FACIAL EXPRESSION RECOGNOTION USING MACHINE LEARNING

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled **"Facial Expression Recognition using Machine Learning"**, submitted by Nishat Tasnim Nabila ID: 182-15-984 and Ebnath Umayra ID: 182-15-983 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 24/02/2022.

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We hereby declare that, this project has been done by us under the supervision of **Mohammad Monirul Islam, Senior Lecturer of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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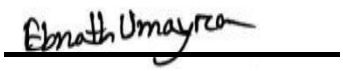

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ABSTRACT

This is a research based project named “FACIAL EXPRESSION RECOGNOTION USING MACHINE LEARNING.” Nowadays, Machine Learning(ML) has played a vital role in modern technology. For facial detection, recognition, and detection of facial expressions, artificial intelligence (AI)-based computer technology is employed. Machine learning has a branch called "Deep Learning"(DL). For tracking and classifying the human face, several approaches are necessary. Deep learning algorithms have been outperforming traditional methods in computer vision tests. Facial detection and recognition applications are used in various fields to ensure security, identification, and verification. Facial emotion recognition helps identify a person’s feelings from facial expressions. In this paper, we will work on detecting human faces, recognizing faces accurately, and classifying facial expressions.To detect and identify facial expressions accurately, we used deep learning algorithms. We divided our work into three segments: the first segment, where we are going to capture a face in real-time and to detect the face accurately, for that purpose we are using the Haar-Cascade detection algorithm; now in the second segment, where it processes the first part’s input based on face feature as well as the database we used (CNN). The final segment is where it authenticates the face so that it can classify the expression of the face into such categories as happy, sad, disgust, surprise, angry, and neutral.The proposed work’s objective is to simplify face detection, recognition, and emotion recognition.In short, we planned to ensure the performance of the automatic face expression detection and recognition systems is dignified with accuracy.

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CHAPTER 1

Introduction

1.1 Introduction

These days, human-computer interaction has become a common trend where image processing plays a vital role. A few years ago, it was quite challenging to solve problems that were related to computer vision. Besides that, recognizing the facial expressions was quite an arduous task.The advent of modern technologies and the rapid use of innovative technologies have helped us a lot to improve the problems of light issues, aging, and so on.Nowadays, these applications are used rapidly to accurately identify people and sometimes even identify people's moods by interpreting their facial expressions.After interpreting the facial features and their actions, we can determine anyone's emotional condition.Firstly, in the identification process, it (the system) identifies the human face in real time.After identifying it correctly, the system starts the recognition process. Convolutional Neural Networks (CNN) was developed to make feature selection easier and to outperform other machine learning techniques. The working steps of facial expression recognition as well as classification include several terms. For instance, we can say pre-processing, orientation, detection, feature extraction, and so on.All these procedures can be performed with the deep learning model.It outplays the handy computations.In the below sections, we tried to discuss all three phases of this work.

1.2 Objective

The goal of the emotion detection and recognition system is to identify accurately a human face expression after it has been detected and recognized. That is, the system must recognize sadness, happiness, rage, disgust, surprise, fear, and neutrality.

1.3 Motivation

Face emotion detection and recognition is one of the most extensively employed technologies in the motivation of supreme fields. In the fields of schools and college attendance systems, face detection and recognition technologies are used. They can also catch criminals and terrorists. It can be considered for the safety of regular citizens as

well as the country's critical security. Face recognition can be used by the government to verify voter lists, locate missing people, determine the population or census, as well as provide security against internet fraud, secure e-commerce, and be widely employed in medicine and healthcare. Another major area of research for human-computer interactionis emotion recognition through facial expression detection. Nonverbal communication cues are conveyed through facial expressions and various gestures.

1.4 Summary

Doubtlessly, we can say that image processing and object classification have gotten a lot of attention, but facial expression classification has gotten less attention.

Our research is a novel technique that employs different models to simplify the complex difficulties of human-machine interaction. With our pre-trained model, we make every attempt to increase the accuracy and efficiency of our classification.

1.5 Research Question

Throughout my time working on this project, I've encountered numerous challenges as well as some questions. Some of the most common queries are given below:

- Which platform will be the easiest or best to use for this project?
- In deep learning research, is it possible to acquire data from row images?
- Is it possible to detect and recognize multiple faces in real time?
- Is it possible to improve real-time facial expression recognition systems by using this approach?
- Is this required database divided into sections for different emotions?

1.6 Expected Outcome

The end result of this project:

- Capable of detecting and recognizing human faces in real time,
- It is capable of detecting human emotions in real time.
- Capable of distinguishing between seven different emotions in human beings.

1.6 Report Layout

In this report, the first chapter describes the overview, objective, motivation, summary, research questions, and expected outcome of our project.Chapter 2 discussed related work's background study, comparative analysis of our work, and the challenges of our project.Chapter 3 provides our research methodology, which includes research subject and instrumentation, data collection, statistical analysis, an explanation of our proposed methodology, our proposed methodology design, flow chart and design classification, and lastly, the requirements that are needed for implementation.Chapter 4 illustrates the result of the experiment and the discussion part.Chapter 5 provides Impact on society of our proposed project and chapter 6 is all about summary and conclusion.

CHAPTER 2

BACKGROUND

2.1 Related Works

Several papers on face-emotion categorization and identification have been published in recent years. In 2020, Shaik Asif Hussain and Ahlam Salim Abdallah Al Balushi published a paper on "real-time face emotion classification and recognition using deep learning models." [7]They use the VGG-16 model.Also, by using convolution neural networks (CNN), they generated the facial encoding. They worked on six types of facial expressions. The work of C. Shan, S.G.a., P.W.M, 2009. ([1] This work experimentally evaluates facial representation based on statistical local features and local binary patterns for person-independent facial emotion identification. There is another work by Bin Li (2009), [5] which presents an overview of steganography and steganalysis for digital photos, with a focus on the underlying principles, the evolution of steganographic approaches for images in spatial representation and JPEG format, and the creation of associated steganalysis systems.

2.2 Comparative Analysis and Summary

We applied several pre-trained network models with the CNN architecture. With the Lenet-5 model, we got around 86% accuracy, but we could not find that much better performance in real-time implementation at the expression classification stage. Also, we applied VGG-16, from which we got 62% accuracy.
To get better accuracy, we apply the "deep CNN model," which refers to the number of layers in the existing network. A deeper network means a more convolutional layer. We simply increase the number of layers of convolution operations. We have got 94% accuracy with our customized CNN model.

2.4 Challenges

This project is quite challenging for us.We faced several difficulties implementing the project according to our plans. Especially in the training process, it takes a long time to complete the process. To detect human emotions, we have to give a lot of time to this.

CHAPTER 3

Research Methodology

3.1 Introduction

In this section, we attempted to share all of the necessary knowledge that we gathered while working on this project.We mainly worked on seven human emotions.For executing our project, we need to collect multiple data.We need to process that data, and then we can be able to use them as per our requirement.

3.2 Research Subject and Instrumentation

I use deep CNN model in my project where human face detection and expression recognition are the main things.For executing our project, we used the "Windows" operating system, and, as a language, we chose the Python programming language. We need to install a few packages also. Besides that, some
other instruments that I used are given below:

1. PC
2. Image dataset (for testing)
3. Internet Connection
4. Several journals for references
5. Web Camera
6. Human face to check my project's accuracy

3.3 Data Collection

The system's design model is evaluated functionally at multiple levels. 1) We need to build a dataset so that we can classify emotions using the architecture of a neural network (CNN).I used kaggle datasets for my proposed work.Here is the link to the given dataset (https://www.kaggle.com/msambare/fer2013). This dataset contains a total of 35887 images. Train folder contains 28709 images and test folder contains 7178 images,

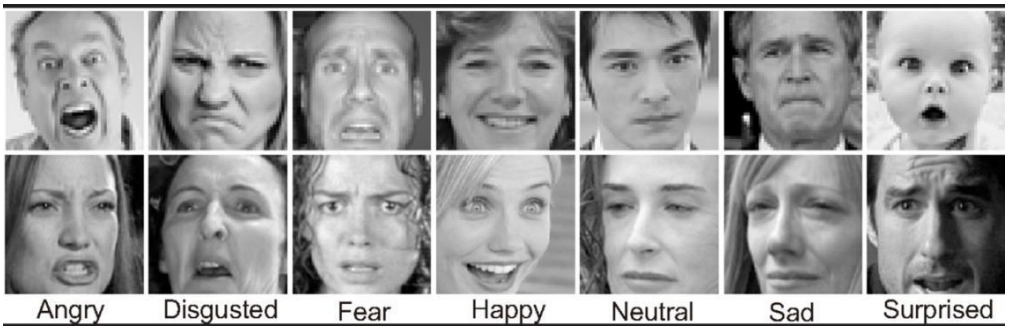

Fig-3.3.1: sample kaggle dataset

3.4 Workflow

The working procedure of our project are given below-

1. Data Processing: We collected pre-processed datasets online. But if we want to make our own dataset, then we need to collect a lot of raw data, resize all the raw data, and if the data is not enough, then we need to go through the data augmentation process. Working on raw data is quite difficult as there you might find noise and errors in many of the images.So, first we need to process those images manually. We collected the dataset online, so we don't need to do data augmentation. But we resized our dataset images into 50 x 50 dimensions before applying any model to it.

2. Selecting Model: There are multiple CNN models. After researching different types of models, we decided to apply the deep CNN algorithm to our project. Besides that, we applied the transfer learning model as well as the vgg-16 model to our dataset. We get different types of accuracy on them.And finally, we selected the deep CNN model for our project, where we got 95% accuracy.

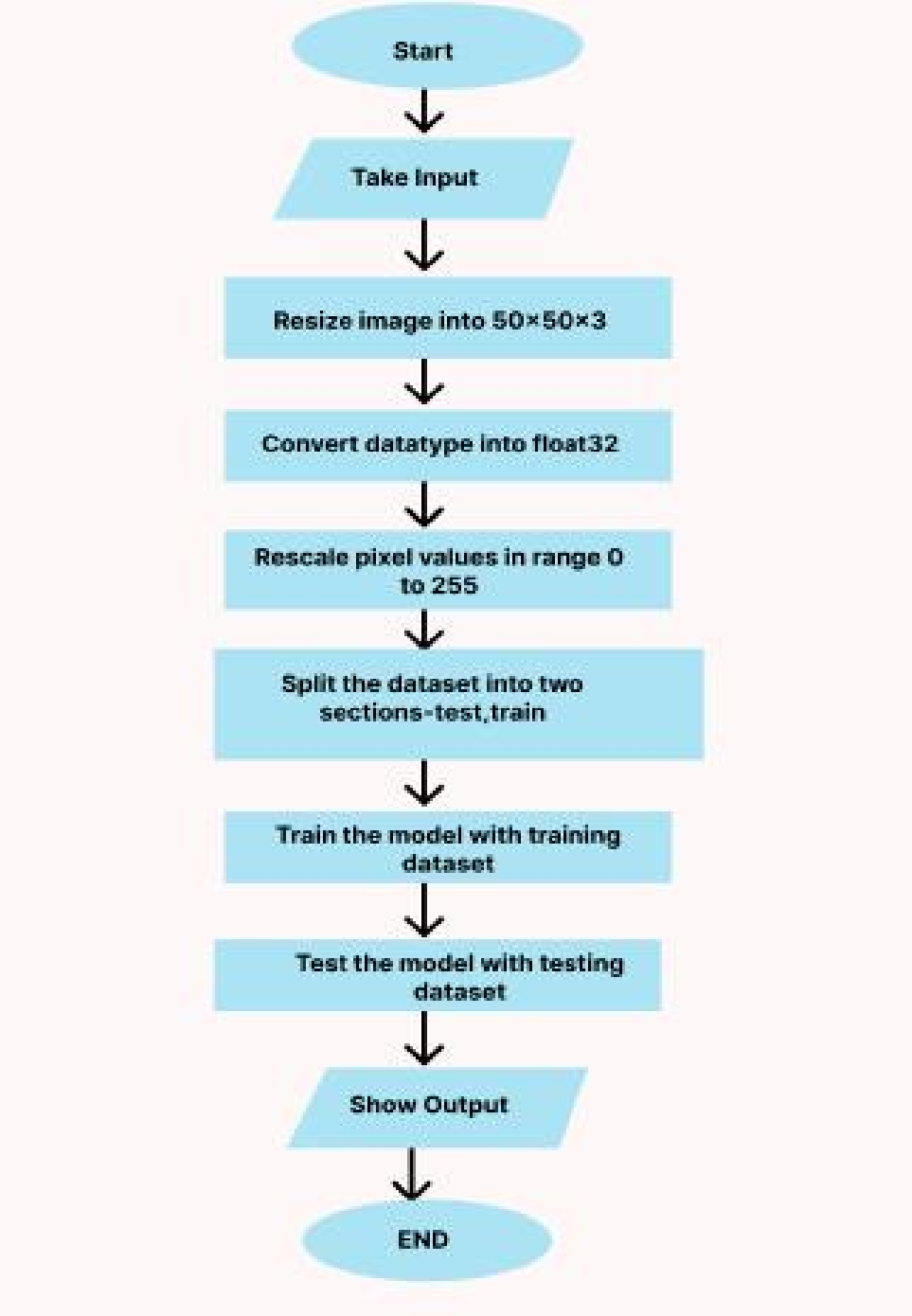

Figure 3.4.1: Project's workflow

3.5 Proposed Methodology

The proposed paper is about detecting human faces, recognizing emotions, and classifying them using Python.This work is carried out in three steps. The steps are as

follows: the first is to detect faces; the second is to recognize faces in real time; and the third is to classify facial emotions. Before starting the process we worked on our database that we collected from online. We resized the images in 50x50 pixels. After this process, the video camera can detect the face.In the first step, the Haar cascade algorithm is used for face detection. This algorithm was implemented using open-source computer vision software. Two algorithms with unique features are combined to identify faces. The algorithms are Viola-Jones and Haar Cascade. The images can detect structures, objects, and so on.In this step, a human face is identified and the pictures are extracted. Finally, for the next step, they are stored in the database, which is face recognition.The deep CNN model is used to match human faces that are stored in a data set, and it is recognized with the name of the detected or identified face.The faces are recognized from the data set.For the proposed work's execution, Anaconda and Python software are used.The expressions are anger, fear, disgust, happiness, neutral, and surprise.

3.5.1 Proposed Model(CNN Layer)

Convolution neural networks are a part of DNN, which is used to analyze visual information.In our proposed work we used deep CNN model that is made up with 10 convolutional layers.Besides that it has four max pooling layers, and one fully connected layer.It is a key stage and capacity to recognize objects. CNN is composed of three layers: the first is the input layer, the second is the hidden layer, and the third is the output layer.CNN's buried layers and layers that perform convolutions. In these models, kernels are employed to track picture border functions. RGB is the most common color space, and it combines three colors light in a variety of ways to produce a wide spectrum of colors. It interprets each pixel's RGB (red, green, and blue) color components.RGB image, corresponding filter for convolution, and the result of a convolution.

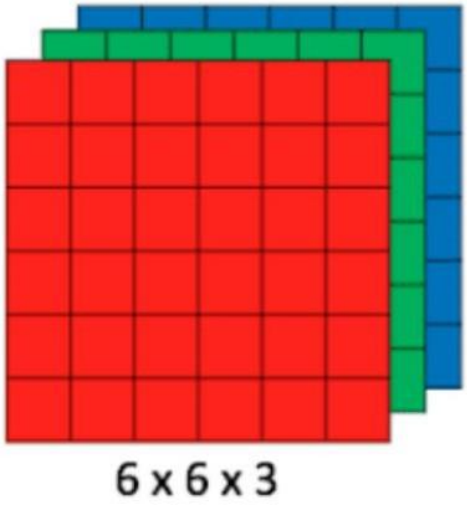

Fig-3.5.1(a): RGB image

The local field of sight, weight arrangement, and time or space sub-sampling to separate functions and reduce the number of training parameters are the most essential technologies in CNN. The CNN algorithm has the advantage of avoiding clear function separation as well as indirect learning of trained data. Stability, size, and speed can be achieved by employing the sub-sample structure in time or space. The advantages of voicerecognition and picture processing suggest that network entrance and topology can be rather satisfactory. In order to acquire the optimal solution for a certain CNN application architecture, the CNN algorithm needs more project design knowledge and must allow for application practice errors on a regular basis. This, after pre-processing, produces 32*32, which has 17 different photos, based on an input gray value of 96*96 at the pre-processing stage. The total processing of CNN in training faces is determined by fig-3.5.1 (b).

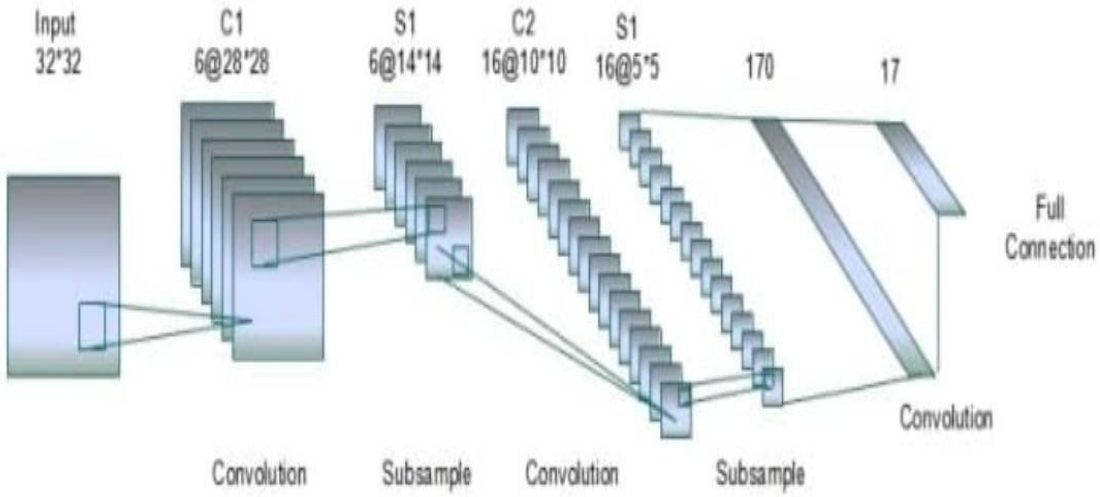

Fig-3.5.1(b): CNN model stages

We used 2*2 filters in our modified CNN and added more layers as we went deeper, as well as a 2*2 max-pooling layer that selects the maximum value at a specified area. To avoid linearity and learn complicated characteristics, we employed the RELU activation function. We utilized dropout regularization, which selects a node based on a probability that we specified, and it prevented the model from becoming overfit. To categorize and find the loss function, a softmax unit was employed.

3.5.2 Max Pooling Layer

This layer is used as a degenerating testing procedure in the CNN system. The main function of this layer is to calculate the maximum value from the feature map that is covered by the filter. Basically, in CNN, the pooling layer is considered a building block. The maximum pooling layer counts the brighter pixels in an image.

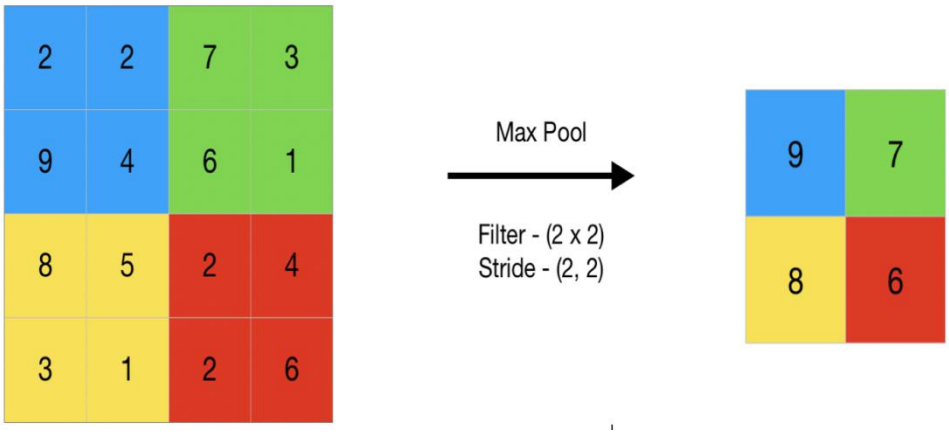

Fig-3.5.2: Maxpooling Layer

3.5.3 Dense Layer

This layer is commonly used in artificial neural networks. This layer's neurons receive output from their preceding layer. There, the dense layer's neurons do matrix-vector multiplication. In matrix vector multiplication, the output of the row vector from the preceding layers and the column vector of the dense layer is equal. In matrix-vector multiplication, the row vector must have the same quantity of columns as the column vector.

$$\mathbf{A}\mathbf{x} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \\ \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n \end{bmatrix}.$$

Fig-(3.5.3):General formula for a matrix-vector

3.5.4 Soft Max

We used the SoftMax layer in our project, which is typically used as the final output layer. This layer is used with sigmoid activation functions so that it can do multi-class classification tasks properly. This function helps to activate other functions that are necessary in the output layer of our model. The formula of SoftMax activation probability dissemination is given below:

$$\sigma(\vec{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}}$$

σ = softmax

$\vec{z}$ = input vector

e^{z_i} = standard exponential function for input vector

K = number of classes in the multi-class classifier

e^{z_j} = standard exponential function for output vector

e^{z_j} = standard exponential function for output vector

3.6 Proposed methodology design

Each of the functional blocks has its own set of operations. The camera is further preprocessed before being fed into the neural networks that collect images. To construct and train the dataset for identification and classification, the image is customized using network architecture. The steps of the function are given bellow.

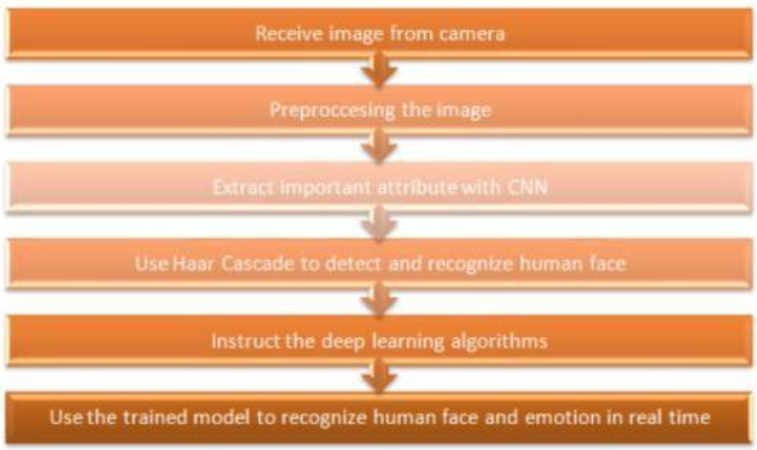

Fig-3.6: Block diagram of face detection, recognition and emotion classification

3.6.1 chart and design specification

A flow chart of real-time face detection, recognition, and categorization is shown in Figure (3.6.1). The photos are boxed and converted to binary patterns, which are then specified as feature vectors and stored in a database. The photos are trained to recognize different facial expressions in the input images and label them as sad, angry, delighted, disgusted, or neutral. The training procedure consists of seven steps: loading the dataset, processing, augmenting the data as a feature vector, developing and assembling the design model, training and storing the feature vector, and evaluating the test model.

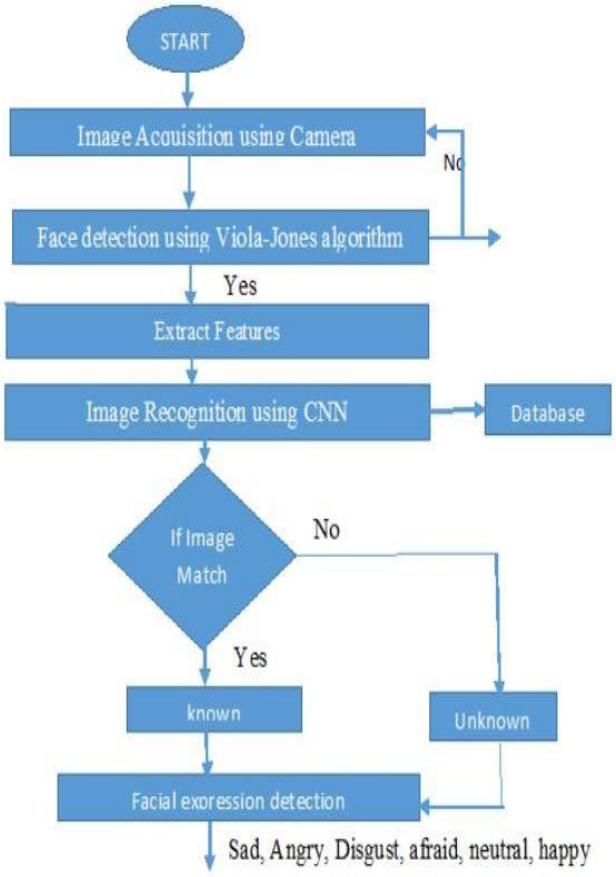

Fig-3.6.1: Face detection and recognition flow-chart

3.7 Implementation Requirement

We have explored a list of needs for face detection, recognition, and emotion classification after thoroughly analyzing all statistical and theoretical concepts and approaches.

Software/Hardware:

- Operating system(windows 7 or above)
- Hard disk(minimum 500GB)
- RAM(minimum 4GB)

Developing tools:

- Colab environment
- Visual Studio
- Good internet connection.

CHAPTER 4

EXPERIMENTAL RESULT AND DISCUSSION

4.1 Experimental Setup

The required libraries we used :

```
import keras
from keras.layers import Dense, Dropout, Activation, Flatten, Conv2D, MaxPooling2D, Lambda, MaxPool2D, \
    BatchNormalization
from keras.utils import np_utils
from keras.utils.np_utils import to_categorical
from keras.preprocessing.image import ImageDataGenerator
from keras import models, layers, optimizers
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix, accuracy_score
from sklearn.utils import class_weight
from tensorflow.keras.optimizers import SGD, RMSprop, Adam, Adagrad, Adadelta, RMSprop
from keras.models import Sequential, model_from_json
from keras.layers import Activation, Dense, Dropout, Flatten, Conv2D, MaxPool2D, MaxPooling2D, AveragePooling2D, \
    BatchNormalization
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ReduceLROnPlateau, ModelCheckpoint
from keras import backend as K
from keras.applications.vgg16 import VGG16
from keras.models import Model
from keras.applications.inception_v3 import InceptionV3
import os
from glob import glob
import matplotlib.pyplot as plt
import random
import cv2
import pandas as pd
import numpy as np
import matplotlib.gridspec as gridspec
import seaborn as sns
import zlib
import itertools
import sklearn
import itertools
import scipy
import skimage
from skimage.transform import resize
import csv
from tqdm import tqdm
from sklearn import model_selection
from sklearn.model_selection import train_test_split, learning_curve, KFold, cross_val_score, StratifiedKFold
from sklearn.utils import class_weight
from sklearn.metrics import confusion_matrix
from imblearn.over_sampling import RandomOverSampler
from imblearn.under_sampling import RandomUnderSampler
from sklearn.utils import shuffle
```

Fig: 4.1(a)-Required library

We mount our google drive to connect our directories:

```
train_dir = "/content/drive/MyDrive/LThesis/train/"
test_dir =  "/content/drive/MyDrive/LThesis/test/"

X_train = None
y_train = None
labels = None


# Load train data
X_train, y_train, labels = load_data(train_dir)
```

Fig:4.1(b)-Connected directories

Class labels after loading data:

```
{0: 'angry',
 1: 'disgust',
 2: 'fear',
 3: 'happy',
 4: 'neutral',
 5: 'sad',
 6: 'surprise'}
```

Fig:4.1(c)- class labels

There are up to 217,447 training parameters in the classical model. The improved training parameters are 217,447, and the improved model parameters are 0, resulting in a huge reduction in training parameters and a faster model training speed with less computer resource usage.

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 50, 50, 16)        208

 activation (Activation)     (None, 50, 50, 16)        0

 max_pooling2d (MaxPooling2D  (None, 25, 25, 16)       0
 )

 conv2d_1 (Conv2D)           (None, 25, 25, 32)        2080

 max_pooling2d_1 (MaxPooling  (None, 12, 12, 32)       0
 2D)

 conv2d_2 (Conv2D)           (None, 12, 12, 64)        8256

 max_pooling2d_2 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_3 (Conv2D)           (None, 6, 6, 128)         32896

 max_pooling2d_3 (MaxPooling  (None, 3, 3, 128)        0
 2D)

 dropout (Dropout)           (None, 3, 3, 128)         0

 flatten (Flatten)           (None, 1152)              0

 dense (Dense)               (None, 150)               172950

 activation_1 (Activation)   (None, 150)               0

 dropout_1 (Dropout)         (None, 150)               0

 dense_1 (Dense)             (None, 7)                 1057

=================================================================
Total params: 217,447
Trainable params: 217,447
Non-trainable params: 0
_________________________________________________________________
```

Fig: 4.1(d)-sum of total prams, trainable prams and non-trainable prams

4.2 Performance Evaluation

When a demonstration is linked to footage from a separate class, approval precision is achieved. In our model, we have a tendency to plan ahead of time. The network was run for 50 epochs while working on the original dataset. It was put to the test as well.
On the other hand The training loss is the failure to prepare a group of information results in a training phase. When running the approval set of knowledge across the ready network, the approval adversity is the inaccuracy.
The model that corresponds to the data generated by the model is graphed and the training and validation losses are plotted against epochs in the following graph.

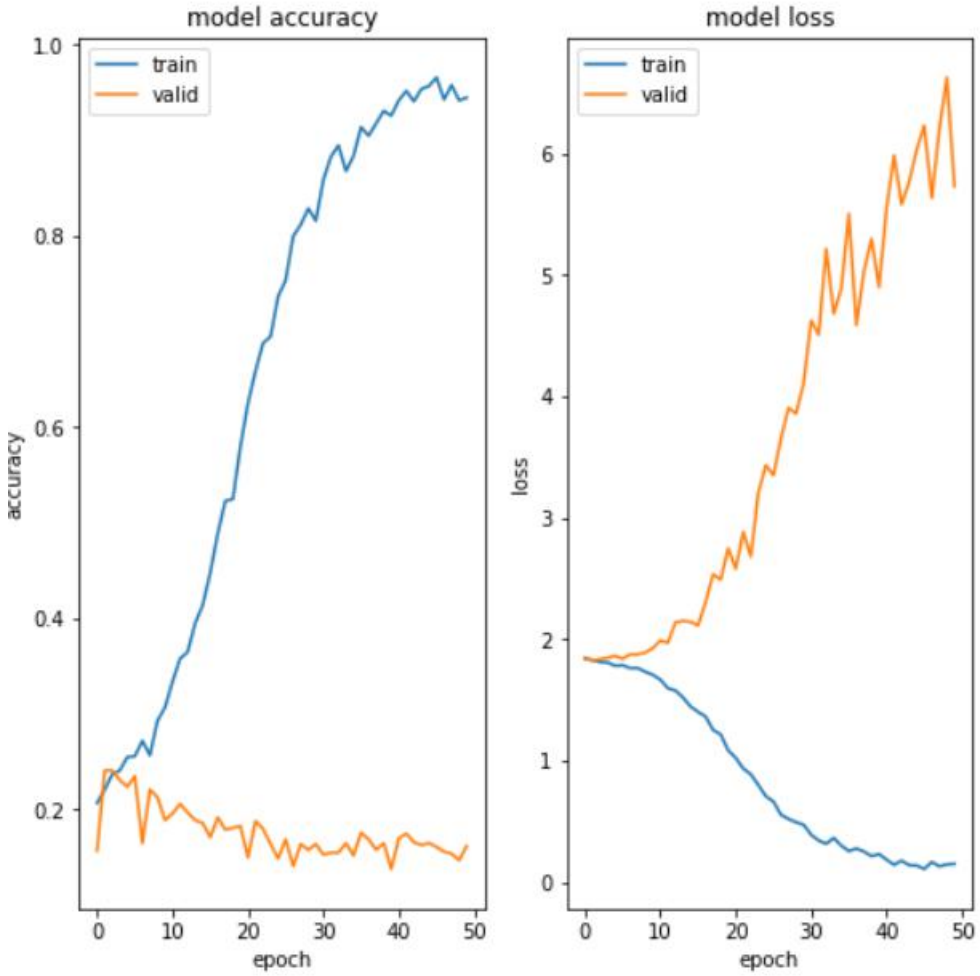

Fig: 4.2(a)- Accuracy and loss of our model

```
{0: 'angry', 1: 'disgust', 2: 'fear', 3: 'happy', 4: 'neutral', 5: 'sad', 6: 'surprise'}
```

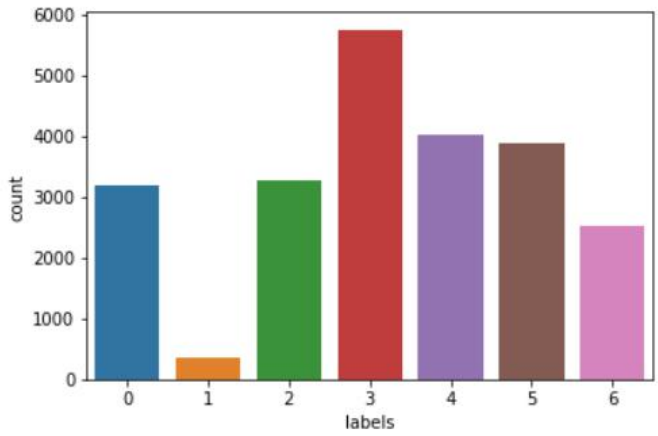

Fig: 4.2(b)-Bar chart of training phase

```
{0: 'angry', 1: 'disgust', 2: 'fear', 3: 'happy', 4: 'neutral', 5: 'sad', 6: 'surprise'}
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarning: Pass th
  FutureWarning
```

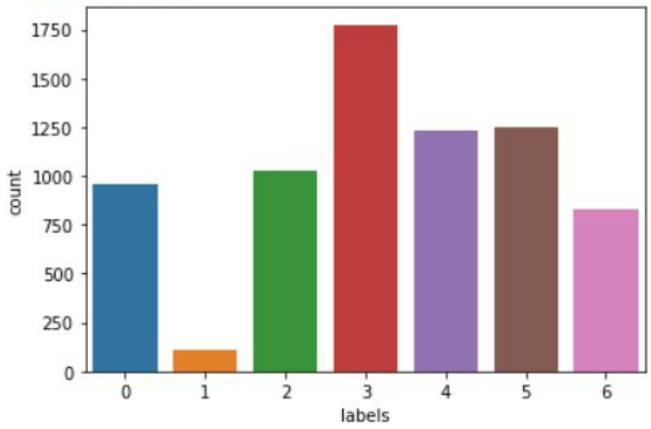

Fig: 4.2(c)- bar chart of testing phase

4.3 Experimental Result and Analysis

We have calculated precision, recall and F1 -score from test dataset containing pictures. From the classification report we are able to see precision normal is 0.34, recall normal is 0.33 and F1- score is 0.33. the execution of our classification is average.

Precision: Precision is one of the measures of the performance of a machine learning model, which refers to the accuracy of the model's positive prediction. The number of true positives is divided by the number of positive predictions.

$$\text{precision} = \frac{|\{relavent\ documents\} \cap \{retrieved\ documents\}|}{|\{retrieved\ documents\}|}$$

Recall: The recall is the proportion of relevant occurrences that are recovered compared to the total number of relevant occurrences. The high recall indicates that most of the many outcomes were calculated.

$$\text{recall} = \frac{tp}{tp+fn}$$

Accuracy: Accuracy is defined as the degree to which a measured value is comparable to a specific value. The total number of true positives, true negatives, false positives, and false negatives is divided by the total number of true positives, true negatives, false positives, and false negatives to determine the accuracy of a machine learning model.

$$\text{accuracy} = \frac{tp+tn}{tp+tn+fp+fn}$$

The classification report is given bellow:

	precision	recall	f1-score	support
angry	0.22	0.24	0.23	136
disgust	0.29	0.33	0.31	12
fear	0.20	0.17	0.18	133
happy	0.53	0.47	0.50	270
neutral	0.22	0.33	0.27	153
sad	0.32	0.20	0.25	177
surprise	0.40	0.51	0.45	119
accuracy			0.33	1000
macro avg	0.31	0.32	0.31	1000
weighted avg	0.34	0.33	0.33	1000

Fig: 4.3(a)- classification report

Output :

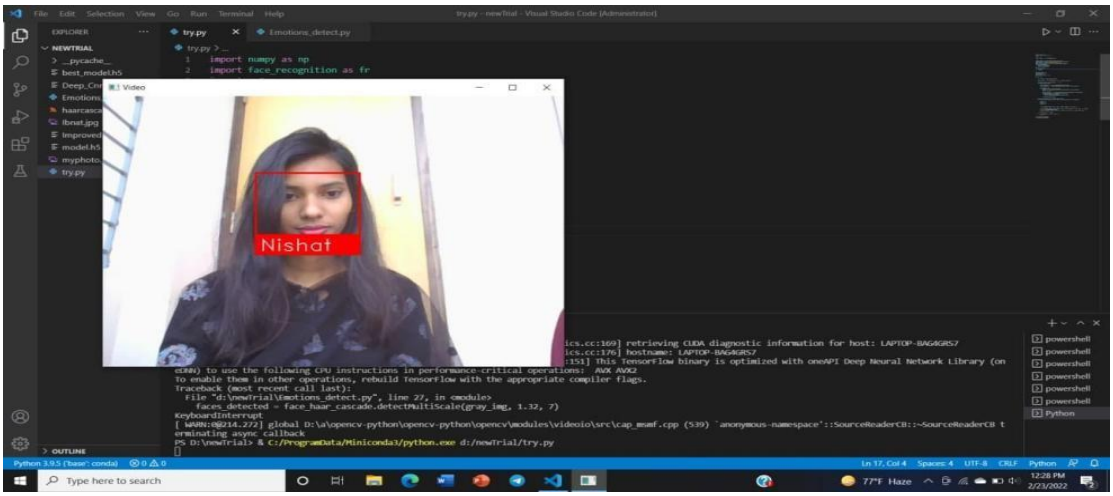

Fig:4.3(b)-face recognition of Nishat

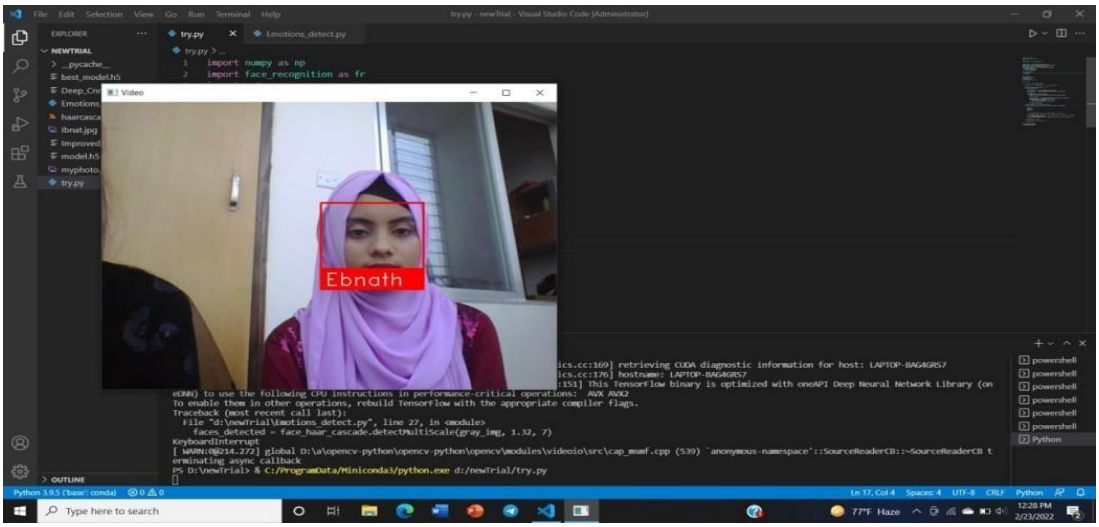

Fig:4.3(c) face recognition of Ebnath

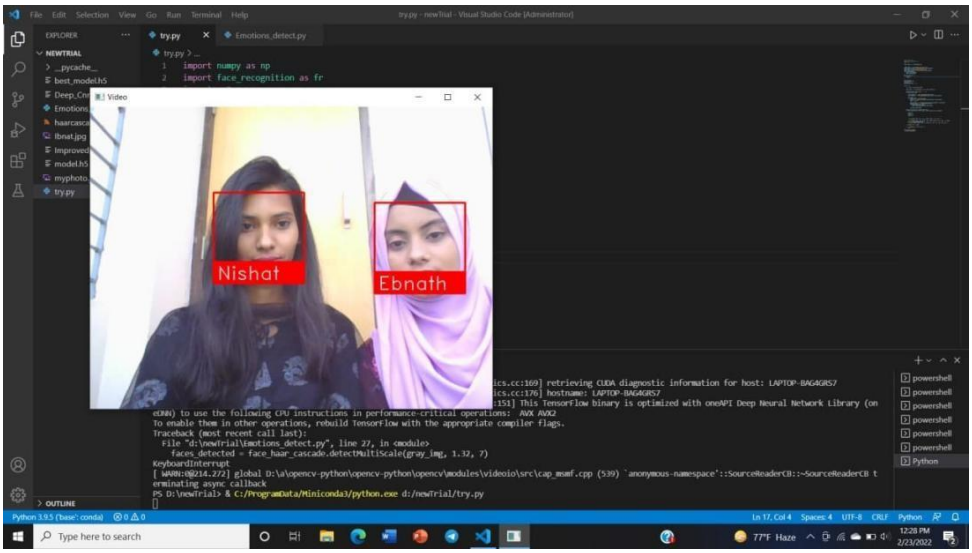

Fig:4.3(c)- Multiple face recognition

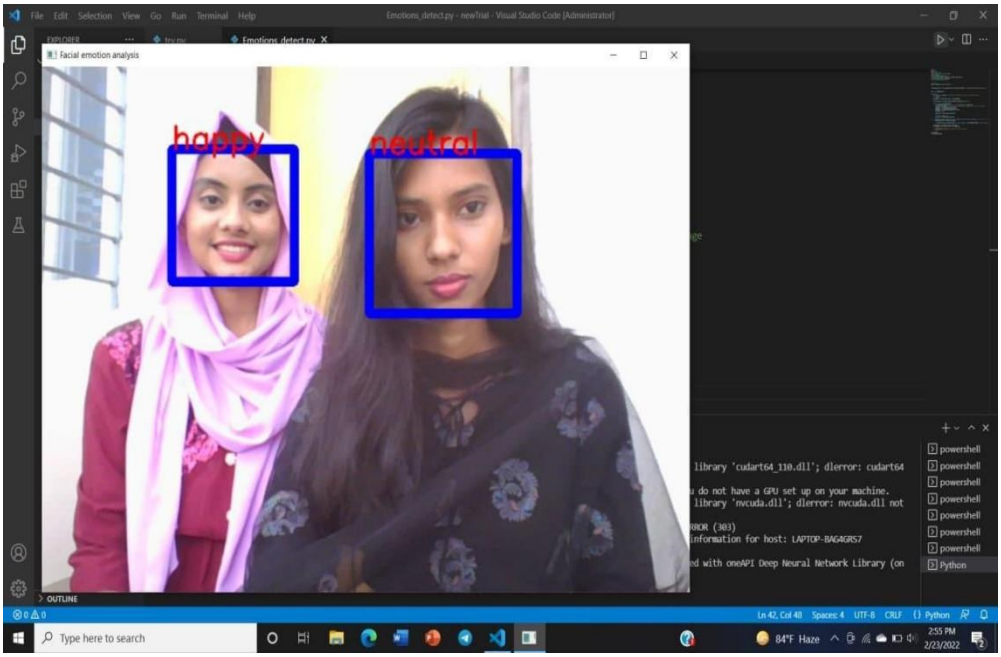

Fig-4.3(d):Emotion Recognition from multiple face

We've already discussed CNN's classification, and those behaviors are nearly flawless. The outcome was also mentioned. We now understand how the project runs and provides us with a nearly accurate result. Now, researchers are working hard to figure out what the problem is and how to solve it. Other datasets are completed by some seekers, who also use a Gabor filter. Convolutional Neural Networks combined with deep learning have resulted in a plethora of new inventions.

4.4 Result Discussion

Bands, facial hair, cosmetics, and aging are just some of the limitations that still exist. The steps for measuring emotion detection studies on a regular basis are outlined in this paper. I took some images and executed them for testing purposes. The majority of the time, it returns results that are close by. Those images aren't included in my datasets. It is advantageous for the user to obtain the ideal emotion. The user usually creates customized datasets, and they can change the images however they want.
In my project I use dataset where in test part it has 7 different emotions

CHAPTER 5

Impact on Society

5.1 Impact on society

A person's facial expressions can reflect their mood, cognitive activity, and intention. Psychopathology and personality They can also be used as a means of communication. in interpersonal interactions Behavioral science, natural human-machine interfaces, and All forms of therapeutic practices can benefit from automatic facial expression recognition.During the current generation Technology is used by a large number of people. Artificial intelligence made our day a lot easier. Everyone now owns a smartphone. Selfies are popular among young people. We can recognize facial emotions using facial emotion detection software.

5.2 Ethical Aspects

There is an ethical component to every scientific project. The following are my ethical considerations:

1. I honestly used all of the information.
2. When I choose this assignment, I research this type of project to understand more about it.
3. I'm attempting to avoid plagiarism.

CHAPTER 6

Summary & Conclusion

6.1 Summary of the study

All of the internal code was run using CO Lab and Visual Studio. Here I worked with a significant number of human faces. I'm attempting to figure out what a person's true expression is. The scientific culture of face expression is regarded as one of the most powerful and early expressions of emotions and communication. A person's emotional state, such as grief, surprise, delight, or rage, can be changed by their facial expressions. We wish to introduce the animus to cutting-edge approaches and system procedures that will be of particular interest to facial image experts. That discovery may be a necessary determinant of the fields on which future research trends will be based across the board. human facial expressions play an important part in man-to-man communication. People can communicate their moods or emotions, such as sadness, happiness, or angryness, through facial expressions.

6.2 Conclusion

The research employs a deep convolution neural network architecture to classify human facial expressions like happy, sad, surprised, fear, rage, disgust, and neutral. This article's purpose is to document and speculate on recent advancements in human facial emotion recognition. I designed and developed a general framework for real-time CNN generation. To keep the number of parameters to a minimum, we constructed our recommended guidelines using a systematic approach. We began by eliminating all fully connected layers and reducing the number of parameters in the remaining convolutional layers, utilizing depth-wise sustainability. We've shown that our proposed multi class classification models can be stacked while still allowing for real-time inferences. We've developed a vision system that can distinguish faces in particular.

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Appendix

Initially, we had little knowledge about machine learning and artificial intelligence detection, recognition, and classification. To gain this knowledge, we have researched a lot about this field and various papers related to our project idea. Our supervisor has given us valuable guidance and helped us a lot with our research. Through this research, we learned many new techniques, a lot of information, and gained knowledge about various algorithms and different methods. We also learned about some new software tools such as Google Colab, Visual Studio Codes, and the Python programming language. We were bothered about our data collection, as during this pandemic situation it was quite difficult to collect a lot of data for our dataset. So we decided to use an online dataset for our project. After a great deal of research, we gradually became acquainted with some new techniques to discover our solution.

Finally, conducting this research has inspired us to do more and better with our project in the future.

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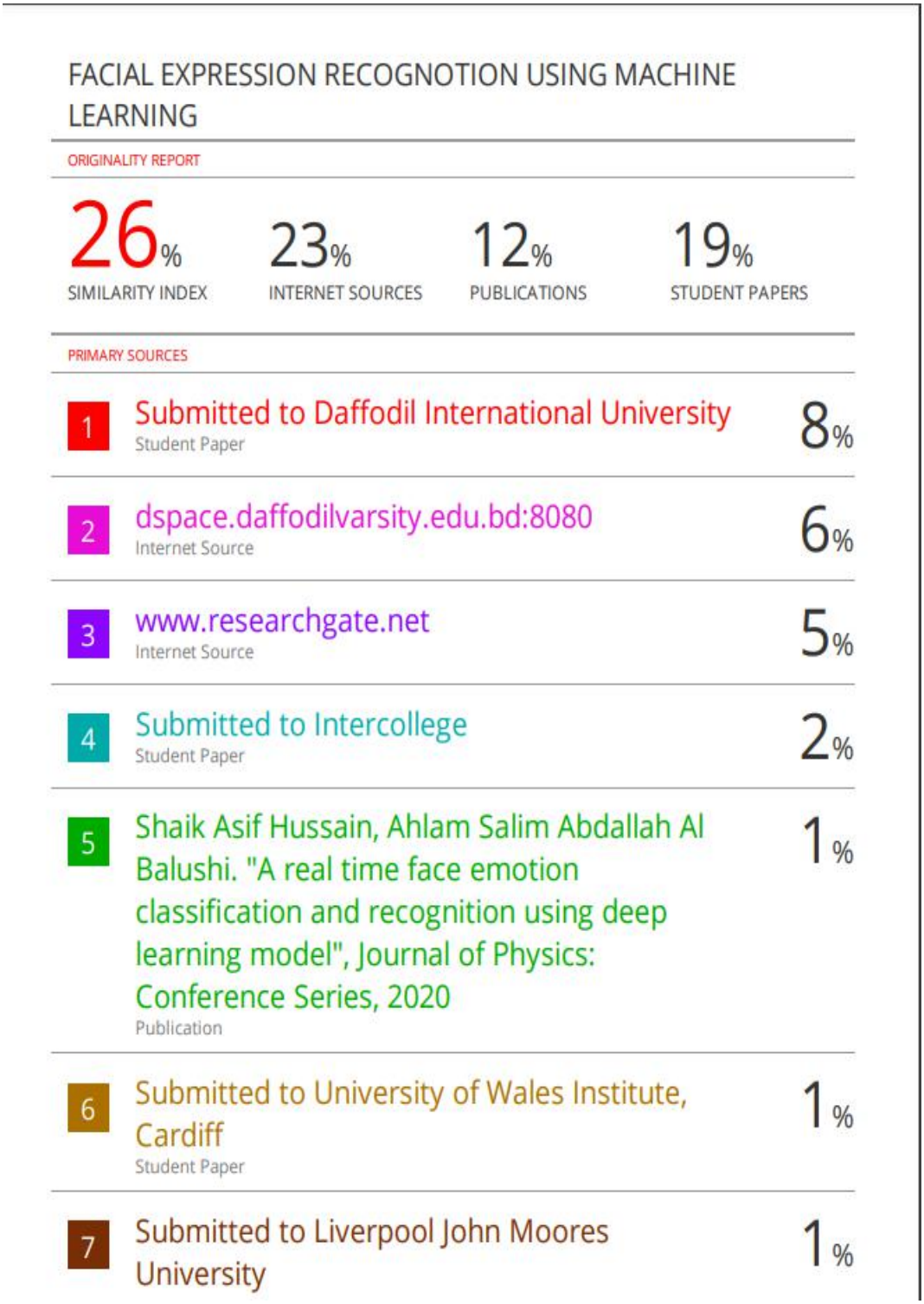

FACIAL EXPRESSION RECOGNOTION USING MACHINE LEARNING

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