10	
2.	Sourav Das	18	
3.	Ishita Shadhukhan	28	
4.	Milan Halder	72	
5.	Utsav Saha	88	
6.	Souvik Chakraborty	101	

Date:

CERTIFICATE

This is to certify that the project entitled, **"EMBEDDED PROJECT ON FACIAL EMOTION RECOGNITION SYSTEM USING MACHINE LEARNING"** submitted by the following students in partial fulfilment of the requirements for the award of Diploma in COMPUTER SCIENCE & TECHNOLOGY as per the regulation of W.B.S.C.T.V.E. & S.D at the Technique Polytechnic Institute, Panchrokhi, Sugandha, Hooghly, is an authentic work carried out by the team under my supervision and guidance.

To the best of my knowledge, the matter embodied in the project has not been submitted to any other Institute for the award of any Degree or Diploma.

Project Team:

Sl. No.	Name of the Student	Section / Roll No.
1.	Hillol Das	10
2.	Sourav Das	18
3.	Ishita Shadhukhan	28
4.	Milan Halder	72
5.	Utsav Saha	88
6.	Souvik Chakraborty	101

_____   _____

(Mr. Shibdas Bhattacharaya)   **(Mr. Debasish Hati)**
Project Guide   **In-charge, Department of CST**

Date:

PROJECT COMPLETION CERTIFICATE

Project Title: Embedded Project on Facial Emotion Recognition System Using Machine Learning

Project Team: Group C

Sl. No.	Name of the Student	Section / Council Reg. No.
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2.	Sourav Das	D192023685
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5.	Utsav Saha	D192007921
6.	Souvik Chakraborty	D192007918

This is to certify that the Project Team consisting of the above students has successfully completed the project work entitled as **"EMBEDDED PROJECT ON FACIAL EMOTION RECOGNITION SYSTEM USING MACHINE LEARNING"** in partial fulfilment of the requirement for the award of DIPLOMA IN COMPUTER SCIENCE AND TECHNOLOGY prescribed by the DEPARTMENT OF COMPUTER SCIENCE AND TECHNOLOGY, TECHNIQUE POLYTECHNIC INSTITUTE, HOOGHLY.

This project is the record of authentic work carried out during the academic year (2021-2022).

_____   _____

(Mr. Shibdas Bhattacharaya)   **(Mr. Debasish Hati)**
Project Guide   **In-charge, Department of CST**

Date:

ACKNOWLEDGEMENT

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PROJECT PROGRESS PLAN

The Project Progress Plan of the Final Year Project for
Academic Session 2021-2022

Project Title:	**Embedded Project on Facial Emotion Recognition**
Broad Topic:	**Embedded Project using Machine Learning**
Institute Name:	Technique Polytechnic Institute
Address:	Panchrokhi, Sugandhya, Hooghly, PIN-712102
Department:	Computer Science and Technology (CST)
Project Guide:	Mr. Shibdas Bhattacharaya, Lecturer, CST
Group No.:	Group C
Group Members:	Hillol Das (Registration Number - D192023656)
	Sourav Das (Registration Number - D192023685)
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	Ishita Sadhukhan (Registration Number - D192023658)
	Utsav Saha (Registration Number - D192007921)
	Souvik Chakraborty (Registration Number - D192007918)
Academic Session:	2021-22

GANTT CHART for 5th Semester

Particulars Of the Task	Weeks								
	1	2	3	4	5	6	7	8	
Estimate Date of Completion	06/11/2021	13/11/2021	20/11/2021	27/11/2021	04/12/2021	11/12/2021	18/12/2021	31/12/2021	31/12/2021
Introduction to Machine Learning	�								
Tools Selection for Project		▓							
Python Overview		▓							
Python Project Recruitment			▓						
Python Road Map			▓						
Data Analysis				▓	▓				
Image Enhancement					▓				
Noise Reduction					▓				
Video to Frames Extract						▓			
Selection of Frames						▓			
Histogram Equalization							▓		
Color Segmentation							▓		
Finding Training Model							▓	▓	
Solution								▓	
Training Database								▓	▓
Actual Date Of Completion	06/11/2021	13/11/2021	20/11/2021	27/11/2021	04/12/2021	11/12/2021	18/12/2021	31/12/2021	31/12/2021

GANTT CHART for 6th Semester

Particulars Of the Task	Weeks							
	1		2		3		4	5
Estimate Date of Completion	19/04/2022	21/04/2022	26/04/2022	28/04/2022	03/05/2022	05/05/2022	10/05/2022	11/06/2022
Created Model.h5 file	■							
Capturing Frame from Webcam		■						
Cascade Classifier		■						
Creating Rectangular Frame on Face Detection			■					
Classifier Predict			■					
Live Video Analytics				■	■			
Showing Emotion					■	■		
Validation						■		
Testing						■	■	
Timing							■	
Launching								■
Actual Date Of Completion	19/04/2022	21/04/2022	26/04/2022	28/04/2022	03/05/2022	05/05/2022	10/05/2022	11/06/2022

Submitted By:

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The Project Progress Plan is prepared by the students under my look after. The distribution of the project work throughout the academic session is made considering all the other academic activities as per the Academic Calendar of WBSCTVESD. The effort made by the students for preparing this work plan is commendable.

...…………………………………………………..
Signature of the Project Guide
Mr. Shibdas Bhattacharya
Department of Computer Science & Technology,
Technique Polytechnic Institute

INTRODUCTION

Facial Emotion Recognition using Machine Learning is the identification of different emotion of the humans by the unique characteristics of their faces. Facial Emotion Recognition is an Image Classification problem located within the wider field of Computer Vision. Facial expressions are detected by analyzing the discrepancy in various features of human faces such as color, posture, expression, orientation etc. To detect the expression of a human face it is required to detect the different facial features such as the movements of eye, nose, lips, etc. and then classify them by comparing with trained data using a suitable classifier for expression recognition.

Machine Learning: Machine Learning is all about machines learning automatically without being explicitly program. It trains the machines by building various machine learning models using the data and different algorithms. The choice of algorithms depends on what type of data we have and what kind of task we are trying to automate.

Deep Learning: Deep learning is a subset of machine learning, which is essentially a neural network with three or more layers. These neural networks attempt to simulate the behaviour of the human brain. Deep learning technology lies behind everyday products and services (such as digital assistants, voice-enabled TV remotes, and credit card fraud detection) as well as emerging technologies (such as self-driving cars).

Neural Network: A neural network can be understood as a network of hidden layers, an input layer and an output layer that tries to mimic the working of a human brain. The hidden layers can be visualized as an abstract representation of the input data itself. These layers help the neural network understand various features of the data with the help of its own internal logic. An output layer can be used as a translator that helps us to understand the logic of the network and convert the target values.

Embedded System: Embedded means something that is attached to another thing. An embedded system can be thought of as a computer hardware system having software embedded in it. An embedded system is a microcontroller or, microprocessor-based system.

Computer Vision: Computer vision is simply the process of perceiving the images and videos available in the digital formats. In machine learning, Computer vision is used to train the model to recognize certain patterns and store the data into their artificial memory to utilize the same for predicting the results in real-life uses.

We are creating a Facial Emotion Recognition System on Embedded System using Machine Learning. We have used Deep Learning approach combining a Convolutional Neural Network (CNN) training model to train dataset of different emotions to get the most accurate result.

Some of the different emotions are –

1. Angry
2. Disgust
3. Fear
4. Happy
5. Neutral
6. Sad
7. Surprised

ABSTRACT

Facial Emotion Recognition using Machine Learning is used to identify different emotion of the humans by their unique characteristics of their faces. Facial Emotion Recognition is an Image Classification problem located within the wider field of Computer Vision. So, we are creating this project to enhance the work efficiency any company for keeping an eye on their employees' behaviour. Facial expressions can be detected by analyzing the various features of human faces viz, the movements of eye, nose, lips, etc. and then classify them by comparing with trained data using a suitable classifier for expression recognition. At first we installed some libraries to make our project by using python. Then we created a training module and loaded the datasets which we created on different emotions as grayscale images, 64x64 pixels in training module as train and test datasets and then tested the accuracy through the CNN module, but at first we didn't got the accuracy so, we increased the dataset to 30000 images then the accuracy came near about 99.75%.

OBJECTIVE

Our objective for the project is used to detect the user's emotion from a video captured from the webcam by extracting frames on the embedded system using machine learning and we used the Deep Learning with CNN dataset training model for getting the best accuracy.

METHODOLOGY

Import the libraries:

At first, we decided which libraries we are going to use. There are many libraries that is already installed during installation of Python 3.7.9. Some of the libraries, we had to download manually through "pip install "<library name>" command. The libraries we used are following –

- Loadmat - The function loadmat loads all variables stored in the MAT-file into a simple Python data structure, using Python dictionary and list objects.
- NumPy - NumPy is a Python package, it is used as a library consisting of multidimensional array objects and a collection of routines for processing of array.
- CSV - A comma-separated values (CSV) file is a delimited text file that uses a comma to separate values. Each line of the file is a data record.
- Initialize - Initialize is a procedure to set the weights of a neural network to small random values that define the starting point for learning or, training of the neural network model.
- Predict – Predict function enables us to predict the labels of the data values on the basis of the trained model. The predict function accepts only a single argument.
- Minimize - The minimize function provides a common interface to unconstrained and constrained minimization algorithm.
- OpenCV - OpenCV is a huge open-source library for computer vision, machine learning, and image processing. OpenCV supports a wide variety of programming languages.
- OS - Operating system (OS), program that manages a computer's resources, especially the allocation of those resources among other programs.
- Pandas - Pandas is a fast, powerful, flexible and easy to use open source data analysis and manipulation tool, built on top of the Python programming language
- Matplotlib - Matplotlib is an amazing visualization library in Python for 2D plots of arrays. Matplotlib is a multi-platform data visualization library built on NumPy arrays.
- Scikit-Image - Scikit-image is a collection of algorithms for image processing. It is available free of charge and free of restriction.
- Time - The time function returns the number of seconds passed since epoch.
- Globe API - Application Programming Interface (API) is a set of subroutines, functions, and procedures that help a developer create application software.
- Pillow - Pillow is built on the top of PIL (Python Image Library) and is considered as the fork for the same as PIL supports many image file formats including BMP, PNG, JPEG, and TIFF.
- Keras - Keras is a neural network library while TensorFlow is the open-source library for a number of various tasks in machine learning
- TensorFlow - TensorFlow is an end-to-end open-source platform for machine learning. It's a comprehensive and flexible ecosystem of tools, libraries and other resources that provide workflows with high-level APIs.
- Augmenter - Augmenter is a Python package designed to aid the augmentation and artificial generation of image data for machine learning tasks.

Load the dataset:

There were already many datasets on internet like Keras, MNIST, Kaggle dataset. But we preferred to create our own dataset. So first we had to take photos of each class. Data variety was needed therefore we all captured photo of our own face emotions. After collecting all of our facial emotions we learned that wasn't enough, so we had to augment the data. After augmenting we had a fixed amount of data for each class. Then we converted them into grayscale and resized them into 64 shapes. Then we put all the data into same place and made the X.npy file and Y.npy file. X.npy is our training dataset and we also created another npy file for the testing set. We used one hot method to create the Y.npy as testing set.

Preprocess the data:

The image data cannot be fed directly into the model so we need to perform normalization operations then we resized and grayscale the images and after this processing our images data is ready for our neural network. The dimension of the training data is (30000,64,64), The CNN model will require one more dimension so we reshape the matrix to shape (30000,64,64).

Create the model:

Now we will create our CNN model in python for Facial Emotion Recognition project. A CNN model generally consists of convolutional and pooling layers. It works better for data that are represented as grid structures; this is the reason why CNN works well for image classification problems.
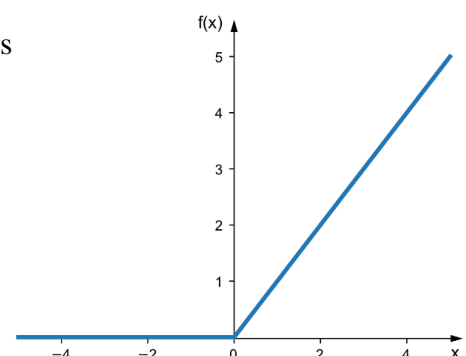
Train the model:

We trained the dataset then we validated data by the number of epochs and test size. It takes some time to train the model for better accuracy.

Training Activation Function:

The activation function of a node defines the output of that node given an input or set of inputs. A standard integrated circuit can be seen as a digital network of activation functions that can be "ON" (1) or "OFF" (0), depending on input. This is similar to the linear perceptron in neural networks. However, only nonlinear activation functions allow such networks to compute nontrivial problems using only a small number of nodes, and such activation functions are called nonlinearities.

- **Softmax** – The softmax activation function is the mathematical model that accepts a vector of numeric data variables as input and then normalizes the data. That is, it normalizes (scales the data values) to a probability distribution wherein the probability of every data value is proportional to the scale of every value present in the vector. As a result, all the data values will be in the range of 0 to 1. Also, the summation of all the data values would be equal to 1 as they are being interpreted as probabilities.
- **Relu** – The Relu or Rectified Linear Activation Function is a type of piecewise linear function. Relu activation function is computationally fast hence it enables faster convergence of the training phase of the neural networks. Hence it is a good choice in hidden layers of large neural networks. The units function is the positive integer, dimensionality of the output space. It's mathematical expression is f(x)=max(0,x).
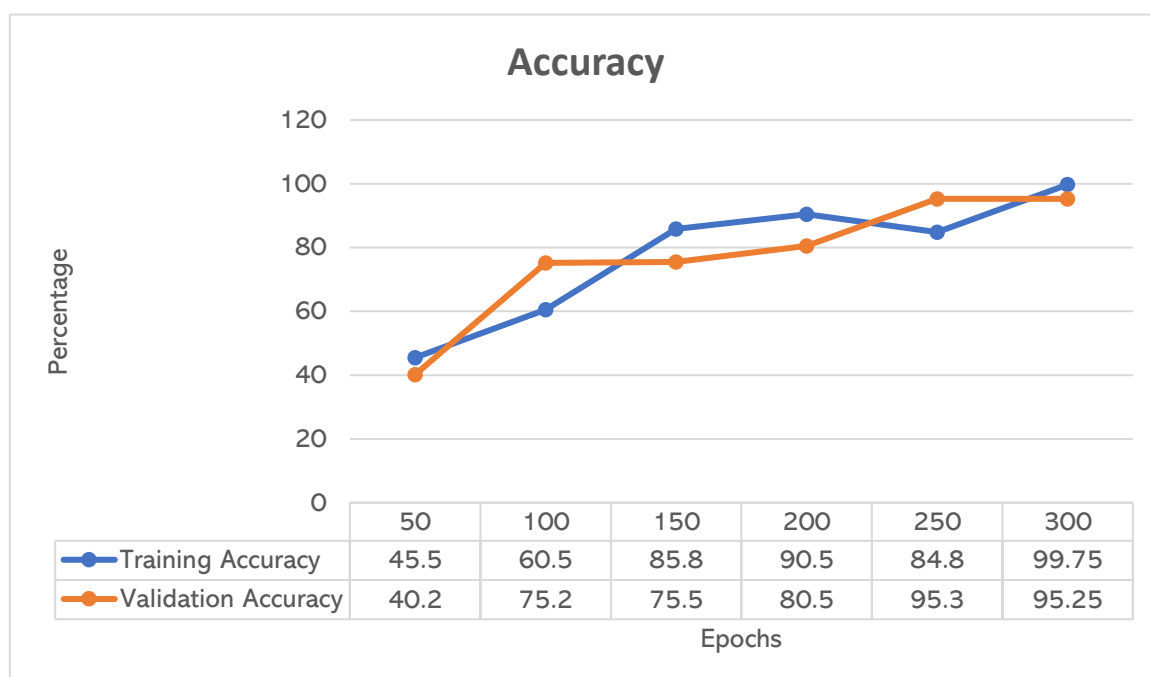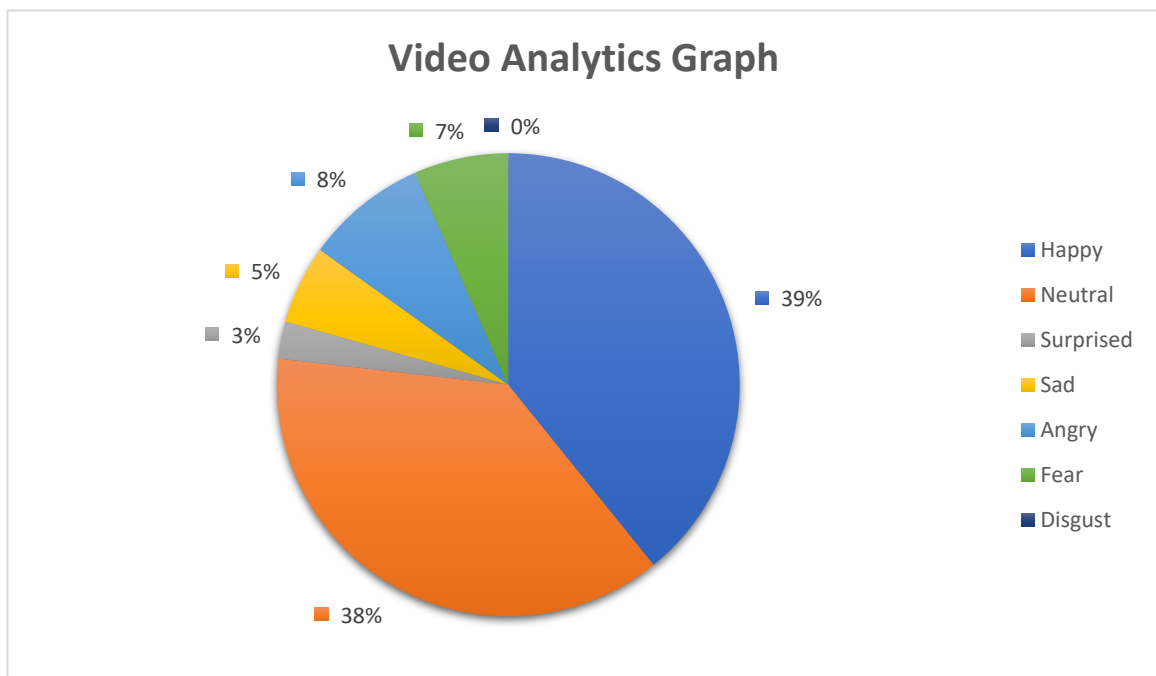
Evaluate the model:

We have 30,000 images in our dataset which will be used to evaluate how good our model works. The testing data was not involved in the training of the data therefore, it is new data for our model. At first we trained the dataset with deep learning dataset training model where we got the accuracy of 82.58% then we implemented deep learning with CNN module dataset training model where we got the accuracy of 99.75%.
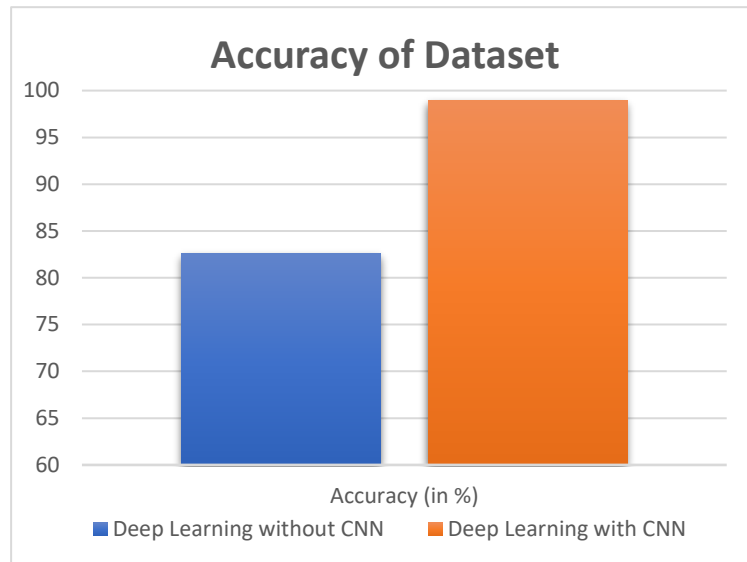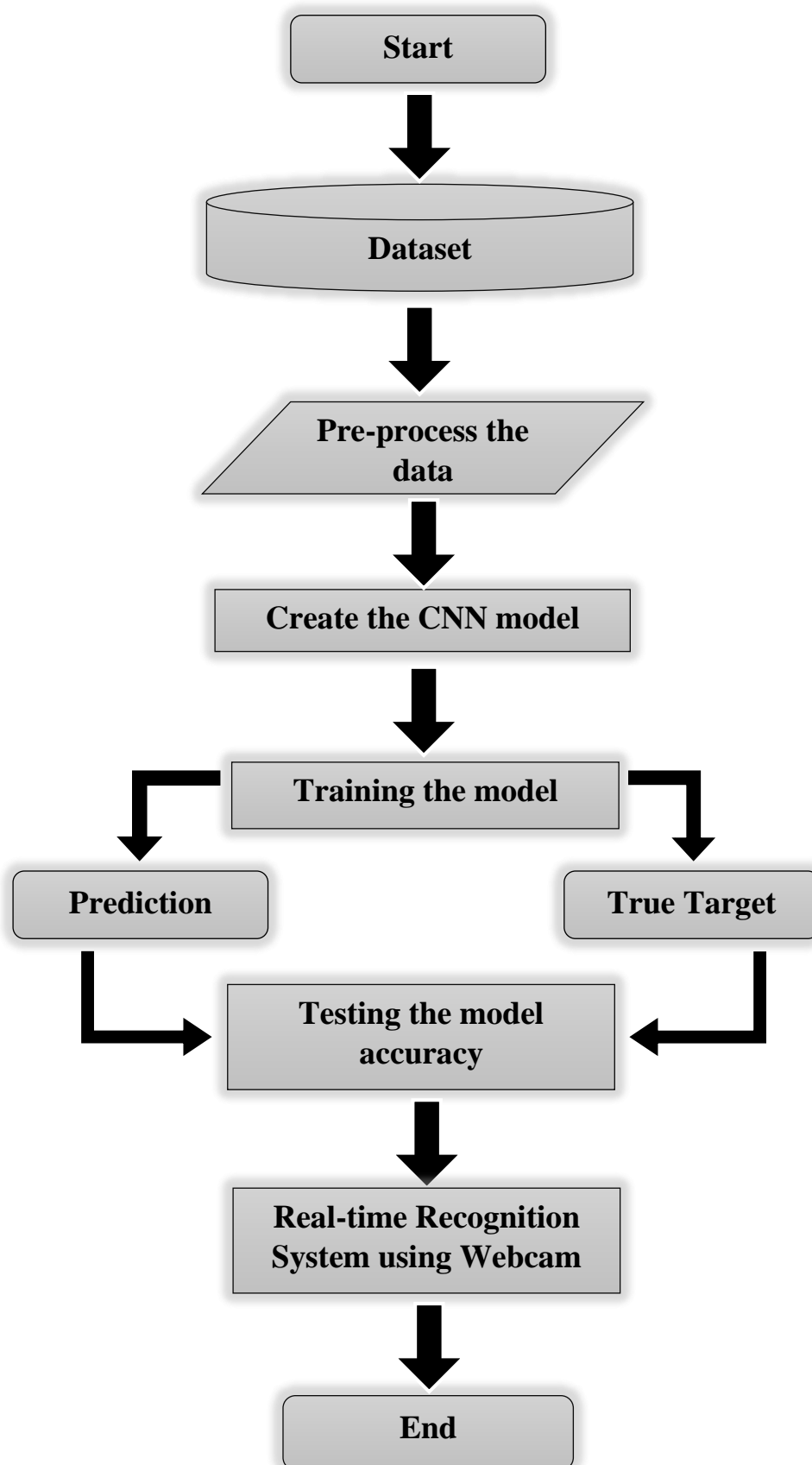

Real-time recognition system:

A real time face recognition system is capable of identifying persons emotion from the webcam by capturing videos and extracting frames. To recognize the face emotion in a frame, first we checked whether the face is present in the frame. If it is present then mark it as a region of interest (ROI) as the yellow square box then extract and process it for facial emotion recognition system. After processing the image then it shows on the screen which emotion the person is having right now.

	50	100	150	200	250	300
Training Accuracy	45.5	60.5	85.8	90.5	84.8	99.75
Validation Accuracy	40.2	75.2	75.5	80.5	95.3	95.25

Loss

Video Analytics Graph

Flowchart:

```
                    ┌─────────────┐
                    │    Start    │
                    └─────────────┘
                           │
                           ▼
                    ╭─────────────╮
                    │   Dataset   │
                    ╰─────────────╯
                           │
                           ▼
                   ╱───────────────╱
                  ╱ Pre-process the╱
                 ╱      data      ╱
                ╱───────────────╱
                           │
                           ▼
              ┌──────────────────────┐
              │  Create the CNN model│
              └──────────────────────┘
                           │
                           ▼
              ┌──────────────────────┐
         ┌────│   Training the model │────┐
         │    └──────────────────────┘    │
         ▼                                 ▼
  ┌─────────────┐                  ┌─────────────┐
  │ Prediction  │                  │ True Target │
  └─────────────┘                  └─────────────┘
         │                                 │
         └────┐      ┌──────────────┐      │
              └─────▶│ Testing the  │◀─────┘
                     │ model        │
                     │ accuracy     │
                     └──────────────┘
                           │
                           ▼
                  ┌──────────────────┐
                  │ Real-time        │
                  │ Recognition      │
                  │ System using     │
                  │ Webcam           │
                  └──────────────────┘
                           │
                           ▼
                    ┌─────────────┐
                    │     End     │
                    └─────────────┘
```

Sample Dataset:

- **Angry:**

Fig 1.1 (Original Image)   **Fig 1.2 (Resized and Grayscale Image)**

- **Happy:**

Fig 2.1 (Original Image)   **Fig 2.2 (Resized and Grayscale Image)**

- **Neutral:**

Fig 3.1 (Original Image)   **Fig 3.2 (Resized and Grayscale Image)**

- **Sad:**

Fig 4.1 (Original Image)   **Fig 4.2 (Resized and Grayscale Image)**
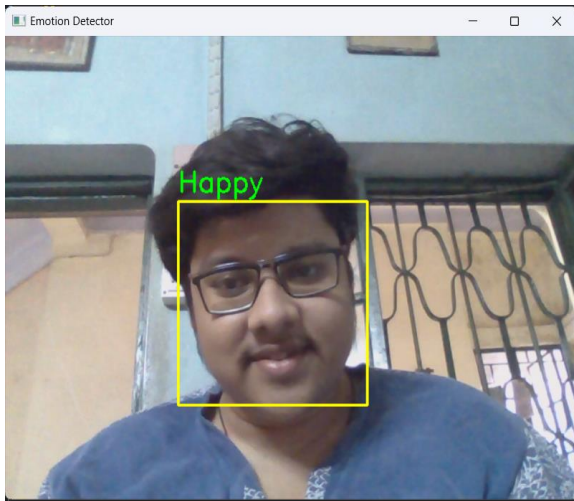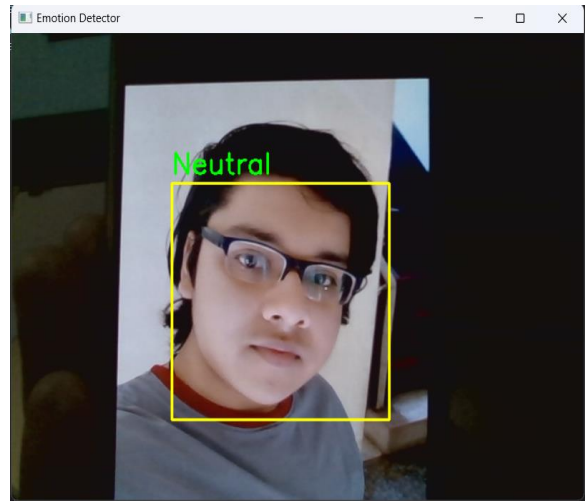
- **Scared:**

Fig 5.1 (Original Image)   **Fig 5.2 (Resized and Grayscale Image)**

Outputs of Facial Emotion Recognition:

Single Face Recognition –

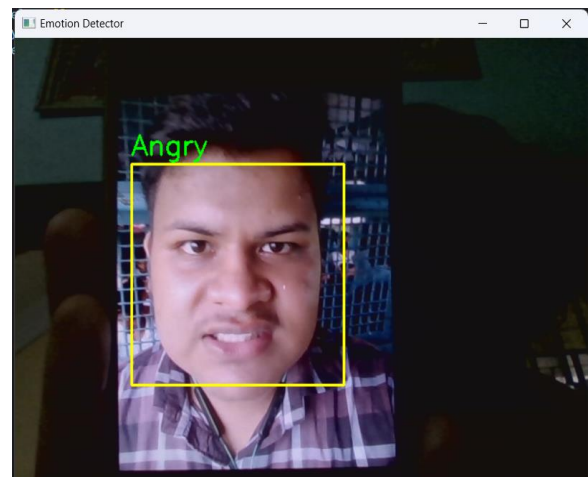**Happy Face Emotion**

Neutral Face Emotion
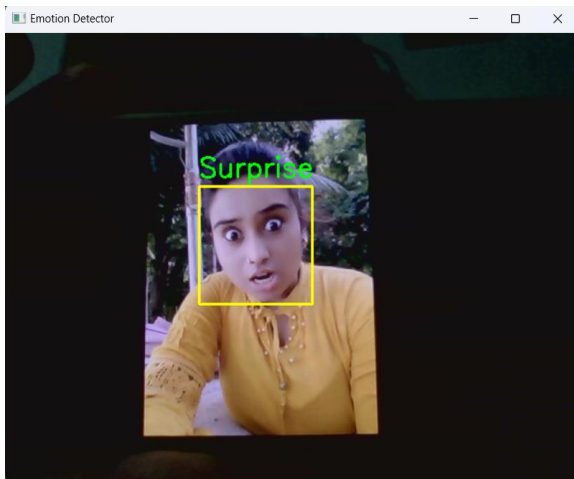
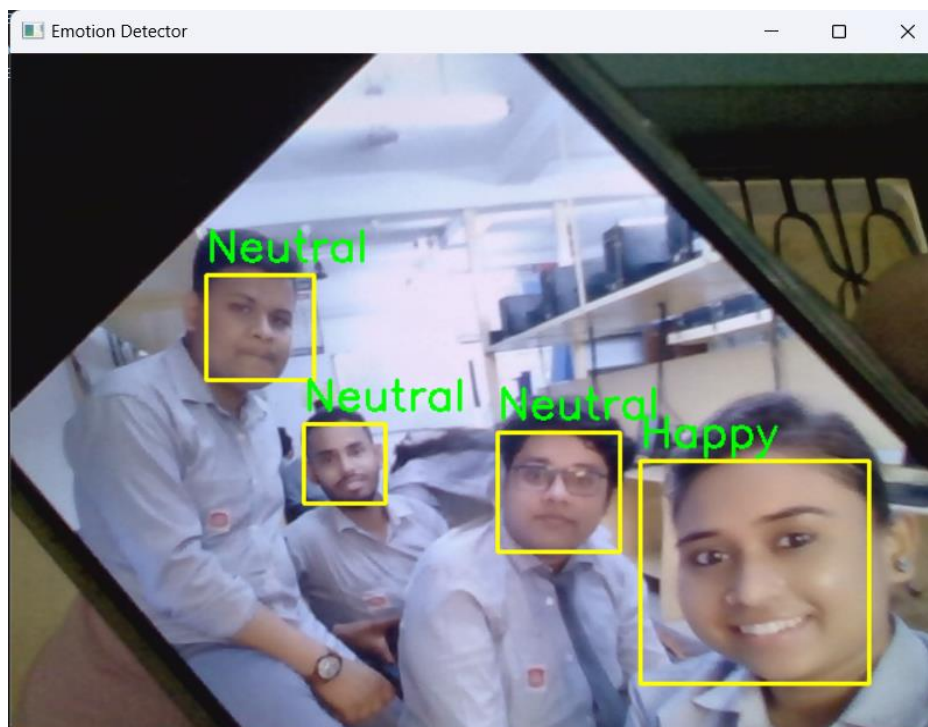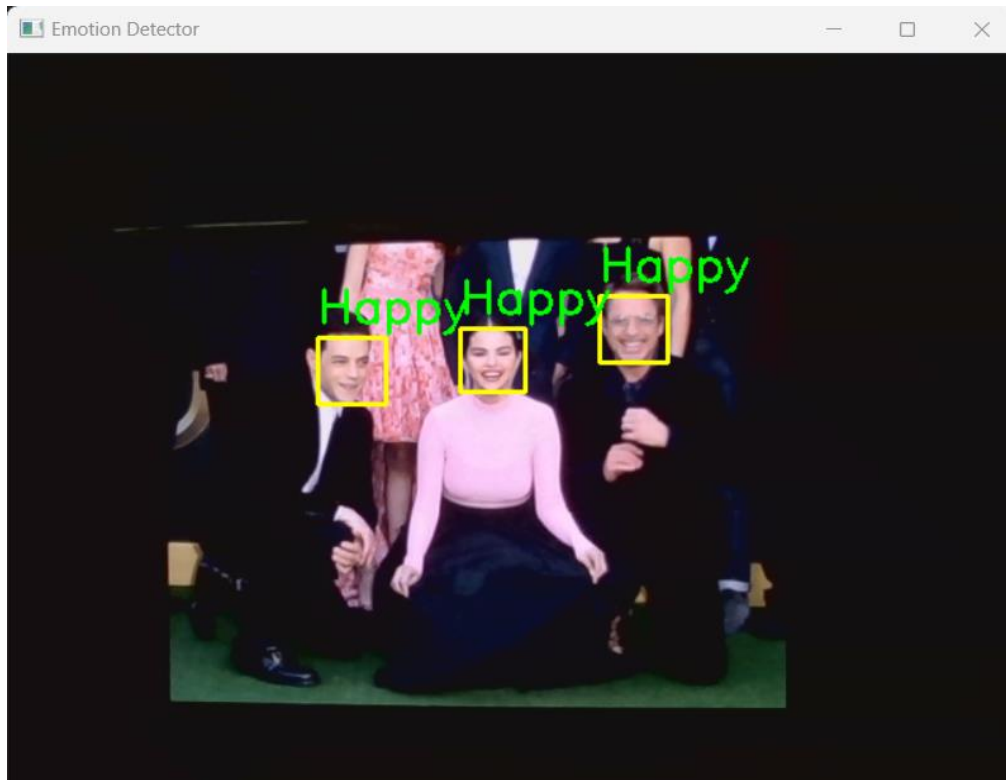
Surprise Face Emotion
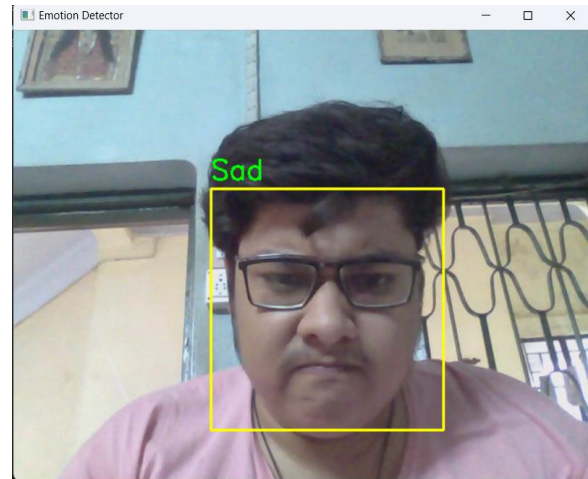
Sad Face Emotion
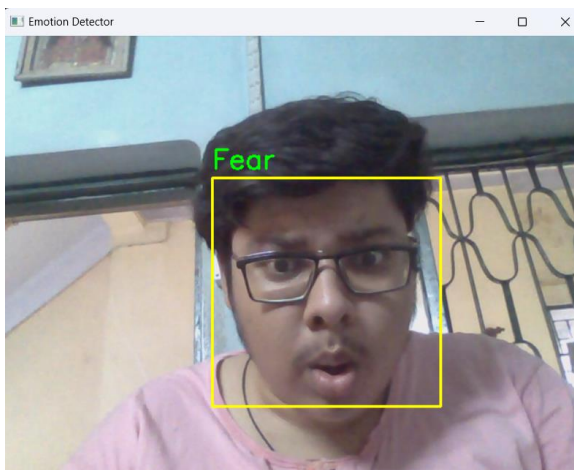
Fear Face Emotion

Angry Face Emotion

Multiple Face Recognition –

ADVANTAGES AND DISADVANTAGES

- **Advantages: -**

    i. Real time emotion-based analysis creates opportunities for automated customer service agents to recognize emotional state of the callers through video.
    ii. This helps companies establish deep emotional connections with their consumers through virtual assistant devices.
    iii. This technology help children and elderly people by providing timely medical care and assistance by alerting to their caregivers or other family members.
    iv. It helps employees and HR (Human Resource) team of any company to manage stress levels. This will create healthy work environment and increase productivity. HR and managers will recognize positive and negative moods of the employees and customers which help to grow the businesses to grow.
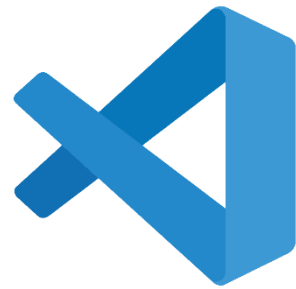
- **Disadvantages: -**

    i. Performance and results of the emotion sensing system depends on accuracy of the sensors such as cameras, thermal image sensors, facial recognition algorithm used and so on. Highly accurate system will be expensive due to use of costly components.

TOOLS USED

Software Used –

- Anaconda
- VS Code
- Spyder
- Python
- Excel

APPLICATIONS

1. Application, if to keep an eye on any behaviour of the salesman while sailing something to the customer then we can do it by using a camera module which will capture the images of the salesman's face and then recognize the emotion by which we can understand the behaviour of the salesman without keeping any other fellowmen to watch.
2. For marketing purpose, the emotion recognition in also used.
3. In e-learning teacher can understand the emotion of the students.
4. It will be helpful of the aptitude round of any company to understand the emotion and behaviour without observing on his aptitude round camera recording.

FUTURE WORK

1. To decrease the rendering speed as to get result on a faster way.
2. To remove the webcam noise which is Gaussian Noise.
3. To develop this facial emotion recognition project in Android Studio for accessing it from the mobile phone by several users.

REFERENCE

1. GitHub – https://github.com
2. Kaggle – https://www.kaggle.com/datasets
3. Google face Emotion Recognition Dataset – https://medium.com/analyticsvidhya/emotionrecognitiondatasets
4. MNIST – https://deepai.org/dataset/mnist
5. Keras – https://keras.io/api/datasets
6. The recognition of facial expressions with automatic detection of the reference face – https://www.superdatascience.com/opencv-face-detection
7. Feature Detection and Description of Face Emotion – http://opencvpythontutroals.readthedocs.io/en/latest/py_tutorials/py_feature2d/py_table_of_contents_feature2d/py_table_of_contents_feature2d.html
8. Books:
    i. Understanding Machine Learning - Written by
        Shai Shalev-Shwartz and Shai Ben-David
    ii. Fundamentals of Machine Learning for Predictive Data Analytics – Written by
        John D. Kelleher