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Deep Learning Based Interactive Dashboard for Enhancing Online Classroom Experience through Student Emotion Analysis

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Abstract: *The rapid shift toward online education has highlighted challenges in maintaining student engagement and monitoring emotional well-being during virtual classes. Traditional teaching methods often fall short in providing real-time feedback on students' emotional states, leading to decreased interaction and learning effectiveness. This project proposes the development of an interactive dashboard powered by deep learning-based facial expression recognition to address this issue. The system captures live video feeds during online classes, detects student faces, and classifies emotional states such as boredom, confusion, interest, and frustration. These emotional trends are then visually presented on a dynamic dashboard, enabling teachers to assess student engagement in real-time. By providing timely emotional insights, the proposed system empowers educators to adapt their teaching strategies, foster more meaningful interaction, and enhance the overall online learning experience*

Keywords: Online education, Student enagement, Facial Expression Recognition, Emotion detection, Deep learning, Interactive Dashboard, Student emotions, Teaching Strategies

I. INTRODUCTION

The shift toward online education due to global circumstances has accelerated the need for intelligent and interactive e-learning environments. One of the pressing challenges in virtual classrooms is the lack of real-time emotional feedback, which limits educator's ability to gauge student engagement and understanding. Conventional video conferencing tools do not offer insight into students' emotional states, resulting in decreased participation, interest, and overall learning quality. To address these issues, advanced technologies such as deep learning and emotion recognition are being explored to enrich the virtual learning experience by making it more adaptive and human-centered.

II. LITERATURE REVIEW

[1] Zhuojun Ren and Liu Yang proposed "Emotion Recognition and Analysis in Gamified Education Contexts for Higher Vocational Students", 2024.The study explores the integration of emotion recognition technology within gamified educational environments aimed at higher vocational students. The authors implemented affective computing techniques to dynamically assess learners' emotional states during interaction with educational games. By analyzing facial expressions and emotional shifts, the system provides adaptive feedback and intervention to enhance motivation and engagement. The findings suggest that gamified systems embedded with emotion recognition can personalize learning and promote deeper student involvement in vocational education settings.

[2] Vishnu Kant and Panchal Sandeep Govindrao proposed "Facial Emotion Recognition Using CNNs: Implications for Affective Computing and Surveillance", 2024. This work applies Convolutional Neural Networks (CNNs) for facial emotion recognition with applications in both affective computing and surveillance. The model is trained on diverse emotion-labeled datasets and exhibits high accuracy in real-time emotion detection tasks. The authors highlight the potential of CNN-based emotion recognition systems to enhance human- computer interaction and improve safety in

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public surveillance systems. Their results affirm the viability of CNNs in reliably interpreting human emotional states in uncontrolled environments.

[3] Wei Xue and Jie Liu presented "Design of Intelligent Teaching Evaluation System Based on Emotion Recognition Algorithm", 2024. This paper introduces an intelligent teaching evaluation framework that utilizes emotion recognition algorithms to assess student responses during classroom sessions. By capturing real-time facial expressions and analyzing emotional feedback, the system evaluates the effectiveness of teaching methods. The proposed model aids educators in adjusting instructional strategies based on student affective states, aiming to foster a more responsive and supportive learning environment. The integration of emotion recognition into pedagogical evaluation signifies a novel step toward AI-enhanced education systems.

[4] Javed Hossain proposed "Leveraging Deep Quantum Convolutional Neural Networks for Student Facial Expression Identification and Mode Assessments", 2024. In this research, the author introduces a quantum-enhanced deep learning model for emotion recognition, particularly focused on student facial expressions. The Deep Quantum Convolutional Neural Network (DQCNN) is leveraged to boost classification accuracy and reduce computational time. The study shows that quantum learning models can efficiently identify student mood and behavior patterns, offering promising applications in intelligent tutoring systems. This hybrid of quantum computing and affective education marks a significant advancement in the field of emotion-aware learning analytics.

[5] Debajyoti Chatterjee proposed "Detection of Student Impulse in the Classroom Using Facial Emotion Recognition", 2024.This study focuses on the identification of impulsive behavior among students through facial emotion recognition technology in classroom settings. The system captures and processes facial data to detect rapid emotional changes linked to impulsive reactions, which may indicate distraction or disengagement. By providing real-time alerts to instructors, the system enables timely intervention to maintain classroom discipline and enhance attention. The results emphasize the growing role of affective monitoring tools in behaviour-aware educational environments.

III. SYSTEM ARCHITECTURE

The proposed system architecture of "Deep Learning Based Interactive Dashboard For Enhancing Online Classroom Experience Through Student Emotion Analysis" aims to transform the online classroom experience by incorporating facial emotion recognition into a real-time interactive dashboard.

The system architecture of this project is a client-server based, modular design that enables real-time facial emotion recognition and sentiment analysis during online classroom sessions. It integrates **computer vision**, **deep learning**, and **dashboard visualization** components to monitor and display students' emotional states to teachers.

The architecture is composed of three primary layers:

Student Client Side:

This layer captures real-time webcam footage from students using a face capture module. It performs local preprocessing such as resizing, normalization, and segmentation to extract clean facial data.

Backend Processing Server:

Preprocessed facial features are sent to the backend via a secure API. A deep learning model (CNN or CNN-LSTM) processes these features to classify emotions like happy, sad, confused, or neutral. The emotion results are stored and updated in a central database along with session metadata.

Teacher Interface (Dashboard Layer):

Teachers log into a dashboard where they can view individual and aggregated emotional data of students. The dashboard visualizes emotion trends through graphs, charts, and alerts, enabling the teacher to adapt their teaching strategies in real time.

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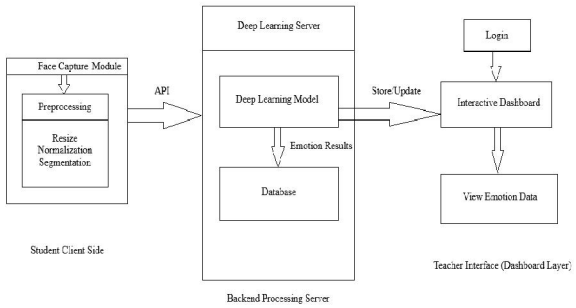

Fig. 1 Architecture Diagram of the Online Class emotion Detection Dashboard.

IV. MODULES AND TECHNOLOGIES

1. MODULES

Student Face Capture Module

The Student Face Capture Module captures students' facial data in real time during online classes using webcam video or image frames. It uses algorithms like Haar cascades or CNNs to detect and extract faces under varying lighting, angles, and backgrounds.

The system ensures efficient, lag-free performance even with multiple video feeds. Clear and accurate face detection is vital for reliable emotion recognition in the next stages.

Preprocessing Module

The Pre-processing Module prepares facial images for emotion detection by performing tasks like alignment, resizing, noise removal, and normalization. Face alignment ensures consistent positioning of features, while resizing standardizes image input for deep learning models. Techniques like Gaussian filtering and histogram equalization enhance image quality and contrast. These steps reduce noise and variability, boosting the accuracy of emotion recognition.

Emotion Detection Module

The Emotion Detection Module analyzes pre-processed facial images to identify students' emotional states using deep learning models like CNNs. It detects emotions such as happy, sad, angry, and neutral by learning patterns in facial features from large datasets. RNNs or LSTMs may be used to capture emotion changes over time in video streams. The module outputs a probability distribution of emotions, providing fast, accurate, and real-time feedback for effective online teaching.

Show Emotion in Display of Staff Module

The Show Emotion in Display of Staff Module presents students' real-time emotional states on the teacher's screen after processing by the Emotion Detection Module. It displays individual or aggregated class emotions, helping teachers assess engagement levels instantly. This enables teachers to adjust their teaching strategies based on students' emotional feedback. User-friendly visuals like icons and color indicators ensure quick and clear interpretation of student emotions.

Staff View Student Emotion Module

The Staff View Student Emotions Module provides a dashboard to monitor individual and overall class emotions in real time. It aggregates emotion data, helping teachers identify trends, shifts, or sudden changes in student engagement. This insight allows educators to adapt teaching methods or offer support as needed during the session. It can also display historical emotion trends to improve future lesson planning and student engagement strategies.

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2. TECHNOLOGIES

TensorFlow

TensorFlow is a deep learning framework used to build and train the emotion detection model efficiently, supporting both CNN and LSTM architectures with GPU acceleration.

LSTM (Long Short-Term Memory)

LSTM is a type of RNN used in this project to capture temporal patterns in students' facial expressions across video frames, helping detect emotion changes over time.

Keras

Keras is a high-level API built on TensorFlow that simplifies building and training deep learning models like CNNs and LSTMs used for facial emotion recognition.

RNN (Recurrent Neural Network)

RNNs process sequential data, and in this project, they help analyze continuous video streams to detect how student emotions evolve during a live class session.

V. DIAGRAMS

A. Use Case Diagram

The use case diagram shows interactions between two primary actors: Staff and Student. Both actors participate in the "Attend class" use case, with Staff also handling "Log in" and "Capture face" activities. Students' faces are captured during class for emotion analysis. The system then performs internal processes like preprocessing, segmentation, feature extraction, and emotion detection. These actions help generate emotional insights for staff during online sessions.

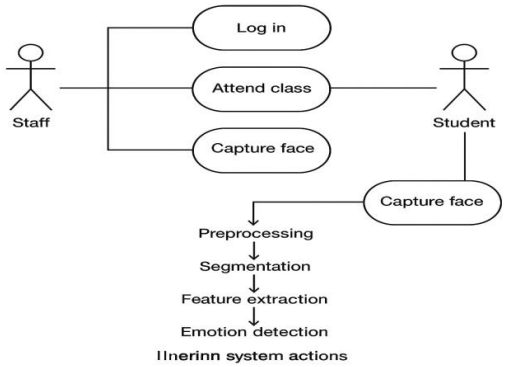

Fig. 2. Use case diagram representing Staff and Student interactions.

B. Class Diagram

This class diagram illustrates a facial emotion recognition system for online classrooms. It starts with the Webcam capturing frames, which are preprocessed by the FacePreprocessor and sent to a CNNModel for emotion classification. The Emotion class holds the predicted labels, which are visualized through the Dashboard. Finally, the Teacher uses this dashboard to gain insights and adapt teaching strategies accordingly..

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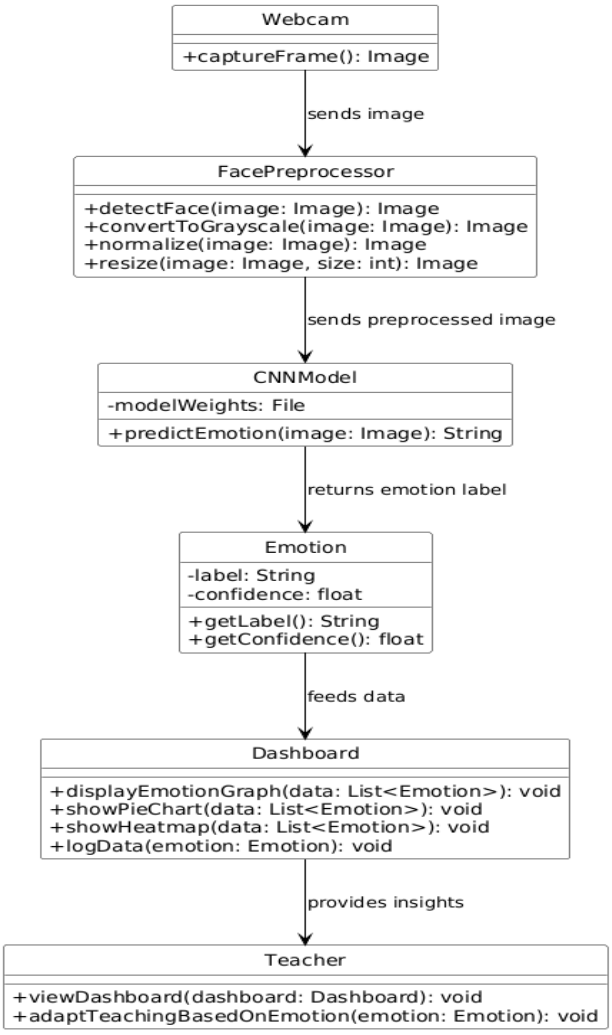

Fig. 3. Class diagram representing relationship and structural design of the system

C. Activity Diagram

This activity diagram illustrates the workflow of a facial emotion recognition system in an online classroom. It begins with starting the class and capturing students' facial expressions through webcam feeds. The images are preprocessed, fed into a CNN model for emotion classification, and the results are logged into a dashboard. Teachers then view the emotional insights and adapt their teaching strategies accordingly.

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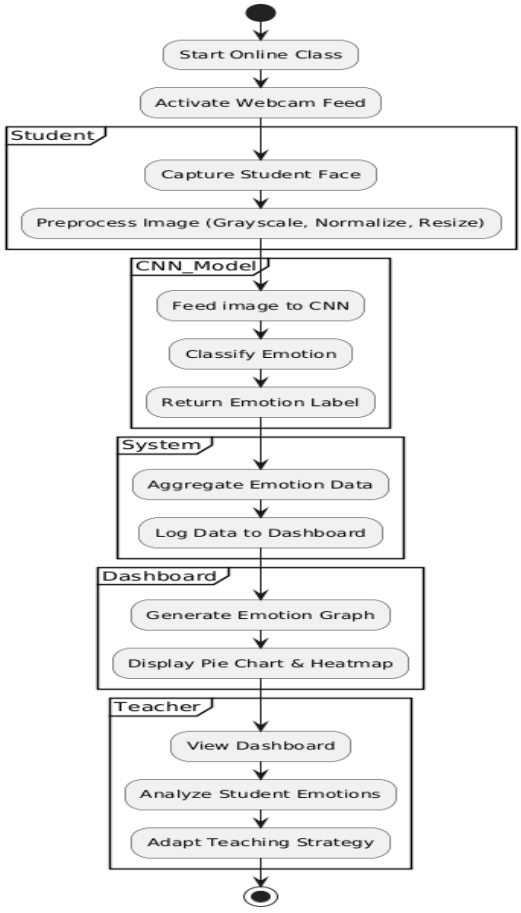

Fig. 4. Activity diagram showing facial emotion recognition system workflow.

D. Sequence Diagram

This sequence diagram shows the interaction between staff, students, the system, CNN model, and dashboard during an online class with emotion detection. The process begins with staff login and class initiation, followed by students joining the class. The system captures and processes student face images, extracts features, and classifies emotions using the CNN model. Finally, emotion trends are updated and displayed on the dashboard for the staff to view in real-time.

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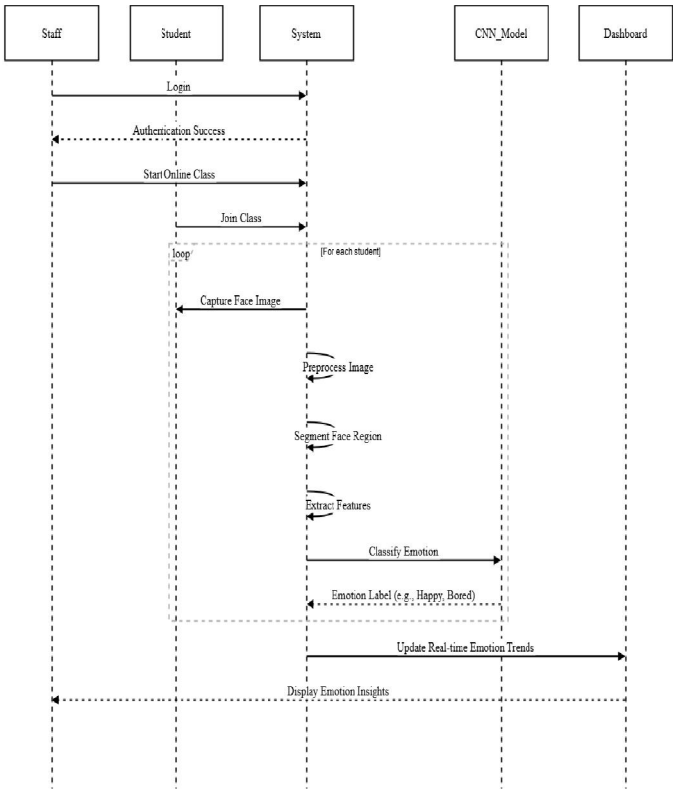

Fig. 5. Sequence diagram outlining interactions between student, staff, the system, CNN model and dashboard.

VI. CONCLUSION

The proposed system successfully addresses the challenge of maintaining student engagement in virtual classrooms by introducing an interactive dashboard powered by facial expression-based emotion recognition. By capturing students' facial cues in real-time and classifying emotional states using deep learning techniques, the system provides educators with a powerful tool to monitor classroom dynamics. The visual representation of emotional trends allows instructors to adapt their teaching strategies instantly, leading to improved interaction, personalized feedback, and a more inclusive and effective learning environment. This integration of artificial intelligence into online education marks a significant step toward data-driven and emotionally responsive teaching.

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