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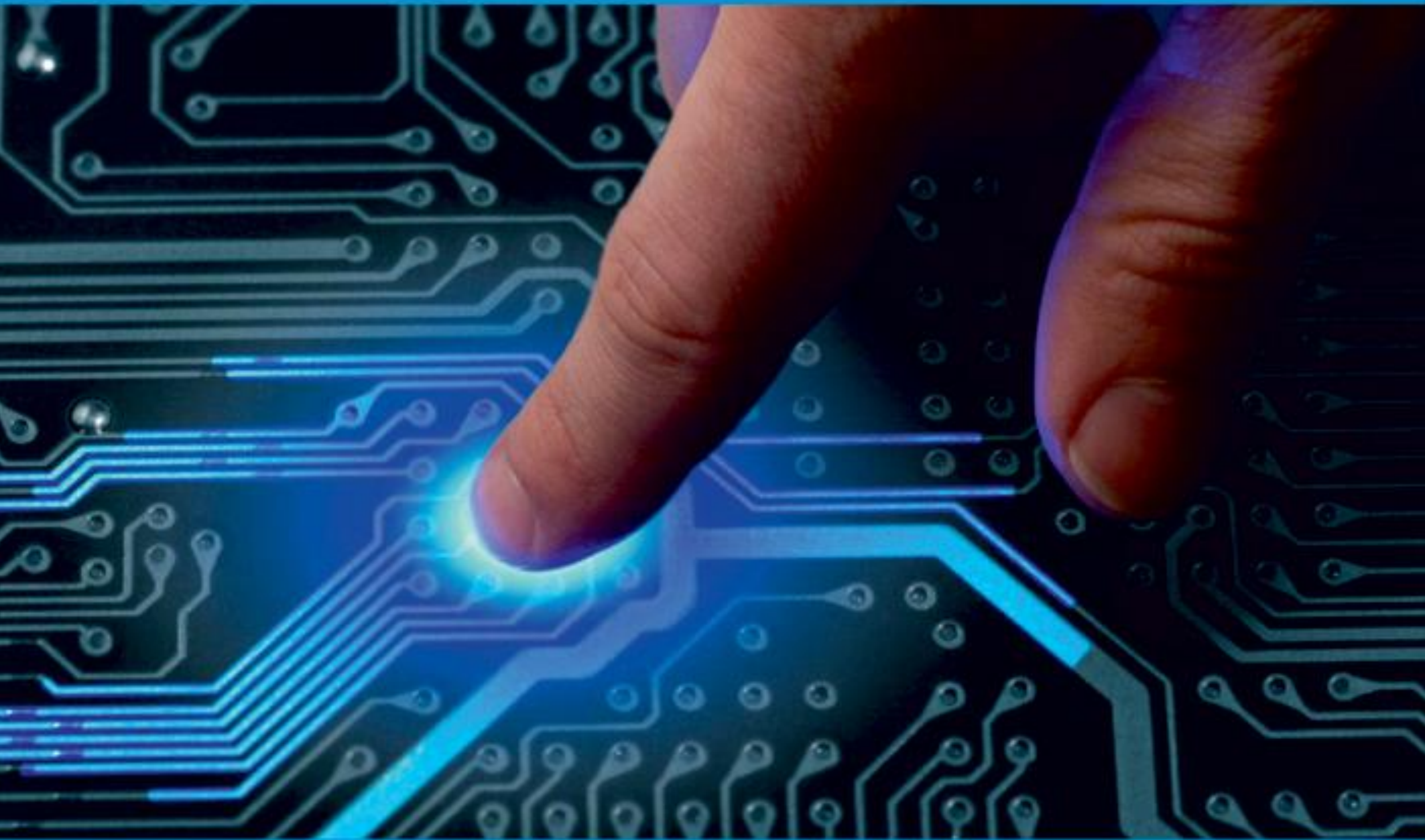

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Emotion Detection using Facial Expressions and Deep learning Technologies.

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ABSTRACT: The purpose of this paper is to Research on technology development in artificial intelligence utilizes deep learning methods in human and computer interactions as an effective system application process. The design proposed in this research aims to create a system that can predict and recognize the classification of facial emotions in real-time using the Convolutional Neural Network (CNN) algorithm with the Open CV library, specifically TensorFlow and Keras. The research design comprises three main processes: face detection, facial feature extraction, and facial emotion classification. One example of the application is the recognition of facial expressions during communication, where sometimes the prediction of emotions or expressions is not fully understood by observers. In psychology, the detection of emotions or facial expressions involves analyzing and assessing decisions to predict the emotions of an individual or a group of people in communication. The research results demonstrate the effectiveness of the Convolutional Neural Network (CNN) method in predicting facial expressions.

KEYWORDS: Artificial Intelligence (AI), Convolutional Neural Network (CNN), Fast Fourier Transform (FFT), Speech Emotion Recognition (SER), Internet of Things (IOT), Facial Emotion Recognition (FER)

I. INTRODUCTION

Due to the rapid advances in network technologies and the increasing scope of IT applications, IoT has become a favourite research topic. Researchers now have access to enriched data from social media and big data environments, which supports the development process of IoT [1]. Simultaneously, there is a growing demand for high-performance computer systems to enhance our quality of life. Human emotion detection has been implemented in various areas to provide additional security or information about individuals. It serves as a second step to face detection [2], where emotions are also detected alongside facial recognition to establish an additional layer of security. This is particularly useful to ensure that the person in front of the camera is not just a 2-dimensional representation. Deep learning is a methodology that can be utilized to calculate emotional factors. This paper proposes an alternative approach that leverages deep learning capabilities through facial expressions as features to enhance the operation of deep learning. Another domain where emotion detection is significant is in business promotions. Businesses heavily rely on customer responses to their products and offers. If an artificial intelligent system can capture and identify real-time emotions based on user images or videos, decisions can be made regarding whether customers liked or disliked a product or offer.Security is a crucial reason for identifying individuals, and it can be based on fingerprint matching, voice recognition, passwords, retina detection, etc. Identifying a person's intent can also be essential to prevent threats, especially in vulnerable areas such as airports, concerts, and major public gatherings that have experienced breaches in recent years. Human emotions can be classified as fear, contempt, disgust, anger, surprise, sadness, happiness, and neutrality[3]. Detecting these emotions can be challenging due to subtle facial muscle contortions and variations in expressions based on context. While focusing on areas of the face that display maximum emotion, such as around the mouth and eyes, extracting and categorizing these gestures remains an important question.

Neural networks and machine learning have been successfully applied to these tasks, yielding good results. Machine learning algorithms are particularly useful in pattern recognition and classification, with the features being the most crucial aspect for any algorithm. This paper explores feature extraction and modification techniques for algorithms like Convolutional Neural Networks, comparing different algorithms and feature extraction methods from various papers[4]. The human emotion dataset serves as an excellent example to study the robustness and nature of classification algorithms and their performance with different types of datasets. Typically, before feature extraction for emotion detection, face detection algorithms are applied to the image or captured frames.

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II. DESIGN

In this work, the system's dataset consists of 7 test subjects. The dataset is divided into training samples and testing samples, with 80% of the data used for training and the remaining 20% used for testing. The focus of this work is on the feature extraction technique and emotion detection based on the extracted features. It explores important features related to the face and provides information on the existing research conducted in this field. The related work encompasses various feature extraction techniques that have been utilized thus far, as well as significant algorithms that can be employed for emotion detection in human faces. The implementation of the proposed feature extraction and emotion detection framework is explained, along with the tools and libraries used for the implementation.

A. FACE OBJECT DETECTION AND COMPUTER VISION

Computer Vision involves transforming data from a video camera, photo, or image into a decision result or a new presentation, aiming to achieve a specific goal. To ensure high-quality image results, standards for image quality, speed, and embedded processing[5].performance must be met. Image segmentation techniques are employed in computer vision for the classification of objects, including the classification of physical shape and size[6]. Another concept in computer vision is Facial Recognition, where algorithms detect features on a human face and compare them with a stored profile containing information such as name, gender, and age.The face, with its unique shape and features, is a crucial part of the human body. Expressions on the face, including raised eyebrows, squinting, lip curves, and eye gaze direction, convey intentions, ideas, and feelings. In the modern era, various methods are used to interpret human facial expressions for different purposes[7]-[9]. One such application is in psychology, where accurate reading of patients' facial expressions is essential. Facial expressions are also assessed to gauge consumer satisfaction with products or services[10]. The system detects and analyzes consumers' facial expressions to gather valuable feedback.The face detection process in this study utilizes the Haar Cascade Classifier method. "Haar" refers to a mathematical function known as Haar Wavelet, which takes the form of a box. Initially, image processing relied solely on RGB values of individual pixels, but this approach proved to be ineffective. Viola and Jones introduced the Haar-Like feature, which processes images in squares, with each box containing multiple pixels. Each box is processed, generating different values that indicate dark and light areas. These values serve as the basis for image processing. The facial region in the image is automatically detected, ensuring that the face's position aligns with the face data in each image.

B. FACIAL EXPRESSION RECOGNITION

The FER2013 dataset, introduced at the International Conference on Machine Learning (ICML) in 2013 by Pierre-Luc Carrier and Aaron Courville, is a facial expression recognition dataset provided by Kaggle[11]. Each face in the dataset has been categorized based on emotion categories. The FER-2013 dataset consists of gray scale images measuring 48 pixels by 48 pixels for each image. The dataset contains a total of 35,887 images(Figure 1), with each image labeled based on 7 different classifications representing 7 different types of micro expressions. The labels range from index label 0 to 6, corresponding to the specific emotion categories.

Fig. 1: Images in Dataset FER-2013(source: [12])

Micro expressions are facial expressions that are brief and involuntary, often lasting only a fraction of a second. They are an important communication method studied in social psychology, as they can provide valuable insights into an individual's true emotions. Facial expressions, in general, serve as a means to convey intentions, goals, and emotions, playing a crucial role in human interaction. The automatic recognition and understanding of facial expressions can greatly facilitate effective communication[13]. The process of classifying human facial expressions typically involves three stages: face detection, feature extraction, and facial expression classification. Face detection is the initial step, where algorithms identify and locate faces within an image or video. Feature extraction involves capturing relevant facial features and encoding them into a suitable representation for analysis. Finally, facial expression classification entails assigning a specific category or label to the detected facial expression[14]. In this

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particular study, the authors developed a system capable of classifying facial expressions at a macro level. The system focused on classifying 7 basic human expressions(Table 1), likely referring to emotions such as happiness, sadness, anger, disgust, surprise, fear, and neutral expressions.

micro-expression (by Classification)	Validation Data		No of Training Data	Data set Total
	Public	Private		
Angry	467	491	3995	4953
Disgust	56	55	436	547
Fear	496	528	4097	5121
Happy	895	879	7215	8989
Sadness	653	594	4830	6077
Surprise	415	416	3171	4002
Contempt	607	626	4965	6198
Total	3589	3589	28709	35887

Table I: Number of data in the FER-2013 dataset

C. ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence (AI), also known as machine intelligence, is a field of computer science that focuses on developing computer systems capable of performing tasks that typically require human intelligence. AI involves studying and modeling human thought processes to design machines that can mimic human behaviour[15].The goal of AI is to create computer systems that are smarter, can understand intelligence, and make machines more useful. Intelligence is characterized by the ability to learn from experience, comprehend contradictory or ambiguous information, adapt to new situations, use reasoning to solve problems, and effectively address challenges[16].

To achieve AI applications, two key components are required:

1, Knowledgebase: This encompasses a collection of facts, theories, thoughts, and their relationships. It serves as the foundation of knowledge that the AI system can utilize.

2, Inference engine: This refers to the machine's ability to draw conclusions and make decisions based on the knowledge and experiences stored in the knowledgebase. The inference engine utilizes reasoning and logic to derive insights and solve problems.

By combining a comprehensive knowledgebase with a powerful inference engine, AI systems can simulate human-like intelligence and perform tasks that would traditionally require human involvement.

D. CONVOLUTIONAL NEURAL NETWORK AND DEEP LEARNING

The input image or feature map, while depth refers to the number of channels or filters applied to capture different features. The layers in a CNN typically include convolutional layers, pooling layers, and fully connected layers. Convolutional layers apply filters to the input data (figure 2), convolving them across the input to extract spatial features. These filters detect patterns such as edges, corners, or textures in the image. Pooling layers down sample the feature maps, reducing their spatial dimensions while preserving important features [17].This helps in reducing computation and extracting dominant features. Finally, fully connected layers connect every neuron in one layer to every neuron in the next layer, allowing for high-level feature representation and classification. The CNN architecture has been highly successful in various computer vision tasks, including image classification, object detection, and facial recognition. Its ability to automatically learn hierarchical representations from raw data, coupled with its impressive performance on image data, has made it a popular choice in the field of deep learning.

The Convolutional Neural Network (CNN) is a deep learning algorithm specifically designed for image data. It utilizes convolutional and pooling layers to extract features from images and fully connected layers for classification. The development of CNN was inspired by studies on the visual cortex and has shown remarkable performance in various computer vision tasks.

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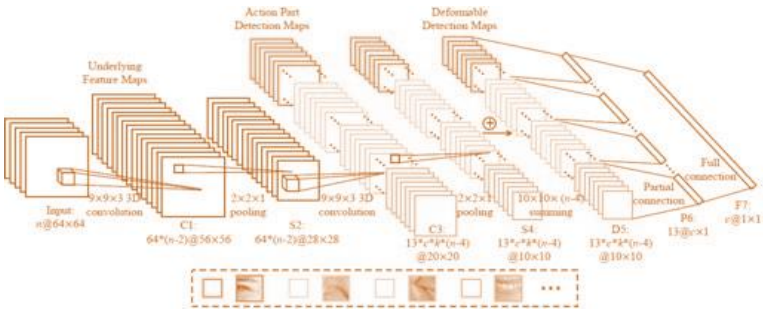

Fig. 2: Convolutional Neural Network Algoritm(source: [18])

III. TESTING OF FACIAL MICRO EXPRESSION SYSTEMS

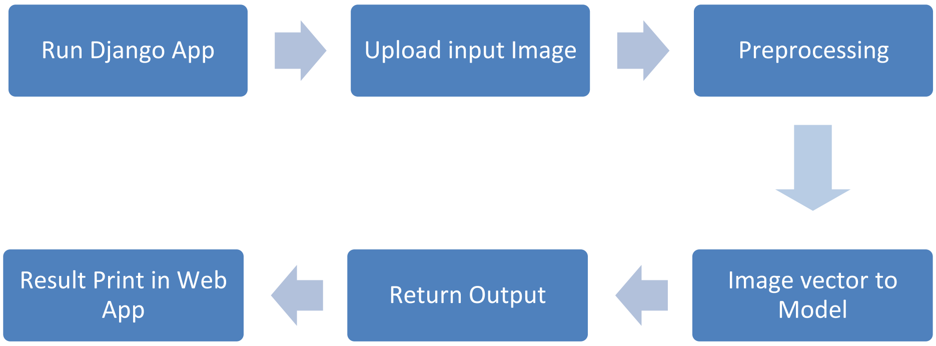

Fig.3: Proposed system design

A. DJANGO APP

A Django application is a Python package that is designed to be used within a Django project. It follows Django conventions and includes modules such as models, tests, urls, and views. Django itself is a high-level web framework for Python that enables efficient and secure development of websites. It simplifies web development by providing pre-built components and eliminating the need to reinvent common functionalities.The development of Django began in the early 2000s when a team of web developers working on newspaper websites realized the need for reusable code and design patterns. As they created and maintained multiple sites, they extracted common code into a generic web development framework. In July 2005, this framework was released as the open-source project called "Django."Over the years, Django has undergone continuous growth and improvement. Major milestones include the release of version 1.0 in September 2008 and the most recent version, 4.0, in 2022. With each release, new features, bug fixes, and enhancements have been introduced. These range from support for different databases, template engines, and caching mechanisms to the inclusion of "generic" view functions and classes, which reduce the amount of code required for common programming tasks.Django's ongoing development and updates have made it a powerful and popular choice for web development, providing developers with a robust framework to build secure and maintainable websites with greater efficiency.

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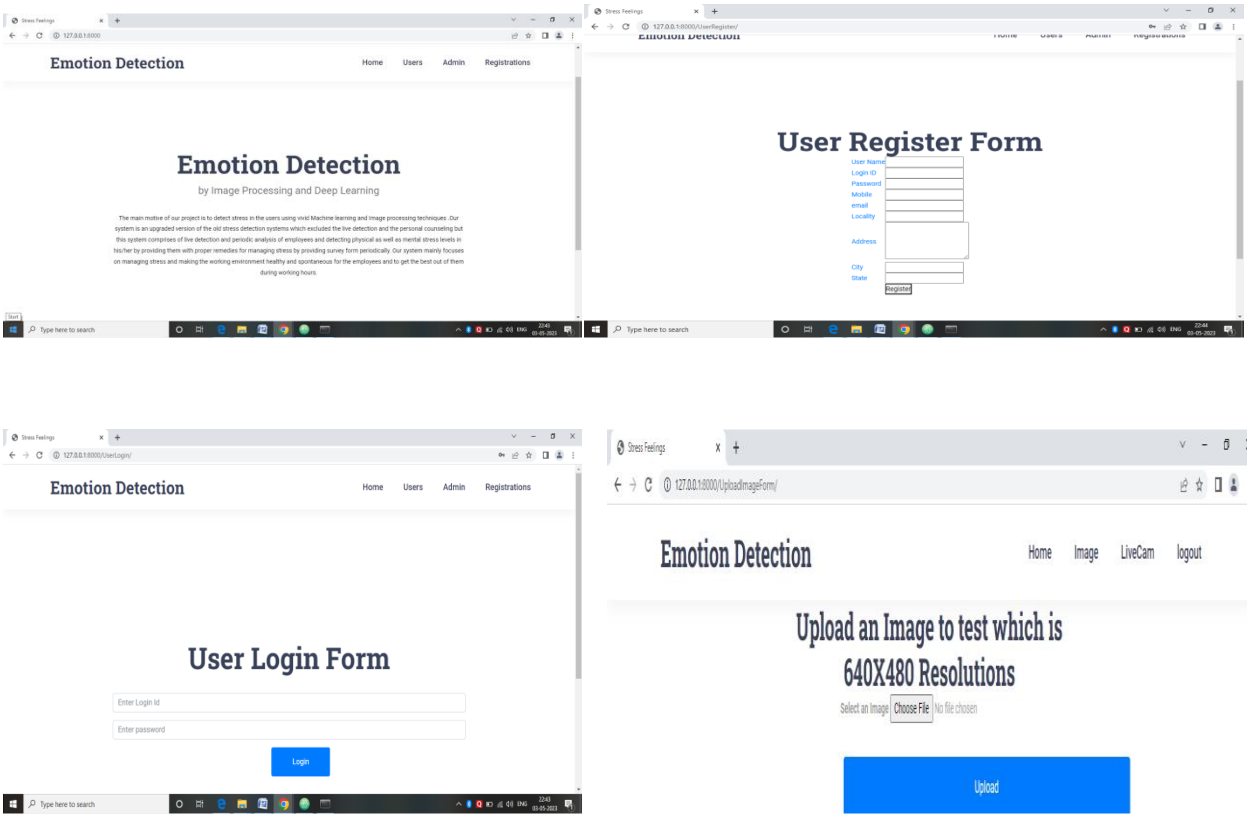

Fig 4 Django web app interfaces

The web app interfaces (Figure 4) consist of a home page, User registration form. The user can be register through the interface and create a login ID and password. After the registration the use can be login through the user login form. After the login leads to move on to the interface which consist of an image upload option and have also the live webcam option. The corresponding image to be tested can be uploaded through the interface and the result will be shown in the result table.

B. TRAINING PROCESS USING DATASET FER-2013

The training process in this study involves using the FER2013 dataset, which has been preprocessed and stored in the file "fer2013.csv". The training process involves compiling and training a model using the specified parameters, such as the number of epochs and batch size. The goal of this training process is to create a trained model that can be used for prediction.During the training process, the CNN algorithm is utilized. CNN stands for Convolutional Neural Network, which is a deep learning algorithm commonly used for image processing tasks. It involves the use of convolutional layers to extract features from the input images. In this study, the CNN model incorporates residual modules and combinations in the convolutional layers.The residual module, also known as a residual block, is a component that modifies the mapping between two layers in the neural network (figure5). It allows the network to learn residual connections, which are the differences between the original input features and the selected features. This mechanism aids in improving the optimization process and facilitates better learning.

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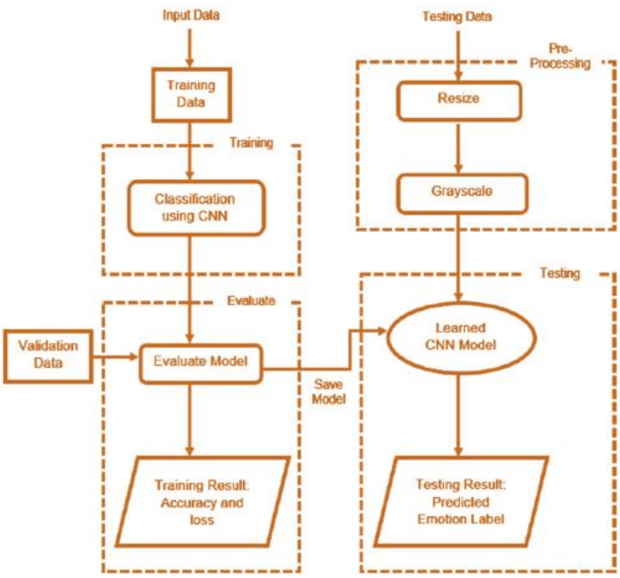

Fig. 5: FER-2013 Training dataset

The training process also involves evaluating the model using validation data to assess its performance. The evaluation results help determine the architecture and hyperparameters that yield the best performance on the validation set. Once the training process reaches the maximum number of epochs, a trained data model is obtained. This model can then be used for real-time testing, where it takes testing data (images obtained from the camera) as input to predict facial expressions.As a result, the desired feature, namely H(x) is modified to make it easier to solve problems in the training process F(x) so that the equation is as follows

$$H(x) = F(x)+x$$

The architectural model in this study consists of four modules in the hidden layer. Each module includes a deep layer of convolution using Depthwise Separable Convolutions. Depthwise Separable Convolutions are a type of convolutional operation that decomposes the standard convolution into two separate steps: a depthwise convolution and a pointwise convolution. This technique helps reduce the number of parameters and computational complexity of the model while maintaining good performance. In each convolution layer of the model, batch normalization is applied to normalize the activations and improve the training process. The ReLU activation function is then applied to introduce non-linearity to the network, allowing it to learn complex representations.The final layer of the model consists of global average pooling, which computes the average value of each feature map across spatial dimensions. This reduces the spatial dimensions of the feature maps to a single value per channel. The output of global average pooling is then passed through the Softmax activation function, which produces a probability distribution over the different classes, enabling prediction generation.The architectural model has approximately 60,000 parameters. This parameter count is significantly lower compared to implementing CNN models with fully connected layers, resulting in a 10-times reduction. During the training process, the accuracy and loss of the model are monitored and plotted.When the training loss and validation loss values decrease with each epoch, it indicates that the model is gradually understanding the patterns in the image data. This reduction in loss signifies that the model is improving its ability to make predictions and capture the underlying patterns in the training data. However, if there are peaks or increases in the loss values, it suggests that the model is facing difficulty in learning certain patterns during the training process. These peaks indicate areas where the model may struggle or encounter challenges in capturing the complex patterns present in the data. In terms of accuracy, the goal is to observe an increase in the accuracy values for each epoch. This indicates that the model is learning and improving its performance over time. However, if there are valleys or decreases in the accuracy values, it suggests that the model may find it challenging to accurately classify certain instances or encounter complex patterns that require further refinement. The first testing in your study involves using images from the FER-2013 dataset. The results of this experiment demonstrate the comparison and accuracy of the facial expression detection application developed in your research. The figure 6 likely shows the correct detection of facial expressions in the input images, indicating the effectiveness of the developed model.

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C. REAL-TIME TESTING TO DETECT FACIAL EXPRESSIONS

In the testing process of detecting micro expressions in real-time, the first step involves preparing the necessary tools, such as a webcam, to capture the input images. The Haar Cascade Classifier method is then used as a feature module to detect facial objects in each captured image frame. Once the facial object is recognized, the next step is to preprocess the image. This preprocessing step aims to enhance the quality and extract relevant features from the face object. After preprocessing, the image segmentation process is performed using the CNN algorithm. This algorithm analyzes the segmented image data and predicts the micro expressions present in the facial input data. The trained model, which was previously developed during the training process, is utilized as the facial expression prediction parameter in the system. It is responsible for labeling the predicted image results with the corresponding micro expressions. These labeled results can then be displayed on a web interface (figure6), providing real-time feedback on the detected micro expressions. It's worth mentioning that the Haar Cascade Classifier is a machine learning-based approach that uses Haar-like features and a cascade of classifiers to detect objects in images. The CNN algorithm, on the other hand, is a deep learning technique commonly used for image analysis tasks, including facial expression recognition.

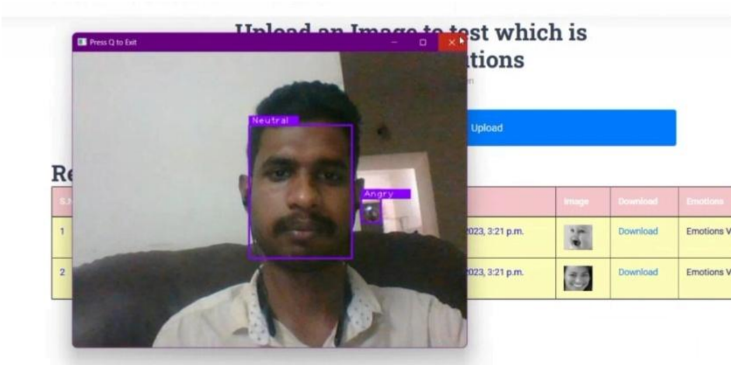

Fig 6: Real time monitoring

IV. **RESULT ANALYSIS**

In the first testing phase, the images used are from the FER-2013 dataset. This dataset consists of labeled facial expression images, which serve as the basis for evaluating the accuracy and performance of the application in detecting facial expressions. During this experiment, the application utilizes the trained model developed in the training process to analyze and classify the facial expressions present in the input images. The accuracy of the application's predictions is then compared against the ground truth labels provided in the dataset. Based on the results shown in the accompanying figure 7, the application demonstrates accurate detection of facial expressions in the input images. This indicates that the model and algorithm employed in the application are performing well in recognizing and classifying different facial expressions.

(a) Angry (b) Disgust (c) Sad

Fig. 7: Test expressions to accuracy comparison using the dataset FER-20133

The accuracy of the application's predictions can be measured by comparing the predicted labels with the actual labels in the dataset. The higher the accuracy, the more reliable and precise the application is in detecting and recognizing facial expressions. The study conducted several testing stages on the system to evaluate the design recognition of micro expressions on faces. The results indicated that the CNN architectural model used in the facial expression detection system performed optimally and in real-time. The study found that using a separate convolution layer during data training helped achieve optimal training results (Table2). The accuracy of the trained model for facial expression detection was reported to be an average of 67.67%. This accuracy value provides important insights for analyzing and evaluating the system's performance.

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Testing in real-time monitoring	Corrected		Total	
	Yes	No	Test	(%)
Facial Expression	73	7	80	91.2
Face Position or Condition	168	82	250	67.2
Distance face Camera	112	58	170	65.8
From Image or Poster	121	139	260	46.5
			Result of Experiment (mean)	67.67

Table 2: Result of facial expression testing

The system achieved a success rate of 91.2% in recognizing facial expressions. This high success rate indicates that the system performed well in accurately identifying and classifying facial expressions

Results table

S.No	User Name	File Name	Emotions	File	Date	Image	Download	Emotions
1	nidhu	im35.png	Fear	/media/im35.png	May 3, 2023, 5:16 p.m.		Download	Emotions View
2	nidhu	im0.png	Happy	/media/im0.png	May 3, 2023, 5:17 p.m.		Download	Emotions View
3	nidhu	im1_qbUQrOn.png	NoFace	/media/im1_qbUQrOn.png	May 3, 2023, 5:17 p.m.		Download	Emotions View
4	nidhu	im20.png	Angry	/media/im20.png	May 4, 2023, 1:08 a.m.		Download	Emotions View
5	nidhu	im0_jFdH9AD.png	NoFace	/media/im0_jFdH9AD.png	May 4, 2023, 1:08 a.m.		Download	Emotions View
6	nidhu	im3_QVn3l6m.png	Angry	/media/im3_QVn3l6m.png	May 4, 2023, 3:58 a.m.		Download	Emotions View
7	nidhu	im4.png	Angry	/media/im4.png	May 4, 2023, 4:04 a.m.		Download	Emotions View

Table 3: result table interface

The experimental results for recognizing different facial expressions using the system were generally successful. The system correctly recognized all tests for the expressions of sadness, surprise, contempt, and happiness. However, there were a few instances where the system had errors in recognizing certain expressions. Specifically, there was one error in recognizing the expression of anger, two errors in recognizing the expression of disgust, and one error in recognizing the expression of fear. These errors indicate that there might be some challenges or complexities in accurately detecting and classifying these specific facial expressions (Table 3). It could be due to various factors such as variations in facial expressions among individuals, image quality, or limitations of the recognition algorithm. To improve the system's performance, further analysis and refinement of the recognition algorithm may be necessary. Additionally, considering a larger dataset and conducting more experiments could help in enhancing the system's accuracy and robustness in recognizing a wider range of facial expressions.

V CONCLUSION

The training process involved utilizing the FER-2013 dataset, which is a facial expression recognition dataset. The CNN method was employed for feature extraction and facial expression prediction. Real-time facial expression recognition was achieved by detecting facial objects using the Haar Cascade method and classifying the expressions using CNN. During the facial expression recognition process, the system displayed the detected expressions on the expression display board. This provided information about the recognized expressions to the user. Based on the testing and implementation of Deep Learning with CNN for predicting seven human facial expressions using the FER-2013 dataset in Python, it can be concluded that the system was able to effectively recognize and predict facial expressions. This achievement demonstrates the potential of Deep Learning techniques, particularly CNN, in the field of facial emotion recognition and opens up possibilities for various applications in areas such as human-computer interaction, affective computing, and psychology.

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Facial Expression Recognition (FER) Technology has diverse applications. In medical research, it aids in autism therapy and deep face detection. By conducting binary classification on images of children with autism and healthy children, early and cost-effective diagnosis of the disease becomes possible. FER technology is also valuable for ensuring road safety. Real-time emotion recognition can prevent fatigue driving and collisions, promoting safety verification and pedestrian protection. Furthermore, FER technology has practical uses, such as automating selfie-taking. If a face is detected and a smile is recognized, an image is automatically captured. This technology can also be employed by businesses to analyze customer feedback emotions. Additionally, it enables live detection and periodic analysis of employee stress levels, providing remedies for managing both physical and mental stress through periodic surveys.

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