

AI-Based Human Stress Detection System Using Facial Expression Recognition and Machine Learning

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ABSTRACT

In recent years, mental health and stress management have become critical concerns due to increasing work pressure and lifestyle changes. Early detection of stress can help prevent serious health issues and improve overall well-being. This project presents an AI-Based Human Stress Detection System that uses facial expression recognition and machine learning techniques to identify stress levels in individuals. The system is developed using the Django web framework and integrates image processing and classification algorithms. Users can register, log in, and upload facial images, which are then analyzed to detect emotions and determine stress levels. The system uses an image-based emotion detection module that extracts facial features and classifies them into emotional states such as happy, sad, angry, or stressed.

A key component of the system is the K-Nearest Neighbors (KNN) classifier, which is used to analyze physiological and behavioral features such as ECG, EMG, GSR, heart rate, and respiration. These features are mapped to stress-related attributes like time pressure, frustration, and physical demand. The KNN algorithm classifies the data and provides performance metrics such as accuracy, sensitivity, specificity, and precision. The system also includes an admin module that allows administrators to manage users, view registered users, activate accounts, and analyze stress detection results. Users can view their stress predictions and track their emotional state over time.

Additionally, the system supports real-time stress detection using a live camera feed, enabling continuous monitoring. A deep learning-based Keras model is also integrated to enhance prediction accuracy. This project demonstrates the effectiveness of combining machine learning and image processing for mental health monitoring. It provides an automated, scalable, and user-friendly solution for stress detection, which can be extended for healthcare, workplace monitoring, and personal wellness applications.

Keywords: Stress Detection, Facial Expression Recognition, Machine Learning, KNN Algorithm, Image Processing, Django, Emotion Recognition, Deep Learning

I. INTRODUCTION

Stress is a major factor affecting human health, leading to various physical and psychological issues such as anxiety, depression, and cardiovascular diseases. With increasing demands in modern life, monitoring stress levels has become essential for maintaining mental well-being. Traditional methods of stress assessment, such as questionnaires and clinical evaluations, are subjective and time-consuming. Advancements in Artificial Intelligence (AI), Machine Learning (ML), and Image Processing have enabled automated systems for detecting human emotions and stress levels. Facial expressions are one of the most reliable indicators of emotional states, making them suitable for stress detection. By analyzing facial features, AI systems can identify emotions and infer stress levels accurately.

This project focuses on developing a Stress Detection System using facial expression recognition and machine learning techniques. The system allows users to upload images or use a live camera to detect emotions in real-time. The detected emotions are then used to determine stress levels. The application is built using Django, a robust web framework that supports rapid development and scalability. It includes user authentication, image upload functionality, and data storage. The system also provides an admin interface for managing users and analyzing results.

The KNN algorithm is used for classification due to its simplicity and effectiveness in handling small to medium-sized datasets. Additionally, a deep learning model is integrated to improve accuracy and performance. The system aims to provide an efficient and automated solution for stress detection, reducing reliance on manual assessment methods. It can be used in various domains such as healthcare, workplace monitoring, and personal wellness.

Overall, this project demonstrates how AI technologies can be applied to improve mental health monitoring and provide timely insights into stress levels.

II. LITERATURE SURVEY (WITH EXISTING METHODS)

Stress detection has been widely studied using various approaches, including physiological signal analysis, behavioral analysis, and facial expression recognition. Researchers have explored machine learning and deep learning techniques to improve detection accuracy. Early methods relied on physiological signals such as ECG, EMG, and GSR to measure stress levels. These methods provided reliable results but required specialized equipment, making them less accessible. Machine learning algorithms such as KNN, Support Vector Machines (SVM), and Decision Trees were used to classify stress levels based on these signals.

With advancements in image processing, facial expression recognition has become a popular approach for stress detection. Techniques such as Haar cascades and Local Binary Patterns (LBP) were initially used for feature extraction. These methods were later replaced by deep learning models such as Convolutional Neural Networks (CNNs),

which can automatically learn features from images. Recent studies have shown that deep learning models outperform traditional machine learning algorithms in emotion recognition tasks. Models such as VGGNet, ResNet, and custom CNN architectures have been used to achieve high accuracy in facial emotion detection. Hybrid approaches combining physiological signals and facial expressions have also been proposed to improve reliability. These systems use multiple data sources to provide more accurate stress detection.

Web-based implementations using frameworks like Django have enabled real-time stress detection systems. These systems provide user-friendly interfaces and support features such as image upload, live detection, and result visualization. Despite advancements, challenges remain, including variations in lighting conditions, facial expressions, and dataset limitations. Ensuring accuracy and reliability in real-world scenarios is still a key research area.

The proposed system combines image-based emotion detection with machine learning classification, providing a practical and scalable solution for stress detection.

III. EXISTING SYSTEM

Existing stress detection systems primarily rely on physiological measurements such as heart rate, skin conductance, and brain activity. While these methods provide accurate results, they require specialized sensors and equipment, making them expensive and less accessible.

Some systems use questionnaires and self-assessment tools to evaluate stress levels. However, these methods are subjective and may not provide reliable results. They also depend on user honesty and awareness.

Facial expression-based systems have been developed, but many of them use basic image processing techniques that lack accuracy. Traditional machine learning models require manual feature extraction, which can be time-consuming and less effective.

Additionally, many existing systems are standalone applications that do not provide web-based access or user management features. They lack scalability and integration with modern technologies.

Overall, existing systems face limitations such as high cost, lack of automation, and limited accessibility. These challenges highlight the need for an AI-based solution that is accurate, scalable, and user-friendly.

IV. PROPOSED METHOD

The proposed system is an AI-powered stress detection platform that integrates facial expression recognition, machine learning, and web-based technologies to provide an automated and scalable solution for stress analysis. Unlike traditional systems that rely on

physical sensors or manual input, this system uses image-based emotion detection to identify stress levels efficiently. The system allows users to register, log in, and upload facial images through a web interface developed using Django. The uploaded images are processed using an image expression detection module, which extracts facial features and identifies emotional states such as happiness, sadness, anger, or stress. These emotional indicators are then used to determine the user's stress level.

To enhance accuracy, the system incorporates the K-Nearest Neighbors (KNN) algorithm for classification. It also supports integration with deep learning models (e.g., Keras-based CNN) for improved performance in complex scenarios. Additionally, the system provides real-time stress detection using live camera input. An admin module is included to manage users, monitor stress predictions, and evaluate system performance using metrics such as accuracy, sensitivity, and precision. The system also maintains historical data for tracking user stress patterns.

The proposed system is cost-effective, user-friendly, and accessible, making it suitable for applications in healthcare, workplaces, and personal well-being monitoring. It addresses the limitations of existing systems by providing automation, scalability, and real-time analysis.

V. IMPLEMENTATION

The implementation of the stress detection system is carried out using the Django web framework, combined with machine learning and image processing techniques. The system architecture is divided into multiple modules, including user management, image processing, classification, and result visualization. The frontend is developed using HTML, CSS, and JavaScript, providing an interactive user interface for registration, login, and image upload. The backend is implemented using Django, which handles user authentication, session management, and database interactions.

The system uses a database (SQLite/MySQL) to store user information, uploaded images, and prediction results. Models such as `UserRegistrationModel` and `UserImagePredictionModel` are used to manage data efficiently.

The image processing module plays a crucial role in detecting facial expressions. When a user uploads an image, it is stored on the server and processed using an expression detection algorithm. This module extracts facial features and maps them to emotional categories. The classification process is performed using the KNN algorithm. The dataset includes features such as ECG, EMG, GSR, heart rate, and respiration, which are mapped to stress-related attributes. The KNN classifier analyzes the similarity between input data and training data to determine the stress level.

Additionally, a deep learning model (Keras-based) is integrated for advanced classification. This model improves accuracy by learning complex patterns in facial

expressions. Real-time detection is implemented using a live camera module, allowing continuous monitoring. The admin module provides functionalities such as viewing registered users, activating accounts, and analyzing stress detection results. Performance metrics such as accuracy, classification error, sensitivity, specificity, and precision are calculated and displayed.

Error handling mechanisms are implemented to ensure system reliability. For example, file format validation ensures that only valid image files are processed. Overall, the implementation combines web technologies, machine learning, and image processing to create a robust and efficient stress detection system.

VI. ALGORITHMS

The system primarily uses the K-Nearest Neighbors (KNN) algorithm along with image processing and deep learning techniques for stress detection.

1. K-Nearest Neighbors (KNN):

KNN is a supervised machine learning algorithm used for classification. It works by identifying the 'k' closest data points (neighbors) to a given input and assigning the most common class among them. In this system, KNN is used to classify stress levels based on physiological and emotional features. The algorithm calculates the distance (usually Euclidean distance) between the input and training data points.

Steps in KNN Algorithm:

1. Load training dataset
2. Choose value of k
3. Calculate distance between input and all training samples
4. Select k nearest neighbors
5. Assign class based on majority voting

2. Facial Expression Recognition (FER):

FER techniques are used to detect emotions from facial images. These techniques involve feature extraction and classification. Modern approaches use deep learning models such as CNNs to automatically learn features from images. FER plays a key role in identifying stress-related emotions.

3. Deep Learning (CNN):

Convolutional Neural Networks (CNNs) are used for advanced image classification. They extract hierarchical features from images and improve accuracy in emotion detection tasks. Recent research shows CNN-based FER systems can effectively detect stress-related microexpressions.

4. Multimodal Analysis (Optional):

Combining facial expressions with physiological signals improves accuracy. Studies show multimodal approaches can achieve higher reliability in stress detection systems.

VII. SYSTEM DESIGN

The system design follows a modular and layered architecture to ensure scalability, maintainability, and efficiency. It consists of the following components:

1. User Interface Layer:

This layer includes web pages for user registration, login, image upload, and result display. It provides an interactive and user-friendly experience.

2. Application Layer (Django Backend):

This layer handles business logic, request processing, and communication between frontend and backend. It includes views, models, and templates.

3. Database Layer:

The database stores user details, uploaded images, and prediction results. It ensures data integrity and efficient retrieval.

4. Image Processing Module:

This module processes uploaded images to detect facial features and extract emotional information. It uses computer vision techniques to analyze facial expressions.

5. Machine Learning Module:

This module includes the KNN classifier and deep learning models. It processes extracted features and predicts stress levels.

6. Admin Module:

Provides functionalities for managing users, monitoring system performance, and analyzing results.

7. Real-Time Detection Module:

This module uses a webcam to capture live video and detect stress in real time.

Architecture Flow:

1. User uploads image
2. Image is stored in server
3. Image processing extracts features
4. ML model classifies stress level
5. Result is displayed to user
6. Data is stored for future analysis

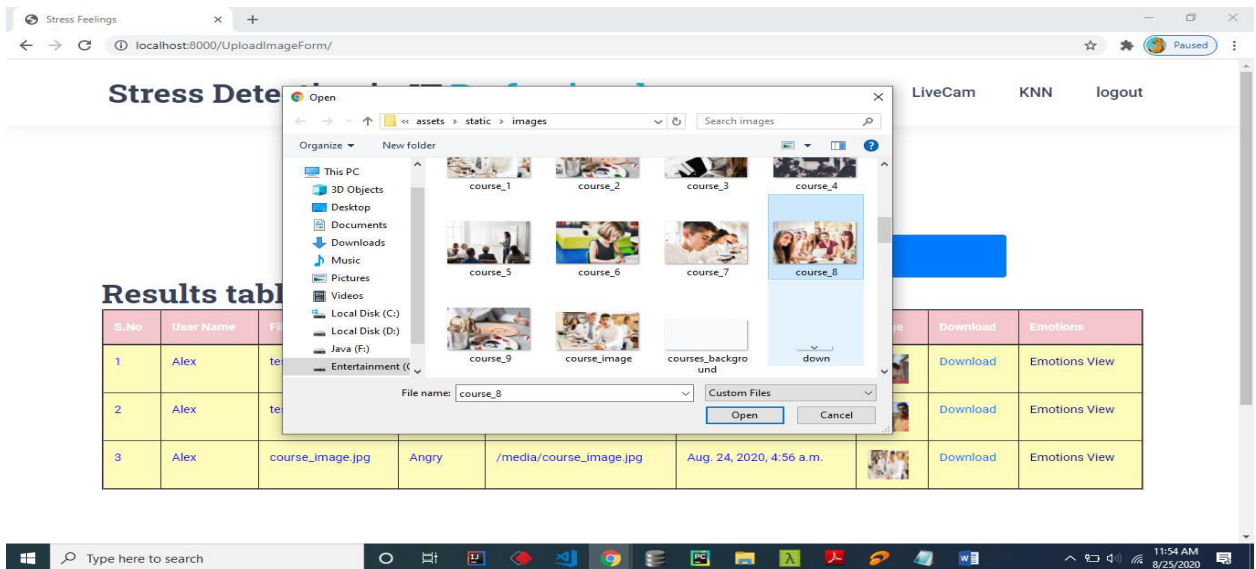
Modern system designs also incorporate FER pipelines that handle variations in lighting, pose, and facial features to improve robustness. The modular design ensures that each component can be updated independently, making the system flexible and scalable.

SYSTEM DESIGN IMAGES

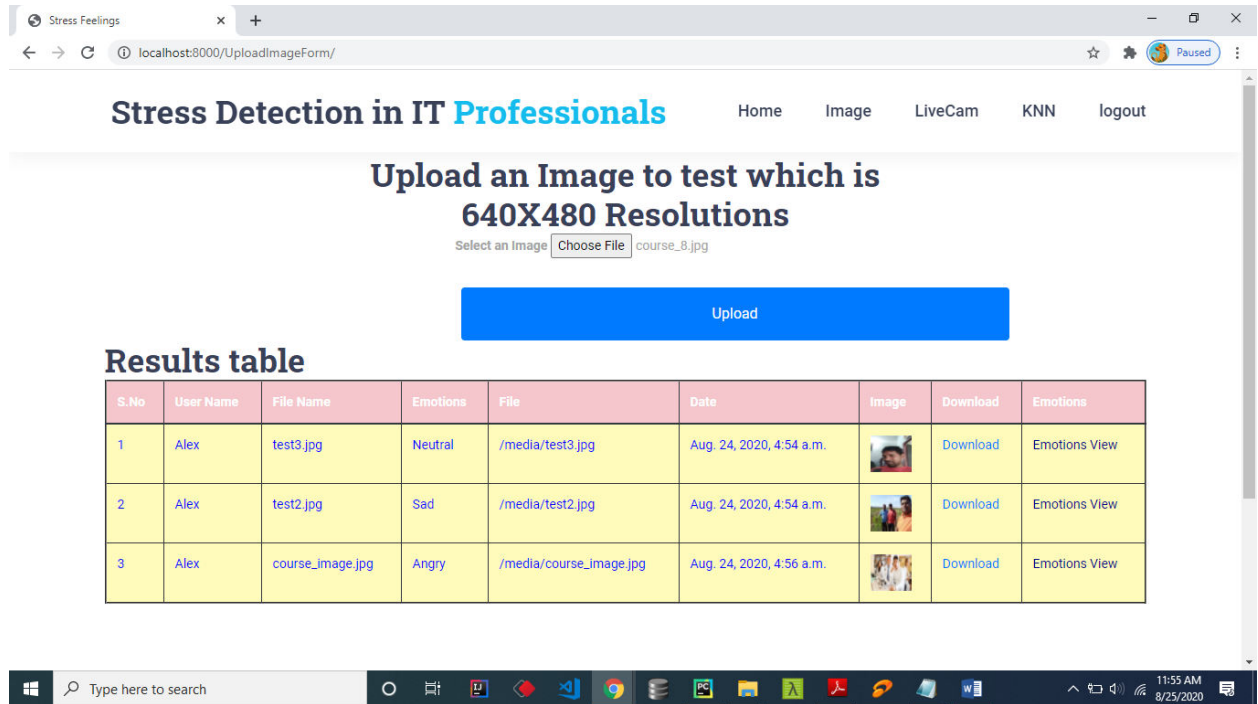
User Login Form:



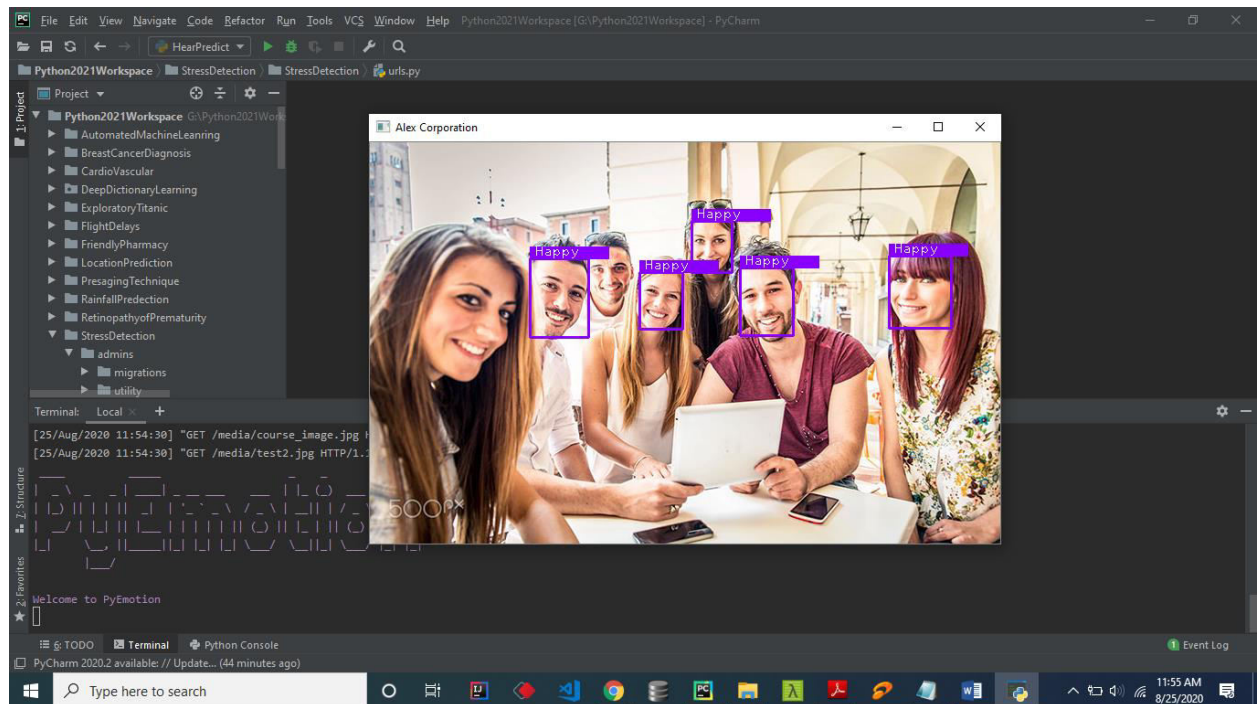
Giving Image as Input:



Upload Image:



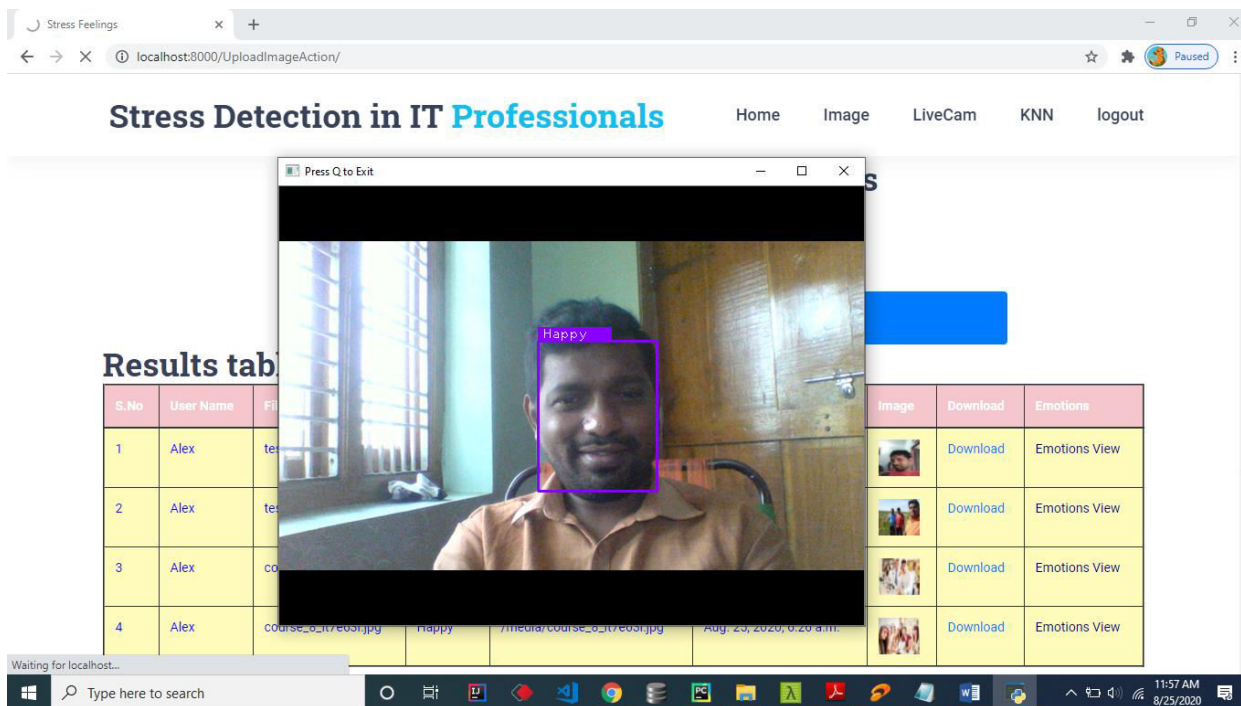
Response Image:



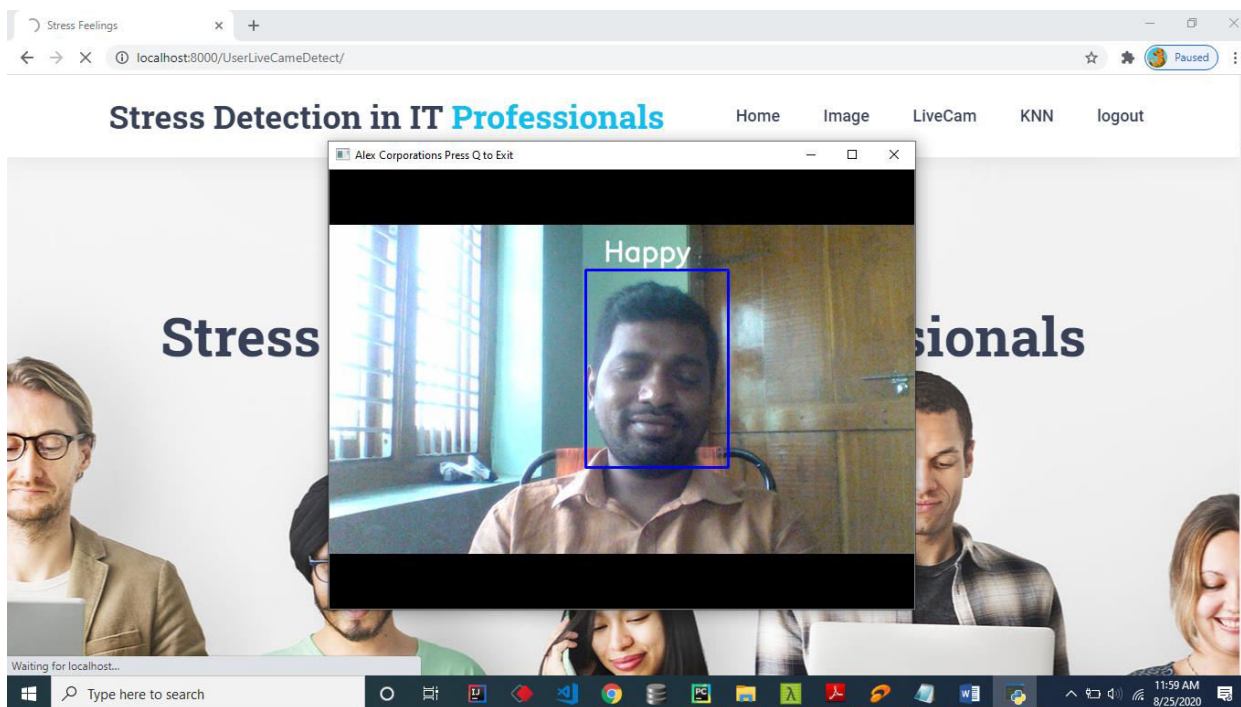
Results:



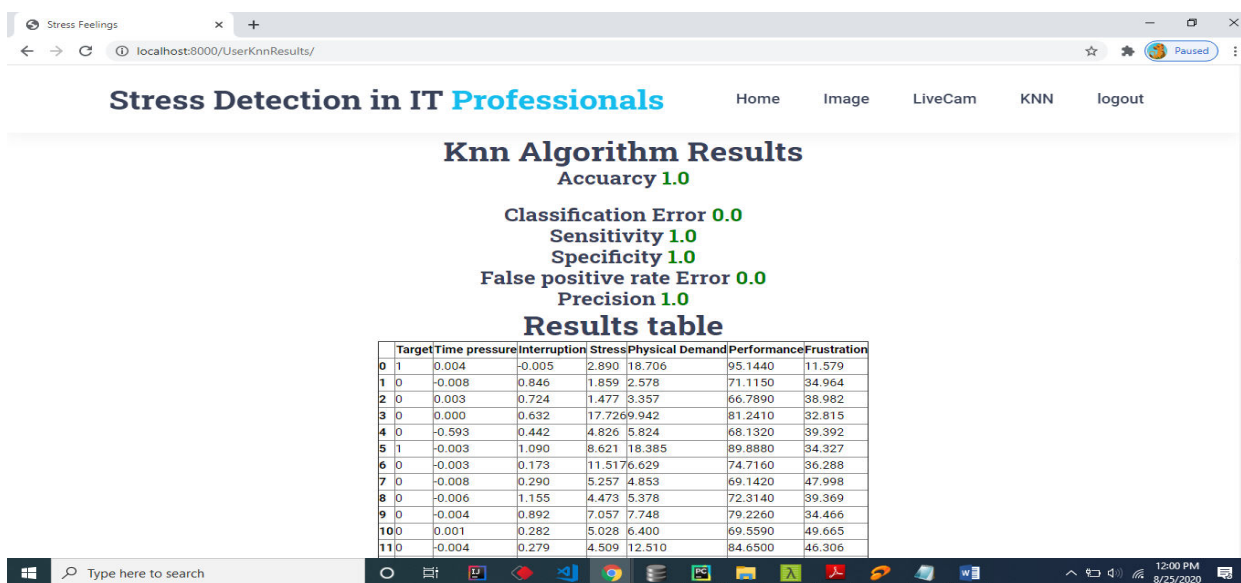
Live Stream:



Deep Learning Frame



KNN Results:



Dataset View:

Results table

	Target	Time pressure	Interruption	Stress	Physical Demand	Performance	Frustration
0	1	0.004	-0.005	2.890	18.706	95.1440	11.579
1	0	-0.008	0.846	1.859	2.578	71.1150	34.964
2	0	0.003	0.724	1.477	3.357	66.7890	38.982
3	0	0.000	0.632	17.7269	9.42	81.2410	32.815
4	0	-0.593	0.442	4.826	5.824	68.1320	39.392
5	1	-0.003	1.090	8.621	18.385	89.8880	34.327
6	0	-0.003	0.173	11.5176	6.29	74.7160	36.288
7	0	-0.008	0.290	5.257	4.853	69.1420	47.998
8	0	-0.006	1.155	4.473	5.378	72.3140	39.369
9	0	-0.004	0.892	7.057	7.748	79.2260	34.466
10	0	0.001	0.282	5.028	6.400	69.5590	49.665
11	0	-0.004	0.279	4.509	12.510	84.6500	46.306
12	1	0.005	0.980	11.0821	17.432	96.7990	38.317
13	1	0.003	0.980	11.0821	17.341	110.0650	38.317
14	0	-0.001	0.947	6.213	6.173	71.0410	43.114
15	1	0.000	0.931	5.910	19.773	101.0650	35.590
16	0	-0.003	0.532	3.086	6.070	73.3550	37.487
17	0	-0.008	0.846	1.859	2.578	65.8920	36.898
18	0	0.003	0.724	1.477	3.357	82.4560	38.788
19	1	0.000	0.931	8.910	19.245	110.0650	32.598
20	0	0.000	0.632	10.234	10.567	77.2340	37.815
21	1	0.004	-0.005	9.890	18.798	99.1440	11.579
22	0	-0.500	0.442	4.826	5.824	56.6780	40.392
23	0	-0.003	0.255	11.5178	2.98	74.7160	35.556
24	0	-0.009	0.450	5.257	4.853	72.4560	45.898

Activate users:

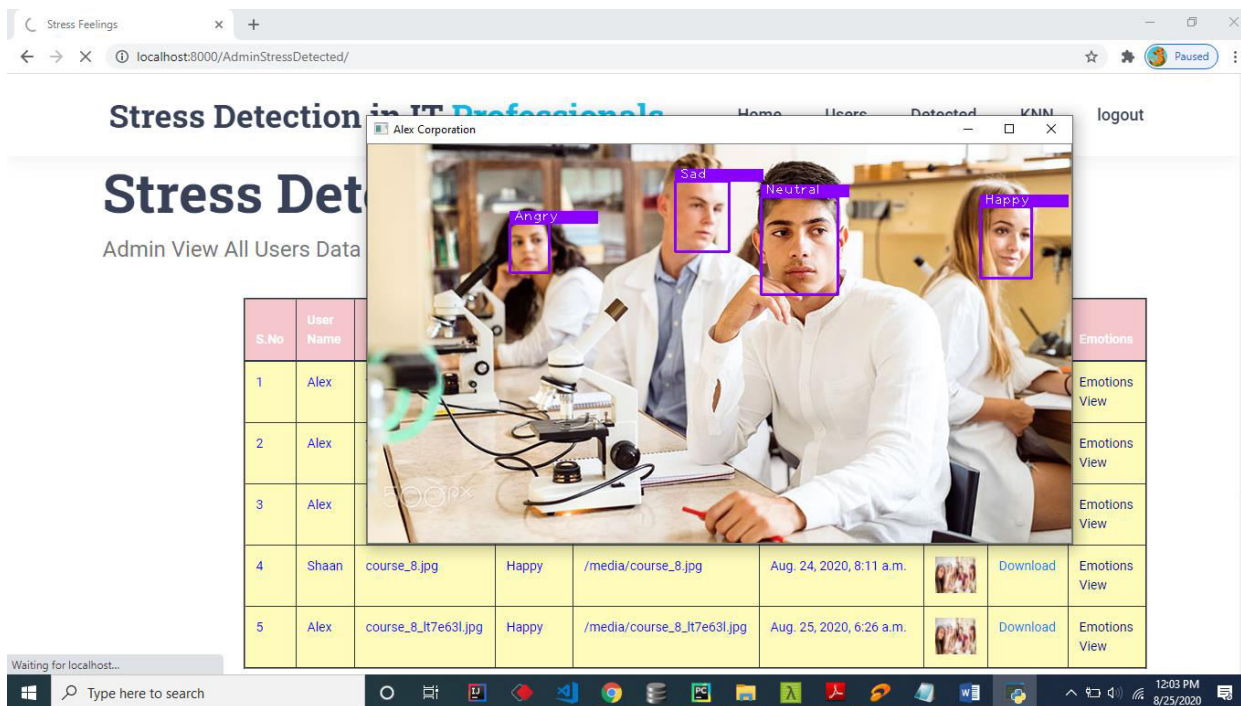
Registered users and Activate them

S.No	Name	Login ID	Mobile	Email	Locality	Status	Activate
1	Shaan	shaan	9700156568	shaanaol@gmail.com	Hyderabad	activated	Activated
2	Alex	alex	9701156568	lx160cm@gmail.com	Hyderabad	activated	Activated
3	sagar	sagar	9701256568	marrisagar121@gmail.com	Godavarikhani	waiting	Activate
4	Meghana	meghana	9705689476	meghanaruth@gmail.com	Vijayawada	waiting	Activate
5	Harish	harish	9700154568	harish@gmail.com	Hyderabad	activated	Activated

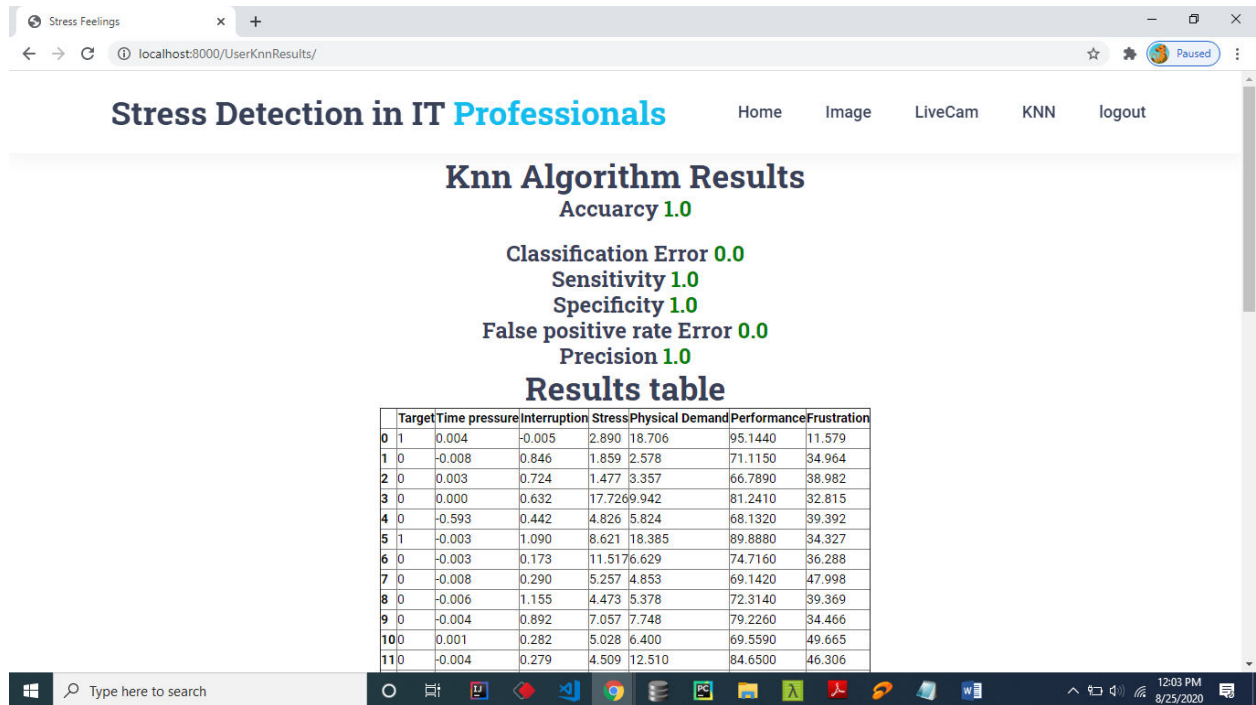
Detected Images:



Admin Side Results:



Admin View knn Results:



VIII. CONCLUSION

The AI-Based Stress Detection System demonstrates the potential of integrating machine learning, image processing, and web technologies for mental health monitoring. By using facial expression recognition and classification algorithms, the system provides an automated and efficient method for detecting stress levels. The use of the KNN algorithm ensures simplicity and effectiveness in classification, while the integration of deep learning models enhances accuracy. The Django framework enables the development of a scalable and user-friendly web application, making the system accessible to a wide range of users.

One of the key advantages of the system is its ability to perform real-time stress detection using a live camera, which is particularly useful for continuous monitoring. The admin module further enhances usability by providing insights into user data and system performance. Recent research highlights the importance of facial expression recognition and multimodal approaches in improving stress detection accuracy. The proposed system aligns with these advancements by combining multiple techniques for better performance.

However, challenges such as variations in lighting, facial expressions, and dataset limitations still exist. Future improvements may include the use of more advanced deep learning models, larger datasets, and multimodal data integration.

Overall, the system provides a practical and scalable solution for stress detection and can be applied in healthcare, workplaces, and personal wellness applications.

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