Facial emotion recognition in real-time using deep convolution networks

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Abstract: The objective of this study is to present a detection method associated to automatic live facial expression identification by analysing the frontal-face image and predicting the most accurate expression out of the seven major countenances. Since our behaviour is strongly correlated to our emotions, the facial expressions and body gestures may act as a noteworthy source of non-verbal communication that may tell about the state of an individual. The interest in emotional computing through facial expressions has increased as it has wide application in industries, market and medical field. The doctors may be helped through facial expression recognition, may be by online machine monitoring system or sometimes when any patient is not able to communicate verbally. This study presents a model for facial recognition that permits disturbances to apprehend information from their surroundings in real-time, thus improving the classification process. The work has been implemented using Python IDLE (3.7) and Open Source Computer Vision Library (Open-CV2). The study proves to provide accurate and precise results.

Keywords: emotion classification; facial landmark detection; 3D facial features recognition; multi-modal sentiment analysis; face detection; feature extraction; tensor flow.

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1 Introduction

Facial recognition is a bio-metric method to map an individual's facial features and store the data and comparing that to a digital image using algorithms in order to validate an individual's identity (Andrejevic and Selwyn, 2020). Our behaviour is strongly correlated to our emotions. Communication plays a vital role in our lives. Facial expressions and body gestures are a noteworthy source of non-verbal communication that tells about the state of an individual (Burgoon et al., 2020). Our actions and behaviour are a measure of our interpersonal relations as well. The seven different types of emotions include fear, neutral, anger, surprise, disgust, happy and sad (Navdeep et al., 2020). Health care plays a very important role in the growth of a country (Abiodun et al., 2019; Ali et al., 2018). Every other emotion is basically an outcome of these elementary emotions. Real-time emotion analysis is another application derived from face recognition that has great importance in recognising an individual's health and behaviour (Egger et al., 2019). Image recognition is playing an important role is identifying various diseases such as cancer, tuberculosis, etc. (Sgouros, 2019; Ilevbare et al., 2018). For parental control and treating internet addiction, the facial recognition may play an important role (Sidal and Kose, 2019). The Facial recognition powered surveillance system can be used to identify if someone is behaving in a suspicious manner (Kaundanya et al., 2017). Individual's behaviour examination and detection is an immense research subject in the field of computer visualisation and prototype identification. Using face recognition for scanning behaviour of individuals is an interesting approach in day to day applications like visual traffic monitoring (Sharma and Lohan, 2019), patient monitoring and medical field (Burgoon et al., 2020; Debnath and Roy, 2019), home securities, luggage thief detection, people attendance, in exam hall or in college/organisation campus (Andrejevic and Selwyn, 2020). This technique can be extremely helpful in improving patient's care and treatment and create a better ambience for them in order to expedite their medication and healing process (Debnath and Roy, 2019). It can also be a good indicator of their mental health. Facial monitoring and eye-tracking in combination with artificial intelligence is revolutionising medicine by recognising and diagnosing diseases. This technology uses modern computers to analyse, sort, and find patterns across huge amounts of data and serve as an extension to a doctor's experience and knowledge allowing faster and more accurate diagnoses. An EEG-based models using transfer data learning techniques is presented in Zheng and Lu (2016) and claimed to get positive (85.01%) emotion detection rate which is higher as compared to other performed approaches. However, they failed for neutral and negative emotions as they showed slight similarity and thus

got mostly confused with each other. In Azam and Khan (2018), a design build on human actions data is presented. They measured human fellow by an eye-tracking activity. By capturing looks and expressions when presented graphics of countenances, they set for the conspicuous regions of a human profile for each individual emotion demonstrated in CK+ data-sets. Their design then extracted attributes from the Regions of Interest (ROI) which were identified by the eye-tracking experiment and classified them with a support vector machine model. The features worked-out as a Pyramid Histograms of Gradients (PHOG) (Duncombe, 1959). They presented the execution slightly above 95% on the CK+ data sets, similar to most of the present models. In Andrejevic and Selwyn (2020), a study about facial recognition for schools is presented. This study may be used to cross-check the faces of all students, employees against the database to mark their attendance and can predict if they are feeling unwell. Face recognition may also be used to lessen online frauds, where hackers unlawfully use passwords and other data to steal from banking institutions. It can be used to validate person's identity before processing any transaction.

Convolution neural networks have risen to prominence in perception-related applications as they have proven to attain some of the greatest accuracy in image categorisation task (Krizhevsky et al., 2012; Ciregan et al., 2012) Characteristics extracted from these neural networks are trained on the classified objects which have unveiled that computing models based on regression modelling can successfully yield splendour performances and without any advance training (Donahue et al., 2014), such as style categorisation for versatile ways to machines for instances in computers, robots, games and toys (Karayev et al., 2013). This is the prime mover in recently generated novel ideas such as emotional computers, emotion-sensing smartphones, headphones and emotional robots for a comprehensive visual structure.

The prime intent of this study is to analyse if these attributes can breeze through an emotion recognition system. This paper presents a methodology for facial recognition to determine the emotional state of a person. Section 2 present the proposed methodology. Section 3 presents the various open sources libraries and how to import them. Section 4 presents results and discussion. Section 5 concludes the paper.

2 Proposed methodology

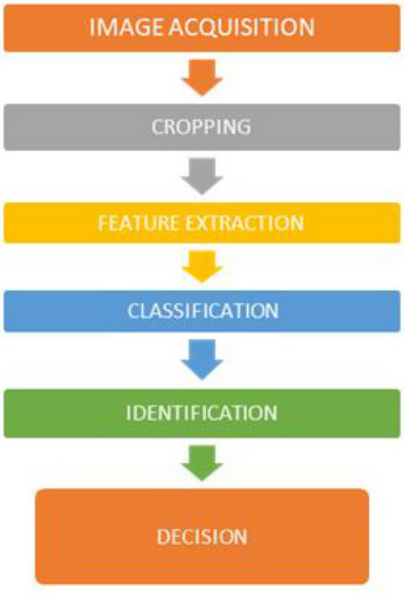
In the succeeding sections, the methodology build to characterise sentiments in still images and motion screening will be described. It will also explain, how its execution is estimated. Here, decisions are classified as ecstatic, sorrowful, indignant, surprise, neutral, repugnance and trepidation. Each emotion is visualised with dissimilar facial attributes like raised eyebrows, opening of mouth, popped cheeks, wrinkles across the nose, wide-open eyelids and others. The features will be snipped by the max-pooling method by fabricating the model of the data sets using .h5 extension and finally compiling the model with optimiser and loss method. Here, we import the haar-cascaded frontal face with .xml file extensions for face recognition.

2.1 Image pre-processing

This is a process of formation of signal modification together with fragmentation, locating or tracking the face as well as its parts. This standardisation is based on the familiarity provided by the human eyes. Face segmentation and realisation is often

harboured over the shape, colour, pattern, texture and spatial configuration of the face and its components can be performed with the distinction of the image sections that convey informative facial expressions (Schuller et al., 2020). The various stages of image pre-processing is shown in Figure 1. Two basic methods that participate in converting a colour image to a grey scale image are Kaundanya et al. (2017).

Figure 1 Stages in emotion detection



1) *Average method:* Through this method, mean of the three primary colours, i.e., Red (R), Blue (B) and Green (G) are chosen from a colour image. Thus, we get Grey-scale:

$$\left(R+G+B\right)/3 \tag{1}$$

Sometimes instead of the grey-scaled image, we get a black image which is because of the fact that when we convert an image we get 33% each of Red, Blue and Green. Therefore, to solve this problem we use the second method called Weighted/Luminosity Method.

2) *Weighted method:* To solve the problem in the Average Method, we use the Weighted method. In this method, we decremented the presence of Red Colour and increment the colour of Green Colour and the blue colour has the percentage in between these two colours. Thus, by equation (1), Grey-scale:

$$\left[(0.3*R)+(0.59*G)+(0.11*B)\right] \tag{2}$$

We use this due to the wavelength patterns of these colours. Blue having the least wavelength while Red having the maximum wavelength.

2.2 Emotions

The various features of face feature which may be extracted from face as shown in Figures 2 and 3 for emotion recognition are discussed in next subsection (Schuller et al., 2020).

Figure 2 Face feature extraction

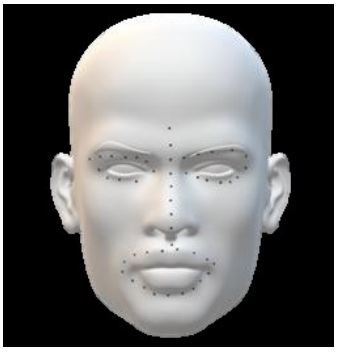


Figure 3 Various facial emotions in human

1) *Happy:* Happiness is generally used in the context of the mental state of a person, including positive emotions ranging from contentment to intense joy and pleasures, it represents the well-being of the person. It is also used in the context of life satisfaction well-being, radiating it through their face. This emotion is generally conveyed through (i) Gestures or body movements such as a relaxed pose, attitude or posture (ii) A sanguine, cheery and positive, confident tone of voice. Facial expressions such as smiling, gleeful state.

2) *Sad:* Sadness is an emotion referred as an evanescent emotional state which is categorised by the sentiments of dismay, grief, sorrow, distress and regret. Similar to other emotions, sadness is experienced by time, minutes and sometimes hourly swings in mood. In rout cases, people can encounter extended periods of sadness that can turns to melancholy and proves fatal. Expressing sadness in numerous ways include: (i) lower or calm mood restfulness, lethargy, withdrawing oneself from others, developing a feeling of sorrow or remorse (ii) The seriousness and depth of sadness can vary from person to person depending upon the origin, and the way an individual deals with such situations and time span also varies at times.

3) *Fear:* Fear is considered to be one of the strongest emotions that plays a crucial role in consistency of a person. When someone deals with a sort of danger or experience fear within, they go through a transition phase called as the flight or fight response. Physiological reactions results muscles to strengthens, a boost in heart rate and respiration is felt, and the mind becomes attentive and alert, notifying the body to either fight or run away from the encountered danger. Such responses helps in ensuring that the individual has developed metabolism to effectively deal with threats and major phase changes in the environment. Not all experience fear in similar ways. People may be tactful to fear in some situations or creatures that can more likely trigger such emotion.

4) *Disgust:* This is another kind of emotion out of the six basic emotions that is difficult to show but can be felt. Disgust can be shown in in human behaviour by: (I) Turning back from the source of revulsion, (ii) Physical reactions like convulsing, (iii) retching or, hiccups, sweating and (iv) facial features like wrinkling of nose and cuddling with the upper lip. Such sense of repercussion can emerge from a numerous things, including vexatious taste, view or scent. It is believed to be said that such emotion has been developed as a response to tasteless, fatal food products. When an individual sense or have such foods that have gone rancid, disgust is a representative reaction.

5) *Anger:* A powerful emotion categorised by the feeling of bitterness, malevolence malice, spite, and antagonism on oneself or others around. When an ultimatum generates an infatuation of anger, one may be infuriated to defend the danger and shield oneself. Anger can be seen through (i) The facial expressions like scowling or glowering and staring, (ii) Pitch of the voice such as speaking gruffly, shouting, screaming and howling, (iii) Physical responses like dripping with perspiration or turnout red-faced and (iv) combative conduct like creating violence, disturbing peace, or throwing objects and hitting someone. Though anger is conception of negative emotion, it sometimes proves to be shown a good sign. It can be constructive as well as destructive in its own ways like it helps clarify your requirements in relations, can also inspire one to take appropriate steps and search the best possible solution for the events that are unbearable.

6) *Surprise:* Surprise is short and is categorised by a physiological response followed by something out of the box or unexpected. Such emotion can turn out to have positive, neutral as well as negative. A displeasing surprise such as someone peeking out from a tree and screaming at you as you walk through the streets at night, or popping of zits on face. Example of pleasurable surprises can be expressed when you are arriving home and you discover that your colleagues have assembled to commemorate such a special day. When such incidents happen, one experiences an increase in adrenaline which prepares one's body and mind to face the situation.

3 Importing library

For successful implementation and analysis of the project to get accurate results, we would like to put in Python 2.7 IDLE and import some libraries like TensorFlow, Keras, Open CV and Numpy. We implemented this project in Jupiter notebook and is capable of being deployed to freely available platforms (Beattie et al., 2020).

3.1 Open-CV

This is a library of Open Computer Vision. It is untied from vast extensive library which consists of quite 2500 algorithms distinctively designed to hold out Computer Vision and Machine Learning related projects. These algorithms are often used to perform different tasks like Face Recognition, Object Identification and Tracking Scenery Recognition, etc.

```
import cv2
print(cv2.__version__)
```

3.2 Tensorflow

TensorFlow an extensive Python library essentially used for fast numerical computing, fabricated and published by Google. It is a foundation library that assists to create Deep Learning models directly that simplifies and eases the processes built on top of TensorFlow. The major implementation of Tensorflow is the assisting the voice to text and vice-versa, recognition while apprehending videos and phonic and text-based administrations.

```
import tensorflow as tf
print(tf.__version__)
```

3.3 Keras

An open-source-based neural networking platform in python, that is appointed for performing specific tasks of pre-processing, modelling, evaluating, and optimisation techniques required to perform a model, useful for high-levels of API's as is controlled by the back-end. It is developed for fabrication of model with optimiser and loss functions, and training the processes with the inbuilt fit functions. Being handles by back-end applications, Keras does not assist low-level statics and models.

```
import keras
print(keras.__version__)
```

3.4 NumPy

NumPy is a Python library which is usually used for complex technical evaluation. It is cased for the practical implementation of multidimensional arrays which consists of diversified mathematical formulas to process (Beattie et al., 2020; Rauber et al., 2020).

```
import numpy as np
print(np.__version__)
```

4 Results and discussions

Conceding emotion in images and video and defining a countenance as an illustration of one's emotion was difficult. These other perspectives seem to be rugged in regards with

the accuracy of every individual emotion, none of them is appreciably unrestricted frequently. Some factors includes: (i) locating an image during a single frame (ii) lack of proper surrounding lights. Changing contrast and background is customary in an licentious environment, detection of one face frame at a time, blocking changes in pose may be a common issue for motion detection in video, differing emotions are often detected in varying genders and races. A lot of things can make emotion recognition problematic, a number of these factors include (i) technical and (ii) psychological aspects. Emotion recognition shares heaps of barriers while detecting objects in motion like identifying an object, continuous detection, incomplete actions, etc. Emotion recognition system scrutinise faces for eyebrows, eyes, noses, mouths, chins, and other countenance.

Sometimes, detection is complicated due to: (i) The distance between features, that the software recollects and the typical distance between landmarks and that appears for it should be only within the stipulated range. For instance, it would have been a bane spotting point of differences between widely spaced eyes and wide-open mouth as surprise (Ramos et al., 2020). (ii) Recognising children's emotions: Infants and toddlers and juveniles designate emotions differently than adults. They understand slighter what they will verbally express, and that they react to things all over them with different facial expressions and face motions. Also, children do not prohibit their emotions (Ringeval et al., 2015). Another matter that comes with the very fact that children's emotions are explicated as adults.

There are many pronounced use cases for sentiment analysis in digital world, which can be a great godsend for marketers and community managers. Examples of some beneficial cases include:

- Gauging sentiments tied to a brand in real-time across social networking sites and media (semantic).
- Campaign evaluation using social media (semantic and facial).
- Large-scale reaction test to products and services at its best (semantic, facial).
- Customer service, for example, prioritising angry customers for faster service (semantic).
- SEO for example, analysing content of given page or documentation (semantic).

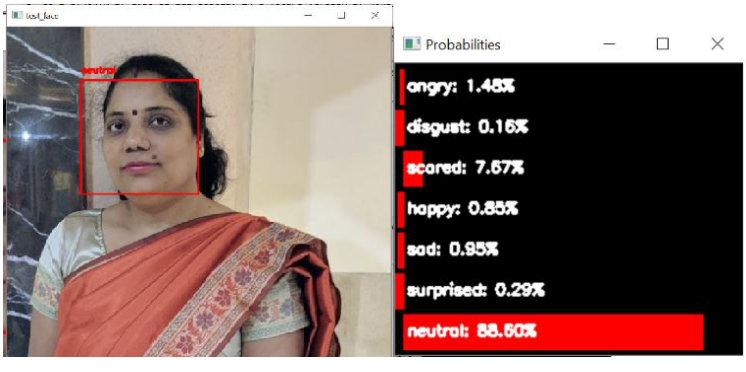
4.1 Recognition of emotion on test images

The paper as a result presents the emotion percentage profile for an individual that ranges accordingly for every movement; it displays all universal emotions that are possible with the help of a probability distribution chart. It unveil the detected face employing a square frame, and eventually, it detects the most accurate emotion depending on the maximum percentage priority out of the given emotion set. In test image Figure 4, the recognition of emotion on a test image is done. It may be seen that according to the facial expressions the program recognises the emotions of the person among seven emotions. In Figure 4, the emotion recognised as happy with a percentage of 78.54, while the other emotions percentage is also shown. Similarly on test image of Figure 5, the emotion is recognised

as neutral with an overall 88.60%, the percentage of other emotions are very less as compared to this. A threshold may be set for minimum percentage for which an emotion may be confirmed as correct state of a person. The emotions recognised in the test images are correct and hence, the work in the paper may be applied to real time images also.

Figure 4 Test image (1)

Figure 5 Test image (2)



4.2 Recognition of emotion on real-time images

Some real time images are also tested and presented in Figures 6, 7 and 8. For the synchronous recognition, the image size used was 96*96 pixels with minimal batch size, such batch size is opted because of competency levels. The data were supplemented by adjusting the region of image of the frontal face from the grey-scale image, resizing it to a fixed 48*48 pixels, and then preparing the region of image for classification via the CNN classifier. Finally, for each and every investigatory method, a rope of post-processing is tethered, considering the following steps during evaluation:

- Filtering (with window size lying between the 0.4s and 20 s) (Soroosh and Carlos, 2015).
- Aligning and scaling (by assessing the partisanship between gold-standard and prognosis as comparative scaling).
- Time-shifting (through regressing the time interval of prediction ranging between 0.04 seconds and 10 seconds), to remunerate for delays in the verdict.

The upshot of the project exhibit the percentage of emotion that would be classified from the image classifier to every individual, i.e., the best percentage of precision accomplished. In Figure 6, the highest percentage of emotion recognised is 33 for surprised In Figure 7, the emotion recognised as scared with highest percentage of 21.12%. In Figure 8, the emotion recognised is happy with highest percentage of 36.76%. However, in all the three images the facial expressions are of mixed emotions, which is also recognised as the percentage of other emotions are also near to the recognised emotion. Thus, overall perceived emotions on real-time images presented an accuracy of 66%, and an accuracy achieved on a sample image is 89%, since it is single image differentiated.

Figure 6 Real-time image (1)

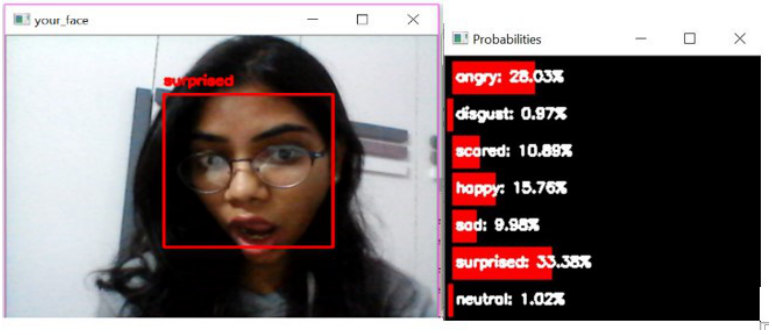


Figure 7 Real-time image (2)

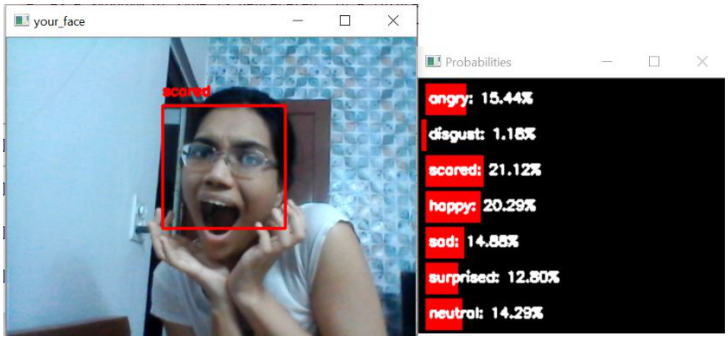
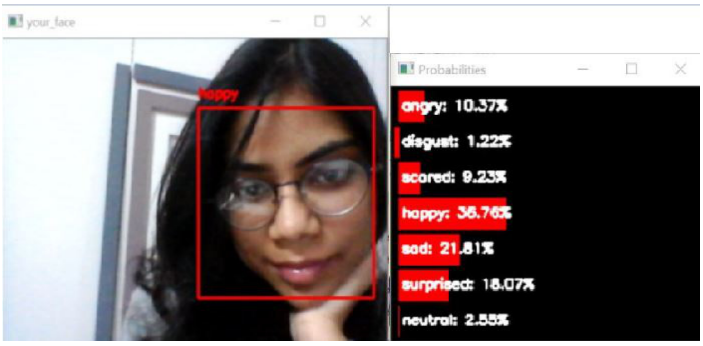


Figure 8 Real-time image (3)



5 Conclusion and future scope

In this paper, automatic live facial expression identification by analysing the frontal-face image and predicting the most accurate expression out of the seven major countenances is done successfully. The emotion percentage profile of an individual with the help of probability distribution chart is successfully identified. It unveil the detected face employing a square frame, and eventually, it detects the most accurate emotion depending on the maximum percentage priority out of the given emotion set for test and real time images. For the synchronous recognition, the image size used was 96*96 pixels with minimal batch size, such batch size is opted because of competency levels. The data were supplemented by adjusting the region of image of the frontal face from the grey-scale image, resizing it to a fixed 48*48 pixels, and then preparing the region of image for classification via the CNN classifier. This technique can be extremely helpful in improving patient's care and treatment and create a better ambience for them in order to expedite their medication and healing process. This system can be used to cross-check the faces of all students, employees against the database to mark their attendance and can predict if they are feeling unwell. Facial monitoring and eye-tracking in combination with artificial intelligence is revolutionising medicine by recognising and diagnosing diseases.

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