FACIAL EMOTION DETECTION AND RECOGNITION

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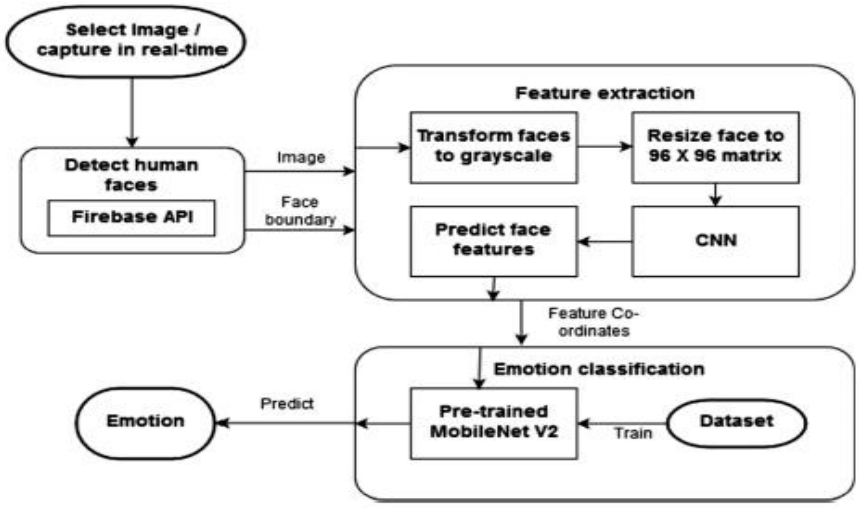
***Abstract*: Artificial Intelligence has many significant fields of work and expression/ emotion detection is one of them. To detect a facial expression, the system should analyze various variability of human faces like color, posture, expression, orientation, lighting, etc. Detecting facial features is a prerequisite to facial emotion recognition. This is achieved by observing the parts of the face, like eyes, lips movement, etc. These are then classified and compared to trained sets of data. In this research, a human facial expression recognition system will be modeled using the eigenface approach. The proposed method will use the HAAR Cascade classifier to detect the face in an image. After that anticipating the test picture upon the eigenspace and computing the Euclidean separation between the test picture and meaning of the eigenfaces. fer2013 dataset will be used for training purposes. The grayscale image of the face is used by the system to classify five basic emotions such as surprise, disgust, neutral, anger, and happiness.**

***Index Terms*: HAAR Cascade classifier, fer2013 dataset, feature extraction, CNN, Xception architecture, ReLU activation function**

I. INTRODUCTION

- Human face detection plays an important role in applications such as video surveillance, human computer interface, face recognition, and face image database management.
- Facial expressions are important cues for non-verbal communication among human beings. This is only possible because humans are able to recognize emotions quite accurately and efficiently. An automatic facial emotion recognition has many commercial uses and can be used as a biological model for cognitive processing and analyzing of human brain.
- Collectively they can enhance their applications like monitoring and surveillance analysis, biomedical image, smart rooms intelligent robots, human computer interfaces and driver's alertness system and can play a vital role in the field of security and crime investigations.

II. ARCHITECTURE DIAGRAM:



III. BACKGROUND STUDY

- Siyue & Xie [1], (2019) have presented a novel method, named deep comprehensive multipatches aggregation convolutional neural networks (CNNs). The proposed method is a deep-based framework, which mainly consists of two branches of the CNN. One branch extracts local features from image patches while the other extracts holistic features from the whole expressional image. In the model, local features depict expressional details and holistic features characterize the high-level semantic information of an expression. We aggregate both local and holistic features before making classification. These two types of hierarchical features represent expressions in different scales. Compared with most current methods with single type of feature, the model can represent expressions more comprehensively.
- Jingu et al. [2], (2005) have presented an up-to-date review of research efforts in face recognition techniques based on two-dimensional (2D) images in the visual and infrared (IR) spectra. Face recognition systems based on visual images have reached a significant level of maturity with some practical success. However, the performance of visual face recognition may degrade under

poor illumination conditions or for subjects of various skin colors. IR imagery represents a viable alternative to visible imaging in the search for a robust and practical identification system.

- Faizan et al. [3], (2019) have explained that the goal of this paper is to evaluate various face detection and recognition methods, provide complete solution for image-based face detection and recognition with higher accuracy, better response rate as an initial step for video surveillance. Solution is proposed based on performed tests on various face rich databases in terms of subjects, pose, emotions, race and light.
- Cowie et al. [4], (2001) have presented both linguistics and technology have invested enormous efforts in understanding the first, explicit channel, but the second is not as well understood. Understanding the other party's emotions is one of the key tasks associated with the second, implicit channel. To tackle that task, signal processing and analysis techniques have to be developed, while, at the same time, consolidating psychological and linguistic analyses of emotion. This article examines basic issues in those areas. It is motivated by the PKYSTA project, in which we aim to develop a hybrid system capable of using information from faces and voices to recognize people's emotions.
- Lisa et al. [5], (2006) have presented what is known about these facial expression repertoires, discusses the importance of social organization in understanding the meaning of different expressions, and introduces a new coding system, the ChimpFACS, and describes how it can be used to determine homologies between human and chimpanzee facial expressions. Finally, it reviews previous studies on the categorization of facial expressions by chimpanzees using computerized tasks, and discusses the importance of configural processing for this skill in both humans and chimpanzees.
- Yanpeng et al. [6], (2017) have presented a simplified algorithm framework using fusion features extracted from the salient areas of faces. Furthermore, the proposed algorithm has achieved a better result than some deep architectures. For extracting more effective features, this paper firstly defines the salient areas on the faces. This paper normalizes the salient areas of the same location in the faces to the same size; therefore, it can extracts more similar features from different subjects.
- Andrinandrasana et al. [7], (2019) have presented CNN-based methods for facial emotion recognition and we propose a new cutting-edge deep learning approach to classify facial expressions from pictures. To guarantee the efficacy of the method, they used multiple datasets: FER2013, AffectNet, RaFD, and KDEF. They obtained results respectively 82.3%, 76.79%, 78.58 %, and 77.08 %. Those results surpassed the current state of the art.
- Zhang et al. [8], (2017) have presented a part-based hierarchical bidirectional recurrent neural network (PHRNN) to analyze the facial expression information of temporal sequences. Our PHRNN models facial morphological variations and dynamical evolution of expressions, which is effective to extract “temporal features” based on facial landmarks (geometry information) from consecutive frames. Meanwhile, in order to complement the still appearance information, a multi-signal convolutional neural network (MSCNN) is proposed to extract “spatial features” from still frames. We use both recognition and verification signals as supervision to calculate different loss functions, which are helpful to increase the variations of different expressions and reduce the differences among identical expressions.
- Kanade [9], (2000) have presented the full range of facial expression, detection, tracking, and classification of fine-grained changes in facial features are needed. We developed the first version of a computer vision system that is sensitive to subtle changes in the face. The system includes three modules to extract feature information: dense-flow extraction using a wavelet motion model, facial-feature tracking, and edge and line extraction. The feature information thus extracted is fed to discriminant classifiers or hidden Markov models that classify it into FACS action units, the descriptive system to code fine-grained changes in facial expression.
- Dawood et al. [10], (2018) have presented Viola and Jones algorithm for front face detection. Facial side images detected through the skin detection methodology. For features extraction step, Histogram oriented gradient (HOG) algorithm is used. This paper suggested using Raspberry pi3 platform in the real time multifaced recognition system to connect three cameras. In the recognition step, Support Vector Machine (SVM) used and compared with the performance of the principal component analysis algorithm (PCA). The system is tested on multiple images of the FEI database.
- Rahim et al. [11], (2013) have presented research work mainly consisting of three parts, namely face representation, feature extraction and classification. Face representation represents how to model a face and determines the successive algorithms of detection and recognition. The most useful and unique features of the face image are extracted in the feature extraction phase. In the classification the face image is compared with the images from the database. In this research work, they empirically evaluated face recognition which considers both shape and texture information to represent face images based on Local Binary Patterns for person- independent face recognition. The face area is first divided into small regions from which Local Binary Patterns (LBP), histograms are extracted and concatenated into a single feature vector.
- Antonio et al. [12], (2002) have presented in this work, to identify a face, three major strategies for feature extractions are discussed. Appearance-based, Model based methods and hybrid methods as feature extractions techniques are discussed too. There is also a review of major person recognition research. The characteristics of good face authentication applications, Classification, Distance measurements, and face databases are discussed while the final suggested methods are presented.
- Aurobinda et al. [13], (2015) have proposed a learning emotion recognition model, which consists of three stages: Feature extraction, subset feature and emotion classifier. A Haar Cascades method is used to detect the input image, a face, as the basis for the extraction of eyes and mouth, and then through the Sobel edge detection to obtain the characteristic value. Through Neural Network classifier training, six kinds of different emotional categories are obtained. Experiments using JAFF database show that the proposed method has high classification performance. Experimental results show that the model proposed in this paper is consistent with the expressions from the learning situation of students in virtual learning environments.
- Ahuja et al. [14], (2002) have presented a deep learning approach based on attentional convolutional network, which is able to focus on important parts of the face, and achieves significant improvement over previous models on multiple datasets, including FER-2013, CK+, FERG, and JAFFE. They also use a visualization technique which is able to find important face regions

for detecting different emotions, based on the classifier's output. Through experimental results, we show that different emotions seem to be sensitive to different parts of the face.

- Rein-Lien et al. [15], (2002) have presented a face detection algorithm for color images in the presence of varying lighting conditions as well as complex backgrounds. Based on a novel lighting compensation technique and a nonlinear color transformation, our method detects skin regions over the entire image and then generates face candidates based on the spatial arrangement of these skin patches. The algorithm constructs eye, mouth, and boundary maps for verifying each face candidate.
- Caifeng et al. [16], (2009) have presented facial representation based on statistical local features, Local Binary Patterns, for person-independent facial expression recognition. Different machine learning methods are systematically examined on several databases. Extensive experiments illustrate that LBP features are effective and efficient for facial expression recognition. They further formulate Boosted-LBP to extract the most discriminant LBP features, and the best recognition performance is obtained by using Support Vector Machine classifiers with Boosted-LBP features.
- Hung-Fu et al. [17], (2012) have presented a method for facial expression recognition. Facial feature vectors are generated from keypoint descriptors using Speeded-Up Robust Features. Each facial feature vector is then normalized and next the probability density function descriptor is generated. The distance between two probability density function descriptors is calculated using Kullback Leibler divergence. Mathematical equation is employed to select certain practicable probability density function descriptors for each grid, which are used as the initial classification.
- Cohen et al. [18], (2003) have presented and test different Bayesian network classifiers for classifying expressions from video, focusing on changes in distribution assumptions, and feature dependency structures. In particular we use Naive–Bayes classifiers and change the distribution from Gaussian to Cauchy, and use Gaussian Tree-Augmented Naive Bayes (TAN) classifiers to learn the dependencies among different facial motion features. They also introduce a facial expression recognition from live video input using temporal cues. We exploit the existing methods and propose a new architecture of hidden Markov models (HMMs) for automatically segmenting and recognizing human facial expression from video sequences.
- Tian et al. [19], (2011) have presented recent advances in facial expression analysis and recognition. The first part discusses general structure of AFEA systems. The second part describes the problem space for facial expression analysis. This space includes multiple dimensions: level of description, individual differences in subjects, transitions among expressions, intensity of facial expression, deliberate versus spontaneous expression, head orientation and scene complexity, image acquisition and resolution, reliability of ground truth, databases, and the relation to other facial behaviors or nonfacial behaviors.
- Nithya [20], (2019) has presented attempts to use deep learning and image classification method to recognize expressions and classify the expressions according to the images. Various datasets are investigated and explored for training expression recognition model are explained in this paper. Inception Net is used for expression recognition with Kaggle (Facial Expression Recognition Challenge) and Karolinska Directed Emotional Faces datasets. Final accuracy of this expression recognition model using Inception Net v3 Model is 35%.
- Fasel et al. [21], (2003) have presented the most prominent automatic facial expression analysis methods and systems presented in the literature. Facial motion and deformation extraction approaches as well as classification methods are discussed with respect to issues such as face normalization, facial expression dynamics and facial expression intensity, but also with regard to their robustness towards environmental changes.
- Williams et al. [22], (2019) have presented in this study have aimed at implementing face detection and expression recognition using fuzzy rule interpolation (FRI) technique. This follows through a development of specifications for fuzzy rule interpolation in emotion recognition using the viola jones algorithm as the detection algorithm and local binary pattern (LBP) algorithm for the feature extraction. The extended Cohn Kanade (CK+) face database was used for the experimentation of the system. The classification of the various expressions was achieved by the image category classifier of Matlab.
- Pankaj [23], (2019) have presented the execution of PCA, GMM, GLCM and SVM to perceive seven distinctive outward appearances of two people, for example, cheerful, unbiased, and furious, nauseate, dismal, dread and astonishment. Our point is to speak to best systems which work best for facial acknowledgment. The present investigation demonstrates the plausibility of outward appearance acknowledgment for viable applications like reconnaissance and human PC communication.
- Ramos et al. [24], (2019) have presented an experiment by applying new methods and techniques in order to provide new results which will increase the scope to consider. Furthermore, this study utilized best performing algorithms: the Haar-Cascade classifier for face detection, Color Feature Extraction for detection of face makeup and Local Binary Pattern Histogram algorithm for extraction and recognition of the features which applied in the experiments considering condition from fluorescent light and sunlight, angle variation of 0 degree, 45% upward and downward and distance of 0.5 meter and 1 meter. The study collected an over-all of 3000 images which will serve as the training datasets. In result, the experiment marked an average accuracy of 88.75% comprises all the methods applied.
- Xiaofei et al. [25], (2005) have presented an appearance-based face recognition method called the Laplacianface approach. By using locality preserving projections (LPP), the face images are mapped into a face subspace for analysis. Different from principal component analysis (PCA) and linear discriminant analysis (LDA) which effectively see only the Euclidean structure of face space, LPP finds an embedding that preserves local information, and obtains a face subspace that best detects the essential face manifold structure.
- Sudeshna et al. [26], (2018) have presented in this paper several existing face detection and recognition approaches are analyzed and discussed. Each approached is discussed briefly & compared with the other in terms of key evaluation parameters. As face detection is the elementary yet an important step towards automatic face recognition, main goal of this paper is to come up with an approach that is a good candidate for face detection and face recognition.
- Zhenguo [27], (2020) has presented a visual attention mechanism guidance model is proposed in this paper, which uses the visual attention mechanism to guide the model highlight the visible area of the occluded face; the face detection problem is

simplified into the high-level semantic feature detection problem through the improved analytical network, and the location and scale of the face are predicted by the activation map to avoid additional parameter settings.

- Zhihong et al. [28], (2009) have presented discussions of human emotion perception from a psychological perspective. Next, we examine available approaches to solving the problem of machine understanding of human affective behavior, and discuss important issues like the collection and availability of training and test data. We finally outline some of the scientific and engineering challenges to advancing human affect sensing technology.
- Baker et al. [29], (2003) have presented collected a database of more than 40,000 facial images of 68 people. Using the Carnegie Mellon University 3D Room, we imaged each person across 13 different poses, under different illumination conditions, and with four different expressions. We call this the CMU pose, illumination, and expression (PIE) database. We describe the imaging hardware, the collection procedure, the organization of the images, several possible uses, and how to obtain the database.
- Yongmin et al. [30], (2004) have presented a novel algorithm for face detection by combining the Eigenface and SVM methods which performs almost as fast as the Eigenface method but with a significant improved speed. Detailed experimental results are presented in this paper including tuning the parameters of the pose estimators and face detectors, performance evaluation, and applications to video based face detection and frontal-view face recognition.
- Hayes et al. [31], (2002) have presented the embedded hidden Markov model (HMM) is a statistical model that can be used in many pattern recognition and computer vision applications. This model inherits the partial size invariance of the standard HMM, and, due to its pseudo two-dimensional structure, is able to model two-dimensional data such as images, better than the standard HMM. They described the maximum likelihood training for the continuous mixture embedded HMM and present the performance of this model for face detection and recognition.
- Toshiaki & Yan [32], (1999) have proposed a system for automatic human face detection and recognition. The procedure consists of five steps: (1) the Haar wavelet transform, (2) facial edge detection, (3) symmetry axis detection, (4) face detection and (5) face recognition. Step 1 decomposes an input image, reducing image redundancy. Step 2 excludes non-facial areas using edge information, whereas Step 3 narrows down face areas further using gradient orientation. Step 4 restricts face-like areas by template matching. Finally, Step 5 determines the best face location in the face-like areas and identifies the face based on principal component analysis (PCA).
- Dilbag [33], (2012) have presented the application of feature extraction of facial expressions with combination of neural network for the recognition of different facial emotions (happy, sad, angry, fear, surprised, neutral etc..). This paper analyses the limitations with existing system Emotion recognition using brain activity. In this paper by using an existing simulator they have achieved 97 percent accurate results and it is easy and simplest way than Emotion recognition using brain activity system. Purposed system depends upon human face as we know face also reflects the human brain activities or emotions. In this paper neural network has been used for better results.
- Ashok et al. [34], (1992) have presented detection of a pattern as a face, identification of the face, analysis of facial expressions, and classification based on physical features of the face. A system that performs these operations will find many applications, e.g. criminal identification, authentication in secure systems, etc. Most of the work to date has been in identification. This paper surveys the past work in solving these problems. The capability of the human visual system with respect to these problems is also discussed.
- Ojala et al. [35], (2002) have presented a method based on recognizing that certain local binary patterns, termed "uniform," are fundamental properties of local image texture and their occurrence histogram is proven to be a very powerful texture feature. We derive a generalized gray-scale and rotation invariant operator presentation that allows for detecting the "uniform" patterns for any quantization of the angular space and for any spatial resolution and presents a method for combining multiple operators for multiresolution analysis. The proposed approach is very robust in terms of gray-scale variations since the operator is, by definition, invariant against any monotonic transformation of the gray scale.
- Tarnowski et al. [36], (2017) have presented in this article presented the results of recognition of seven emotional states (neutral, joy, sadness, surprise, anger, fear, disgust) based on facial expressions. Coefficients describing elements of facial expressions, registered for six subjects, were used as features. The features have been calculated for three-dimensional face model. The classification of features were performed using k-NN classifier and MLP neural network.
- Divya et al. [37], (2019) have presented in this paper the idea related to automated live facial emotion recognition through image processing and artificial intelligence (AI) techniques. They detected emotion by scanning (static) images or with the (dynamic) recording. Features extracting can be done like eyes, nose, and mouth for face detection. The convolutional neural network (CNN) algorithm follows steps as max-pooling (maximum feature extraction) and flattening.
- Pantic et al. [38], (2000) have presented the recent advances and applications in facial expression recognition from the face detection, feature extraction, classification, and the ethnic expression recognition. The methods of feature extraction are divided to several different characteristic categories. Researches of classifications are based on space or time and space. What's more, according to the facial expression recognition history and achievements, the development of ethnic facial expression recognition and the trend of facial expression recognition are given.
- Monika & Lokesh [39], (2016) have presented needs and applications of facial expression recognition. Between Verbal & Non-Verbal form of communication facial expression is form of non-verbal communication but it plays pivotal role. It expresses human perspective or filling & his or her mental situation. A big research has been addressed to enhance Human Computer Interaction (HCI) over two decades. This paper includes introduction of facial emotion recognition system, Application, comparative study of popular face expression recognition techniques &phases of automatic facial expression recognition system.
- Mahmood et al. [40], (2019) have presented a new framework for effective facial expression recognition from real-time facial images. Unlike other methods which spend much time by dividing the image into blocks or whole face image, our method extracts the discriminative feature from salient face regions and then combine with texture and orientation features for better

representation. Furthermore, they reduced the data dimension by selecting the highly discriminative features. The proposed framework is capable of providing high recognition accuracy rate even in the presence of occlusions, illumination, and noise. To show the robustness of the proposed framework, they used three publicly available challenging datasets. The experimental results show that the performance of the proposed framework is better than existing techniques.

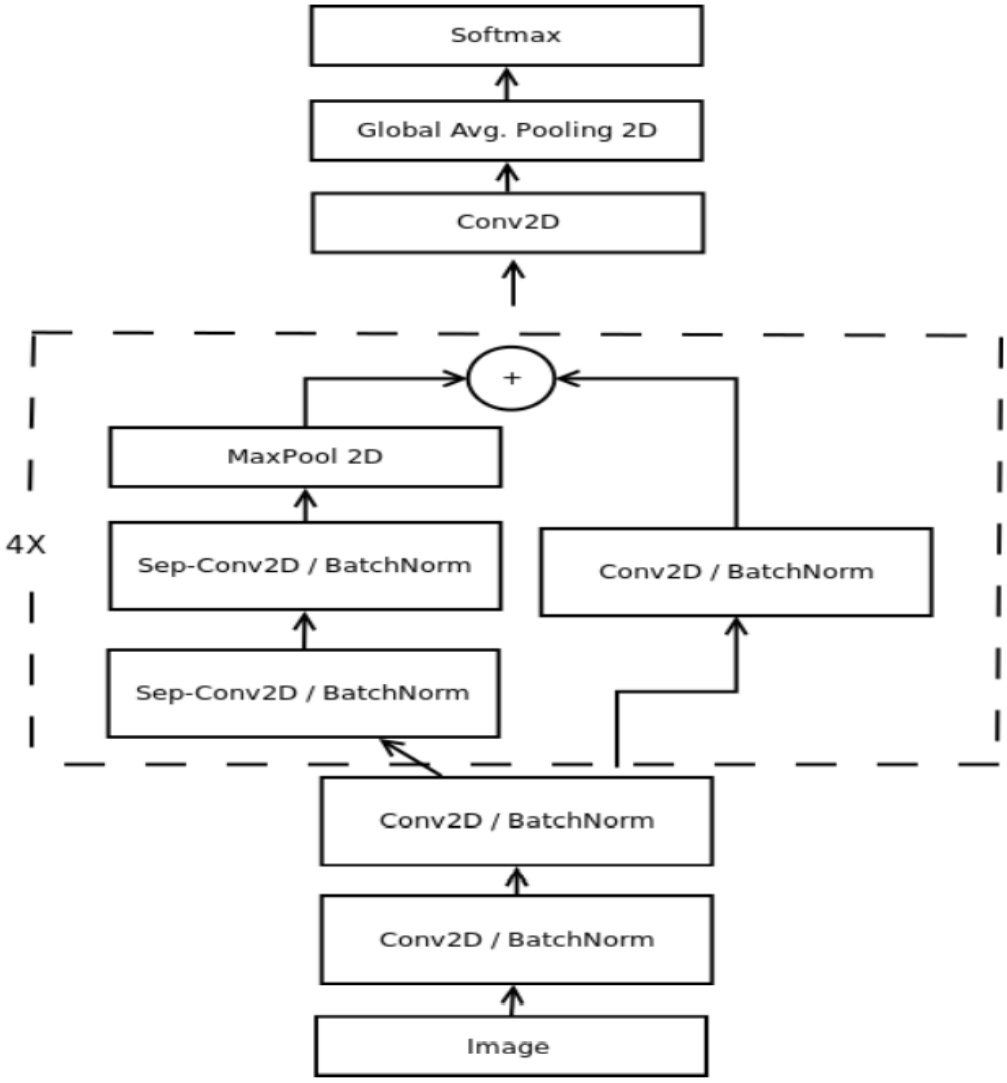
IV. METHODOLOGY:

- First, the Haar cascade method is used to detect faces in each frame of the webcam feed.
- The region of the image containing the face is resized to 48x48 and is passed as input to the CNN.
- The network outputs a list of softmax scores for the seven classes of emotions.
- The emotion with the maximum score is displayed on the screen.

V. PROPOSED MODEL:

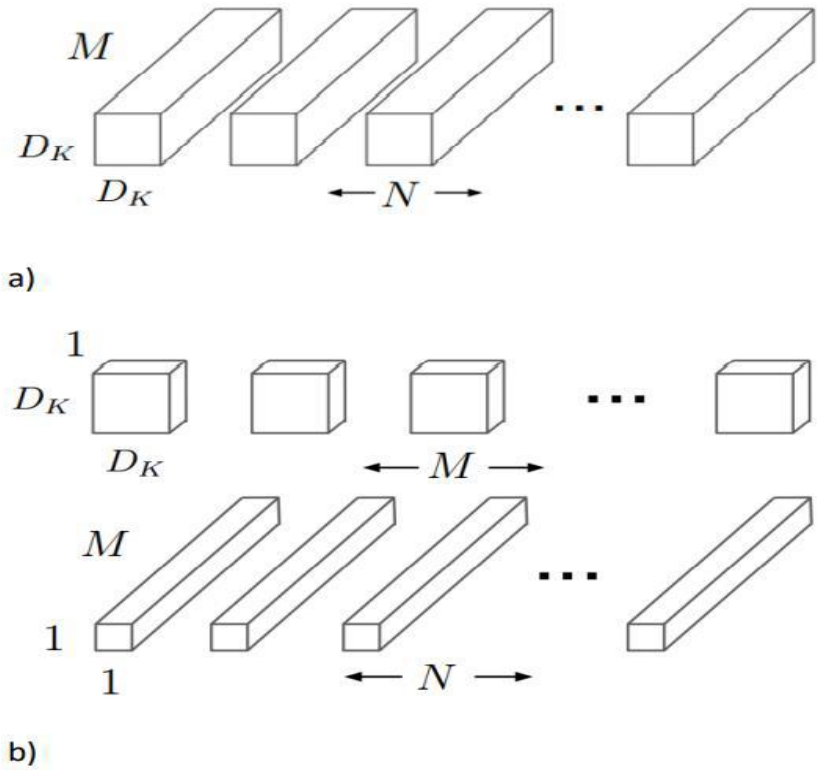
i.Convolutional Neural Network (CNN):

- CNNs are used as black-boxes and often their learned features remain hidden, making it complicated to establish a balance between their classification accuracy and unnecessary parameters. Therefore, we implemented a real-time visualization of the guided-gradient back-propagation proposed by Springenberg in order to validate the features learned by the CNN.
- We propose two models which we evaluated in accordance to their test accuracy and number of parameters. Both models were designed with the idea of creating the best accuracy over number of parameters ratio. Reducing the number of parameters help us overcoming two important problems. First, the use of small CNNs alleviate us from slow performances in hardware-constrained systems such robot platforms. And second, the reduction of parameters provides a better generalization under an Occam's razor framework. Our first model relies on the idea of eliminating completely the fully connected layers. The second architecture combines the deletion of the fully connected layer and the inclusion of the combined depth-wise separable convolutions and residual modules. Both architectures were trained with the ADAM optimizer.
- Following the previous architecture schemas, our initial architecture used Global Average Pooling to completely remove any fully connected layers. This was achieved by having in the last convolutional layer the same number of feature maps as number of classes, and applying a softmax activation function to each reduced feature map. Our initial proposed architecture is a standard fully convolutional neural network composed of 9 convolution layers, ReLUs [5], Batch Normalization [7] and Global Average Pooling. This model contains approximately 600,000 parameters.
- It was trained on the IMDB gender dataset, which contains 460,723 RGB images where each image belongs to the class "woman" or "man", and it achieved an accuracy of 96% in this dataset. We also validated this model in the FER-2013 dataset. This dataset contains 35,887 grayscale images where each image belongs to one of the following classes f"angry", "disgust", "fear", "happy","sad", "surprise", "neutral"g. Our initial model achieved an accuracy of 66% in this dataset.



ii.Proposed model for real-time classification:

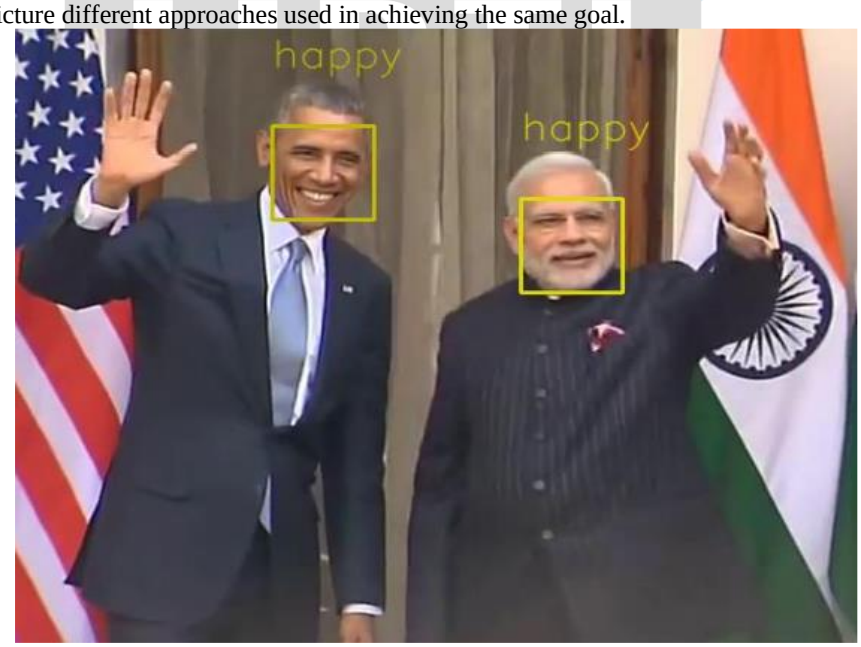
- Our second model is inspired by the Xception architecture. This architecture combines the use of residual modules and depth-wise separable convolutions. Residual modules modify the desired mapping between two subsequent layers, so that the learned features become the difference of the original feature map and the desired features. Consequently, the desired features H(x) are modified in order to solve an easier learning problem F(X) such that: H(x) = F(x) + x



- Difference between (a) standard convolutions and (b) depth-wise separable convolutions.
- Our final architecture is a fully-convolutional neural network that contains 4 residual depth-wise separable convolutions where each convolution is followed by a batch normalization operation and a ReLU activation function. The last layer applies a global average pooling and a soft-max activation function to produce a prediction. This architecture has approximately 60; 000 parameters; which corresponds to a reduction of 10X when compared to our initial naïve implementation, and 80X when compared to the original CNN.

VI. RESULTS AND DISCUSSION:

We can clearly see the wonders of AI in facial recognition. The amazing python library of face_recognition, pretrained deep learning models and open-cv have already gained so much performance and have made our life easier. There are lots of other materials that are helpful and bring into picture different approaches used in achieving the same goal.



Output image

VII. CONCLUSION

We have proposed and tested a general building design for creating real-time CNNs. Our proposed architectures have been systematically built-in order to reduce the amount of parameters. We began by eliminating completely the fully connected layers and by reducing the amount of parameters in the remaining convolutional layers via depth-wise separable convolutions. We have shown

that our proposed models can be stacked for multi-class classifications while maintaining real-time inferences. Specifically, we have developed a vision system that performs face detection and emotion classification in a single integrated module.

We have achieved human-level performance in our classifications tasks using a single CNN that leverages modern architecture constructs. Our architecture reduces the amount of parameters 80X while obtaining favorable results. Finally we presented a visualization of the learned features in the CNN using the guided back-propagation visualization.

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