IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14675

FACIAL EXPRESSION BASED ANALYSIS OF STUDENT ENGAGEMENT IN ONLINE LEARNING

SREEBHARGAVI M[1], KARNAM SUVEER[2], SUDEEP T S[3], VISHWAS T S[4] and NIRANJAN K[5]

Professor, Dept. of CSE, Sri Siddhartha Institute of Technology, Tumkur[1]

Students, Dept. of CSE, Sri Siddhartha Institute of Technology, Tumkur[2-5]

Abstract: In the era of digital education, monitoring student engagement has become a critical factor in ensuring effective learning outcomes. This project presents a facial expression-based system designed to analyze and evaluate student engagement in online learning environments. By leveraging computer vision and deep learning techniques, specifically convolutional neural networks (CNNs), the system detects facial expressions and emotional cues through real-time video input from webcams. These expressions are then classified to determine levels of attentiveness, interest, and emotional state, which are key indicators of engagement.

I. INTRODUCTION

The rapid transition to online learning, accelerated by global disruptions such as the COVID-19 pandemic, has brought forward new challenges in maintaining student engagement and academic performance in virtual classrooms. Unlike traditional in- person settings where instructors can easily observe and interpret student behavior, online platforms often lack mechanisms to provide real-time feedback on learner attentiveness and participation. As a result, ensuring sustained engagement and identifying disengaged or at-risk students has become increasingly difficult in remote educational environments.

Facial expressions are a rich and intuitive source of information for understanding human emotions, attention, and engagement. With advancements in artificial intelligence (AI), particularly in the fields of computer vision and deep learning, it is now possible to automatically detect and interpret facial expressions with high accuracy. This project explores a novel approach to engagement analysis by developing a system that uses facial expression recognition to monitor student behavior during online learning sessions. The system captures video input through standard webcams, processes facial features using convolutional neural networks (CNNs), and classifies emotional states such as interest, confusion, boredom, or concentration.

Unlike traditional methods prone to human error or manipulation, facial recognition technology boasts an impressive accuracy rate, minimizing instances of false positives or negatives. Additionally, these systems offer enhanced security measures, as facial features are extremely difficult to replicate or forge, mitigating the risk of unauthorized access or fraudulent attendance records.

Furthermore, this technology facilitates real-time monitoring and analysis of attendance data, enabling administrators to identify patterns, trends, and discrepancies efficiently. Such insights can inform strategic decision-making, resource allocation, and intervention strategies to improve overall efficiency and productivity.
However, despite its undeniable advantages, the adoption of face recognition technology for attendance tracking raises ethical and privacy concerns. Issues such as data security, consent, and the potential for misuse must be carefully addressed to ensure responsible implementation and protect individuals' rights.

By integrating this system into online learning platforms, educators gain access to real-time analytical data on student engagement, allowing them to adapt their teaching strategies accordingly. The approach is non-intrusive, scalable, and capable of functioning across various educational contexts. Moreover, it addresses the growing need for intelligent tutoring systems and learner-aware environments in the digital education landscape. This paper details the design, implementation, and evaluation of the proposed system, demonstrating its potential to enhance learning experiences through adaptive, emotion-aware interventions.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14675

II. METHODOLOGY

The proposed system utilizes facial expression recognition to analyze and quantify student engagement in real-time during online learning sessions. The methodology is divided into several key stages: data acquisition, preprocessing, facial expression recognition, engagement classification, and result interpretation. Each stage is carefully designed to ensure accuracy, scalability, and usability within an educational context.

Data Acquisition: Facial data is captured using standard webcams during live online sessions. Each frame from the video stream is treated as an image input. These frames contain the facial expressions of students, which serve as the primary indicators of engagement. The system operates in real time without disrupting the learning process.

Preprocessing: Captured images are preprocessed to improve recognition performance and minimize noise. This includes:

- Conversion from RGB to grayscale to reduce computational complexity
- Noise filtering using median filtering techniques

Facial Expression Recognition: After preprocessing, facial features are extracted using Convolutional Neural Networks (CNNs). The CNN model (e.g., ResNet18 or VGG) is trained on labeled datasets containing various facial expressions such as:neutral,happy,sad.

Engagement Classification: An engagement score is calculated by aggregating classified expressions over a session. Threshold-based or rule-based logic is applied to determine whether a student is actively engaged or not

Result Logging and Visualization: The final engagement metrics are logged along with timestamps and student IDs. The data is stored in CSV files and visualized using performance graphs and dashboards. Educators can view real-time analytics or generate session reports to identify disengaged students and adjust their teaching strategies.

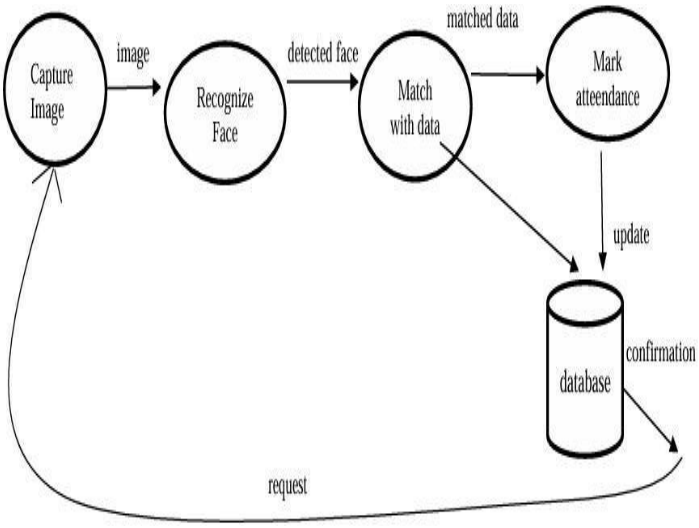


Fig 1: data flow diagram

III. OBJECTIVES

1) To Analyse and Detect Facial Expressions:
The system uses computer vision and deep learning to identify students' facial expressions during online classes. These expressions help determine emotional states like interest, confusion, or boredom, which are indicators of engagement.

2) To Store Results of Each Session with Details of Students and Educator:
Each session's engagement data, including student identity, detected emotions, and educator details, is securely stored. This helps in tracking individual participation and analyzing session effectiveness over time.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁝ Peer-reviewed & Refereed journal ⁝ Vol. 14, Issue 6, June 2025
DOI: 10.17148/IJARCCE.2025.14675

3) To Implement a Model to Compare Results and Produce Performance Graph:
An analytical model processes stored data to compare engagement levels across sessions or students. It generates performance graphs that provide visual insights to help educators improve teaching strategies.

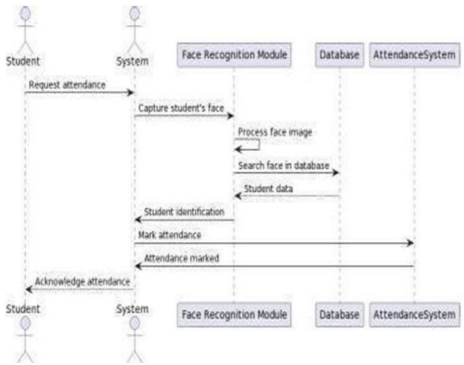


Fig 2: Sequence diagram.

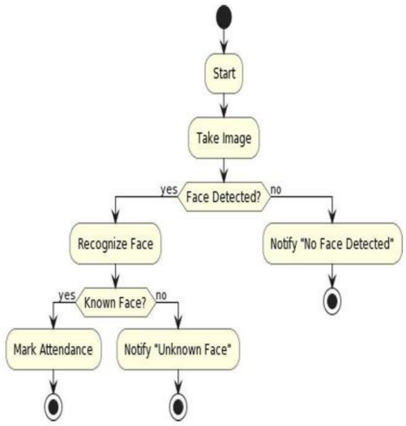


Fig 3: Activity diagram.

HARDWARE REQUIREMENT:

- System: Intel i3/i5 2.4 GHz.
- Hard Disk:500 GB
- Ram: 4/8 GB
- Web Camera/Digital Camera

SOFTWARE REQUIREMENT:

➢ Operating system: Windows XP/ Windows 7.
➢ Software Tool: Open CV
➢ Coding Language: Python
➢ Toolbox: Image processing toolbox.

➢ **Software Tool: OpenCV**
OpenCV is an open-source computer vision library used for real-time image and video processing. It provides powerful tools for face detection, recognition, and manipulation.

➢ **Coding Language: Python**
Python is used due to its simplicity and extensive libraries for machine learning, image processing, and data handling. It integrates well with OpenCV and deep learning frameworks.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⧖ Peer-reviewed & Refereed journal ⧖ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14675

➢ **Toolbox: Image Processing Toolbox**

The image processing toolbox includes functions for filtering, enhancing, and analyzing images. It is essential for preparing facial images before recognition and classification.

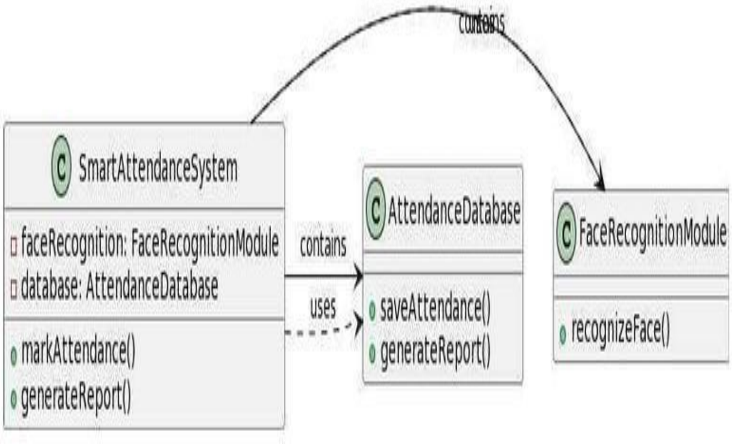


Fig 4: class diagram.

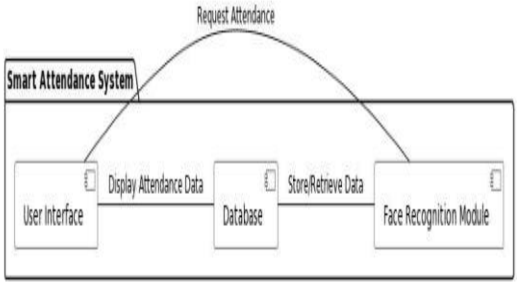


Fig 5: System architecture.

IV. RESULTS AN DISCUSSION

The proposed system was successfully implemented and tested in a simulated online learning environment using real-time video input. The model demonstrated its ability to detect and classify facial expressions into predefined emotional categories such as neutral, happy, sad, confused, and bored. These classifications were then used to derive an engagement score for each student. The system maintained high accuracy in recognizing facial expressions under normal lighting conditions and webcam quality, ensuring reliable detection without requiring high-end hardware.

Session data, including student IDs, emotions detected, and timestamps, were stored in a structured format. This enabled post-session analysis and tracking of individual student engagement over time. The collected data was used to generate performance graphs which visually represented trends in student attentiveness and participation. These graphs allowed educators to identify students who were consistently disengaged, and also helped in evaluating the impact of teaching styles or content on student involvement.

The model's effectiveness was evaluated through unit and integration testing, all of which produced successful results with minimal false positives in emotion classification.
Manual testing confirmed that the system accurately captured facial data and stored session logs without interruption. Overall, the implementation proved efficient, non-intrusive, and adaptable to various online learning platforms. This confirms the system's practical utility in enhancing virtual classroom monitoring and supporting data-driven teaching improvements.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14675

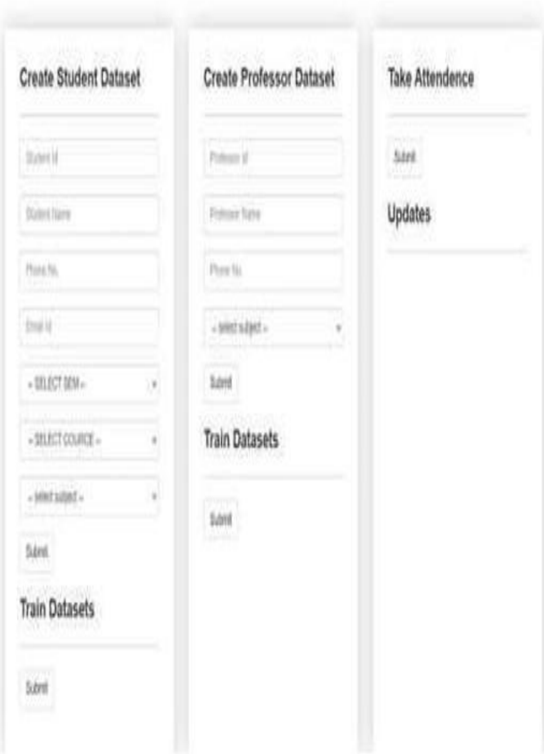


Fig 6: First view of Application and Entering the data.

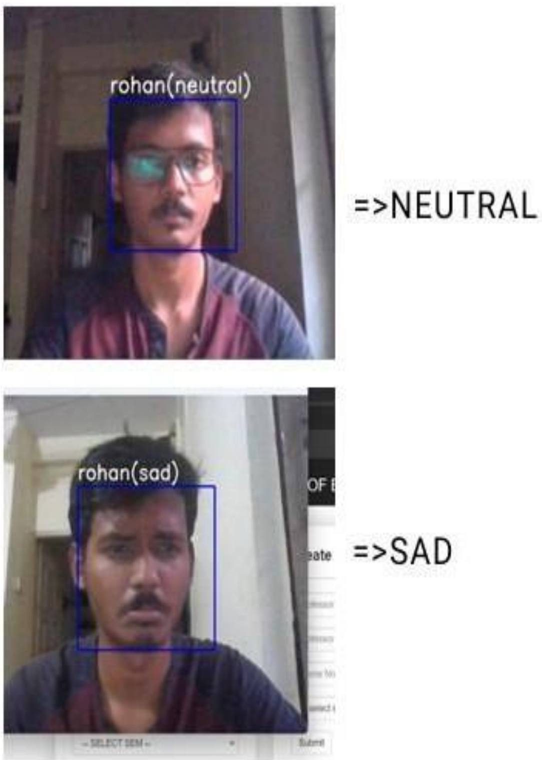


Fig 7: Student is in neutral and sad state.

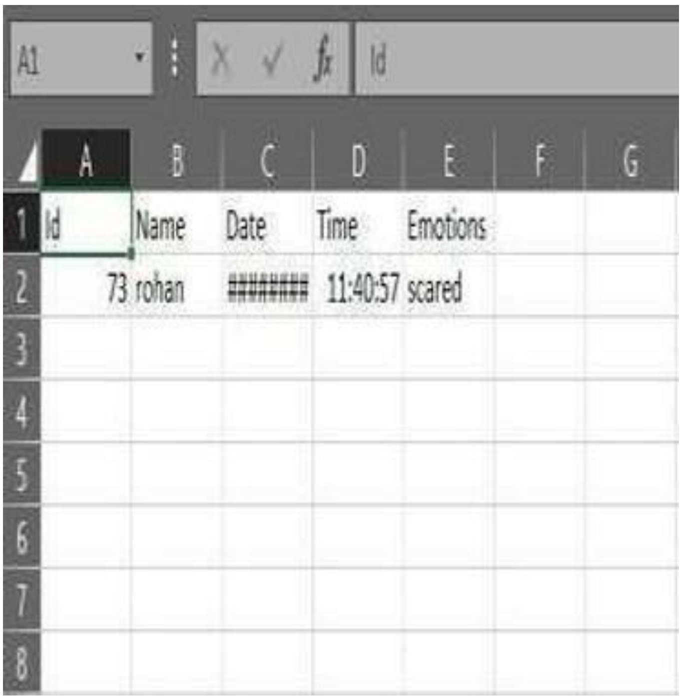
IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14675

Fig 8: Student is in angry and happy state.



A1 Id

	A	B	C	D	E	F	G
1	Id	Name	Date	Time	Emotions		
2	73	rohan	########	11:40:57	scared		
3							
4							
5							
6							
7							
8							

Fig 9: Student performance stored in CSV file.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14675

Id	Name	Phone	Email	Sem	Cource	Branch
1	rohan	8.15E+09	rohan@gn	8th	BE	CSE
44	roh	8.88E+09	thn13@gn	8th	BE	CSE
22	stud3	8.15E+09	stud1312€	7th	BE	CSE
33	stud4	8.88E+09	roh43@gn	8th	BE	CSE
73	rohan	8.15E+09	rohan@gn	8th	BE	CSE
73	rohan	8.15E+09	roh@gmai	8th	BE	CSE
418	Saniya	8.98E+08	saniya@gr	8th	BE	CSE

Fig 10: Students details stored in a CSV file.

V. ADVANTAGES

The proposed system provides an intelligent and automated solution for monitoring student engagement in online learning environments. By using facial expression recognition, it eliminates the need for manual tracking or intrusive questioning. This allows educators to focus more on teaching while the system handles engagement monitoring in the background. One of the major advantages is its ability to detect real-time emotional cues such as boredom, confusion, or concentration, which are directly linked to learning effectiveness.

The system enhances teaching outcomes by providing timely feedback that helps instructors adapt their methods based on students' reactions. It supports data-driven decision-making through session-wise emotion logs and performance graphs. These visual analytics offer insights into individual student behavior and class-wide engagement trends. The use of deep learning models, such as CNNs, ensures high accuracy in detecting facial expressions across different lighting and background conditions.

Another key benefit is its compatibility with standard webcams, making it easy to deploy without the need for specialized hardware. The solution is scalable and can be integrated into existing online platforms or learning management systems. Session data, including timestamps and identity logs, are stored securely for further analysis. This also aids in long-term tracking and personalized learning support.
Additionally, it promotes ethical AI usage by avoiding intrusive techniques and ensuring user privacy. Overall, the system brings efficiency, accuracy, and real-time interactivity to the process of engagement monitoring in virtual education.

VI. CONCLUSION AND FUTURE SCOPE

The proposed system, Facial Expression Based Analysis of Student Engagement in Online Learning, successfully addresses the growing need for intelligent engagement monitoring in virtual classrooms. By utilizing facial recognition and emotion detection through deep learning algorithms, the system offers a real-time, non-intrusive, and automated solution for analyzing student participation and emotional responses. It enhances the teaching-learning process by enabling educators to understand student behavior better and make timely pedagogical adjustments. The system proved to be efficient, accurate, and practical for use with basic hardware, making it a cost-effective solution for a wide range of educational settings.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 14, Issue 6, June 2025
DOI: 10.17148/IJARCCE.2025.14675

Looking ahead, the system can be enhanced by integrating advanced emotion detection models capable of recognizing subtle and complex facial cues that go beyond basic emotions. Future developments could include adaptive learning environments that respond to real-time emotional feedback—for example, slowing down content delivery when confusion is detected or providing interactive quizzes when engagement drops. The system can also be linked with AI-powered tutors that offer personalized support to students based on their emotional state and engagement history. Furthermore, combining facial expression analysis with contextual factors like screen interaction time, facial orientation, and blinking rate can lead to more holistic engagement metrics. To expand its applicability, the model could be adapted for mobile and low-bandwidth platforms, ensuring accessibility for students in remote or underserved areas. Lastly, incorporating multilingual and culturally adaptive emotion recognition models can make the system more inclusive and globally relevant for diverse online learning communities.

REFERENCES

[1]. Pei Wang, Peng Li, Recognition of student emotions in classroom learning based on image processing; Revised: 26 July 2022; Published by IIETA on 2022.
[2]. K.Balasaranya, Pacha Shobha Rani, , N. AnuReethika; Real time classifier based on machine learning approach ;Received: 10 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 28 April 2021.
[3]. Shariqa Fakhar, Junaid Baber, Sibghat Ullah Bazai, Shah Marjan, Zbigniew Leonowicz and Shumaila Hussain, monitoring using real-time facial expressions; published on 15 september 2022 on MDPI.
[4]. Weiqing Wang, Kunliang Xu, Hongli Niu and Xiangrong Miao School of Economics and Management, University of Science and Technology Beijing, Beijing 100083, China Correspondence should be addressed to Xiangrong Miao; miaoxr@bjbeec.cn Received 14 July 2020; Revised 26 August 2020; Accepted 28 August 2020; Published 11 September 2020.
[5]. MD.Hasnine, Huyen T.T, Hiroshi Ueda; Visualisation for online learning platforms; Published on 2021; Published by Elsiver science direct.
[6]. Kshjthi Sharma, Dillenbourg, Michail; Eye-Tracking and Artificial intelligence; 26 April 2020; Published by Smart Learning Environments.
[7]. Manouchihr Tabatabaei; Online teaching and learning management; 2014; Published by eLearning industry.