IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, July 2026
Impact Factor: 8.2

Stress Detection in Facial Expression by Machine Learning

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Abstract: *In today's fast-paced world, stress has become a common problem that affects people of all age groups. Long working hours, academic pressure, and personal challenges can lead to increased stress, which may negatively affect both physical and mental health. Traditional methods of stress assessment mainly depend on questionnaires, interviews, or expert observation. These methods are time-consuming, require human involvement, and may not always provide consistent results. Therefore, there is a need for an automated system that can detect stress quickly and accurately.*

The proposed system presents a web-based Stress Detection in Facial Expression Using Machine Learning application that analyzes facial expressions to estimate a user's stress level. The system uses image processing techniques to detect the face and extract important facial features. A Convolutional Neural Network (CNN) model is trained to recognize facial emotions such as Happy, Sad, Angry, Fear, Neutral, Surprise, and Disgust. Based on the detected emotion, the system predicts the corresponding stress level and displays the result along with a confidence score.

The application follows a simple workflow that includes user authentication, image upload or webcam capture, face detection, image preprocessing, emotion recognition, stress prediction, and report generation. OpenCV is used for face detection and image preprocessing, while TensorFlow and Keras are used to develop the CNN model. The complete application is implemented using Python, Flask, HTML, CSS, JavaScript, and SQLite, providing a user-friendly interface for stress detection.

The system was tested using different facial expression images to evaluate its performance. Experimental results showed that the proposed model successfully recognized facial emotions and predicted stress levels with reliable accuracy. The application also stores prediction history and allows users to generate reports for future reference. Although the system is not intended to replace professional medical or psychological evaluation, it can serve as a useful support tool for the early identification of stress in educational institutions, workplaces, healthcare environments, and personal well-being monitoring. Future improvements can further enhance the accuracy and practical use of the proposed system through larger datasets, real-time video analysis, and mobile application support.

Keywords: Stress detection in facial expression by machine learning

1. INTRODUCTION

Human emotions play a crucial part in communication and significantly influence mental health and overall well-being. Stress, Among the most prevalent psychological conditions in modern society, can negatively impact an individual's physical and mental health if left undetected. [1]. Current developments in artificial intelligence (AI) and Deep Learning has greatly enhanced the functionality of facial emotion recognition systems. Haq et al. proposed a real-time FER Convolutional Neural Network-Based Framework (CNNs) and MobileNet architectures to classify seven universal emotions with high accuracy, showcasing deep learning's potential for real-time emotion analysis. [2]. Furthermore, Pinto et al. conducted A comprehensive analysis of facial expression recognition

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methods and emphasized the efficiency of CNN-based architectures such as VGG and ResNet in extracting meaningful facial features for the categorizing of emotions. Their findings revealed that robust feature extraction as well as large-scale datasets are necessary for improving recognition accuracy. [3].

Apart from conventional facial expressions, micro-expressions provide valuable insights into concealed emotions and psychological states. Xie et al. displayed a comprehensive poll regarding facial micro-expression analysis, discussing datasets, feature extraction methods, transfer learning techniques, and challenges in micro-expression recognition. Their study highlighted the importance of subtle facial movements in understanding hidden emotional responses and emphasized the requirement for stronger and generalized recognition systems.[4]

Despite the fact that previous research has promising results in facial emotion recognition, several challenges remain. Most current systems focus primarily on emotion classification rather than directly assessing stress levels. Additionally, Numerous models are trained with controlled datasets and face difficulties when deployed in real-world environments. Therefore, there is a growing need for an intelligent real-time system capable of analyzing facial expressions and emotional patterns to estimate stress levels accurately and offer insightful suggestions for enhancing mental well-being.[5]

Several studies have used machine learning and deep learning techniques for facial emotion recognition. CNN-based models have shown good performance in classifying emotions such as Happy, Sad, Angry, Fear, Neutral, Surprise, and Disgust. However, many existing systems focus only on emotion recognition and do not predict stress levels or provide features such as report generation, user history, and a web-based interface.

The proposed system addresses these limitations by combining **face detection, emotion recognition, and stress prediction** in a single application. It also includes user login, report generation, and history management, making the system more practical for real-world stress monitoring.

The proposed **Stress Detection in Facial Expression Using Machine Learning** system is designed to automatically identify a user's stress level by analyzing facial expressions. The system consists of several modules that work together to process facial images, recognize emotions, and predict stress levels.

A. Image Acquisition Module

The system captures a facial image through a webcam or accepts an uploaded image from the user. This image is used as the input for further processing.

B. Face Detection Module

The captured image is processed using the **OpenCV Haar Cascade Classifier** to detect the face. The detected face is separated from the background to improve the accuracy of emotion recognition.

C. Image Preprocessing Module

The detected face is resized to **224 × 224 pixels** and normalized before it is given to the machine learning model. This step ensures that all input images have the same format.

D. Emotion Recognition Module

A **Convolutional Neural Network (CNN)** model analyzes the facial image and identifies the user's emotion. The system recognizes emotions such as **Happy, Sad, Angry, Fear, Neutral, Surprise,** and **Disgust**.

E. Stress Prediction Module

Based on the detected emotion, the system predicts the user's stress level. The result is displayed along with the confidence score to indicate the reliability of the prediction.

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F. Report Generation Module

The final prediction is displayed on the web application and stored in the database. Users can view previous results and generate reports for future reference.

II. SYSTEM ARCHITECTURE

The design stage is among the most important stages in software development, as it provides a detailed blueprint for building the entire system. In this phase, the functional and non-functional requirements identified during the analytical phase are converted into a structured system design. It defines the architecture, modules, database structure, workflow, and user interface of the application before implementation begins.

For the proposed Stress Detection in Facial Expression by Machine Learning system, the design phase focuses on creating an efficient and user-friendly application for detecting stress through facial expressions. The system is designed with different modules, including user authentication, face detection, facial image capture, image preprocessing, emotion recognition using a CNN model, stress prediction, report generation, and administrator management.

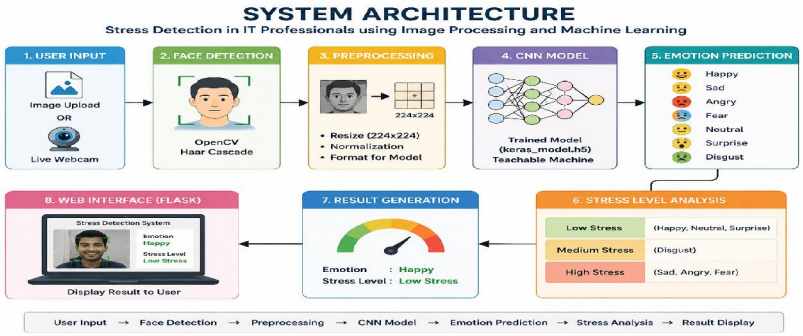

Fig 1. Stress Detection In Facial Expression By machine learning System Architecture.

III. EXPERIMENTAL SETUP

The proposed stress detection system was developed as a web-based application using machine learning and image processing techniques. Facial expression images were collected from the **FER2013 dataset** and used to train and test the Convolutional Neural Network (CNN) model. Image preprocessing techniques such as face detection, image resizing, and normalization were applied before training to improve model performance.

The CNN model was developed using **TensorFlow** and **Keras**, while **OpenCV** was used for face detection and image preprocessing. The web application was implemented using the **Flask** framework with **HTML, CSS, and JavaScript** for the user interface. The prediction results and user history were stored in an **SQLite** database. The trained model predicts facial emotions and determines the corresponding stress level with a confidence score.

Table I. Experimental Setup

Component	Specification
Programming Language	Python 3.12
Frontend	HTML, CSS, JavaScript
Backend	Flask
Database	SQLite
Deep Learning Model	Convolutional Neural Network (CNN)
Image Processing	OpenCV
Deep Learning Framework	TensorFlow, Keras

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IDE	Visual Studio Code
Dataset	FER2013 Facial Expression Dataset
Operating System	Windows 10/11
Image Size	224 × 224 Pixels
Output	Emotion Detection and Stress Level Prediction

IV. CONCLUSION AND DISCUSSION

The proposed **Stress Detection in Facial Expression Using Machine Learning** system provides an effective solution for identifying stress through facial expressions. The system combines image processing and a Convolutional Neural Network (CNN) model to recognize facial emotions and estimate the corresponding stress level. The complete process, including face detection, image preprocessing, emotion recognition, and stress prediction, is integrated into a Flask-based web application.

The developed application allows users to upload an image or capture a live image through a webcam for stress analysis. The system displays the detected emotion, predicted stress level, and confidence score in a simple and user-friendly interface. It also stores previous prediction records, allowing users to review their stress history and generate reports whenever required.

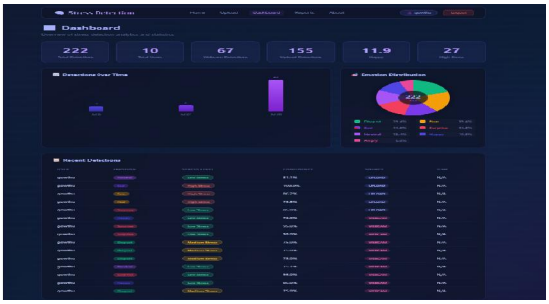

Figure 2:Detection results Dashboard

V. CONCLUSIONS

The **Stress Detection in The area of the Machine Learning for Facial Expression study was effectively accomplished.** developing an intelligent system capable of identifying stress levels through facial expression analysis. The proposed tool integrates machine learning, computer vision, and deep learning strategies to deliver a fast, accurate, and non-invasive approach for pressure detection By OpenCV for facial recognition and image preprocessing and Convolutional Neural Network (CNN) for feature extraction and unexpected stress

Throughout the correction method, the tool was designed using modular architecture that included image acquisition, face recognition, image pre-processing, feature extraction, compression writing, result visualization The model was trained and evaluated using facial feature datasets and its overall performance evaluated gives the estimated C reliable prediction accuracy and plays effectively under specific experimental conditions.

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