Real-Time Classroom Engagement Monitoring System

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***Abstract*— The field of education faced a downfall during the recent pandemic. Every institution had to conduct classes virtually, which limited the student's capacity to learn. Even though the pandemic is over, many institutions follow the same pattern. The concept of Live Classroom Engagement Tracker which we propose is an application which will have features like,Facial detection – which will detect the human face, Emotional Recognition – Which will recognize the student's mind state based on their emotions and the detailed report is generated at the end of the class.**

Keywords—Facial Detection, Emotion Recognition, Report Generation, Virtual Classes, Real-Time Classroom EngagementTracker (RCET).

I. INTRODUCTION

The COVID-19 epidemic has presented previously unheard-of difficulties for the educational sector, requiring institutions all around the world to quickly transition to virtual learning environments. The abrupt change has had a substantial influence on students' educational experiences since digital platforms have frequently failed to match the depth of in-person interactions, replacing the traditional classroom dynamics. Even if the pandemic has subsided, many institutions still mostly rely on remote learning approaches, perpetuating the legacy of virtual education [1].

We suggest creating a RCET as a solution to the continuous need for efficient online learning resources. With the help of cutting-edge technologies like facial detection and emotional recognition, this creative application seeks to overcome the drawbacks of virtual learning [2]. Together, these characteristics give teachers insightful information on the emotional states, engagement levels, and general learning experiences of their pupils.

A key feature of the RCET is facial detection, which uses computer vision algorithms to recognize and track faces in the virtual classroom. With the use of this technology, teachers can keep an eye on their students' attendance, focus, and involvement in virtual classrooms, which may be used to determine how involved and engaged their students are.

Using machine learning approaches [3] to analyse pupils' facial expressions and infer their emotional states, Emotional Recognition significantly improves the application's capabilities. The RCET may detect feelings likehappiness, boredom, perplexity, or aggravation and sendteachers real-time feedback so they can modify their teaching methods to better suit their students' requirements and improve learning outcomes overall.

The RCET's capacity to produce thorough results at the conclusion of each class session is one of its primary features [4]. These reports offer thorough insights into participation levels, attendance records, emotional trends, and student engagement measures. Teachers can utilise this information to evaluate their own teaching strategies, pinpointareas that need work, and modify their lesson plans in order increase student engagement and academic performance. .

The paper organized as follow. Section II explains the literature survey. Section III explains the existing system. Proposed system is presented in Section IV. System architecture is explored in Section V and the conclusion is presented in VI.

II. LITERATURE SURVEY

The literature review explores a number of important works focused on deep learning approaches for behaviour detection and attention evaluation in smart classroom technologies and real-time attention monitoring systems.

The research provides significant insights into the creation of an advanced real-time system capable of monitoring student behaviour and attention using state-of-the-art deep learning algorithms.The authors [5] highlights thetechnical capabilities of these systems and shows how they may be used to significantly improve student involvement inthe classroom by recognising and adapting to changes in attentiveness levels that occur during class.

The work [2] further contributes to the conversation by examining the complex ways in which deep learning methods are used in smart classroom settings. The study demonstrates how using cutting-edge technology to measure students' attention levels through behaviour detection can have a profoundly positive impact. This strategy provides educators with useful insights to customise their teaching strategies and eventually create more engaging and successful learning experiences by real-time analysis of behaviour patterns in the classroom.

Further exploration of the complex integration of face recognition technology into smart educational monitoring systems is provided in Online and Offline Integration of Smart Educational Monitoring System based on Face Recognition Smart Sign-in Devices [6]. This thorough study explores the nuances of both online and offline integration, highlighting the smooth tracking capabilities made possible by smart sign-in devices using facial recognition technology. This integrated approach makes it easier to understand how students interact with the educational ecosystem holistically by tracking their behaviour, attendance, and engagement levels. This allows educators to make well-informed decisionsbased on data.

The combined knowledge gained from these groundbreaking studies highlights how deep learning strategies, real-time monitoring tools, and smart classroom technologies have the power to completely alter current paradigms in education [7]. Education stakeholders can create dynamic, personalised, and interactive learning environments that meet the diverse needs of students and maximise overalllearning outcomes by utilising cutting-edge technologies likefacial recognition and behaviour detection.

Table 1: Related Studies Methodology

S.no	Title	Methodology	Accuracy	Merits &Demerits
1.	Real tim eattention monitoring system- A Deep learning approach forstudents behaviour recognition	Artificial intelligen ce(AI)-based behavior recognitio n technique s	76%	real-time attention monitorin g data security concerns
2.	Smart Classroom: ADeep Learning Approach towards Attention Assessment through Class Behavior Detection	deep learning model –YOLOV5	83.25%	Real-time Feedbac k Ethical Considerati on
3.	Online and Offline Integration ofSmart Educational Monitoring System basedon Fac e Recognition Smart Sign-in Devices	Face imag eanalysis	80.87%	Enhance d attendanc etracking Privacy concern s

III. EXISTING SYSTEM

A. Face Detection Systems

Real-time applications for identifying and tracking human faces in video streams frequently make use of facial detection systems like OpenCV, Dlib, and FaceNet . While Dlib has the ability to recognise facial landmarks, OpenCV offers a vast library of face detection techniques. In contrast, FaceNet is dedicated to face recognition tasks, allowing people to be recognized by their faces alone.These systems' connection with the Live Classroom involvement Tracker makes it possible to monitor students' involvement levels based on facial cues and identify their presence. This technology is essential for comprehending howstudents behave in online learning environments.

B. Emotion Recognition Software

Deep learning models are used by emotion identification software, such Affectiva, Google's ML Kit, and Microsoft Azure's Face API, to interpret facial expressions and infer emotional states. These devices classify emotions including happiness, sorrow, rage, and surprise by using convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to analyse minute variations in facial features. These cutting-edge technologies are integrated, giving the Live Classroom Engagement Tracker the capacity to identify students' emotions in real time. This feature makes it possible for teachers to modify their lesson plans in response to the emotional reactions of their students, which improves the educational process as a whole.

C. Machine Learning Frameworks

Neural networks are developed and trained for a variety of tasks using deep learning frameworks such as TensorFlow, PyTorch, and Keras. Google's TensorFlow provides an adaptable framework for creating deep learning models, whereas Facebook's PyTorch focuses on dynamic computational graphs. Keras offers an easy-to-use high-level API for neural network construction and training.The Live Classroom Engagement Tracker's facial detection and emotion recognition modules cannot be implemented without these frameworks. The capabilities of the system are improved by deep learning algorithms, including CNNs and RNNs, which are trained on enormous datasets to precisely recognise faces and categorise emotions.

D. Video Conferencing Platforms

Video conferencing platforms like Zoom, Microsoft Teams, and Google Meet have become essential tools for virtual classrooms, providing APIs and SDKs for real-time video streaming and interaction. These platforms facilitate seamless communication and collaboration among students and educators, allowing for interactive learning experiences. Integrating the Live Classroom Engagement Tracker with these platforms enables seamless data collection and analysis during virtual classes. The system can leverage video feeds from these platforms to track student engagement, detect emotions, and generate insightful analytics.

E. Data Analytics and Reporting Tools

Strong capabilities are provided by data analytics tools like Tableau, Power BI, and Google Data Studio for processing, visualising, and producing reports from gathered engagement data with the use of these resources, teachers can get practical understanding of student conduct, levels of involvement, and academic achievements. At the conclusion of each class session, the Live Classroom Engagement Tracker may produce comprehensive results by utilising various data analytics and reporting capabilities. These reports give teachers useful data on participation levels, attendance records, emotional states, and student engagement measures, enabling them to make data-driven decisions to improve their teaching methods.

IV. PROPOSED SYSTEM

The proposed framework is planned to offer real-time feeling acknowledgment capabilities inside virtual instruction situations, leveraging a combination of progressed web innovations and profound learning strategies. At its center, the framework comprises a frontend interface created utilizing React.js, TailwindCSS, and FramerMotion, giving a advanced and intelligently dashboard for teachers and understudies. This interface consistently coordinating webcam usefulness through the react-webcam bundle, empowering the framework to capture live video streams from users' webcams at a recurrence of 2-3 times per moment.

The key usefulness of the framework spins around real-time feeling discovery, which is fueled by the face-api.js npm bundle. This JavaScript library utilizes pre-trained profound learning models to perform confront discovery, facial point of interest location, and feeling acknowledgmentspecifically in the browser. As webcam previews are captured, face-api.js forms each picture locally, analyzing facial expressions, points of interest, and relevant signals to gather feelings such as bliss, pity, outrage, shock, and impartial states.

The frontend dashboard powerfully upgrades to show real-time feeling examination comes about, showing clients with intelligently charts, charts, and visualizations that give bits of knowledge into students' passionate states and engagement levels amid virtual classes. Teachers can customize the dashboard, alter visualization settings, and investigate nitty gritty experiences into person understudies or the whole lesson, improving their capacity to tailor instructing techniques and cultivate more successful learningencounters.

In addition, the framework consolidates highlights for PDF detailing utilizing html2canvas and jsPDF libraries,permitting clients to create and download comprehensive reports containing feeling investigation charts, timestamps, and comments. This usefulness empowers clients to record, analyze, and share feeling examination information for assist examination, record-keeping, and collaboration. Performance contemplations are foremost in the system's plan, pointing for close real-time responsiveness in feeling location and investigation whereas guaranteeing offline usefulness and adaptability. Cached ML models downloaded amid the beginning stack empower offline usefulness, guaranteeing consistent operation indeed with constrained or no web network. Furthermore, the system's design is planned to scale on a level plane, obliging expanding client requests and concurrent webcam streams whereas keeping up steady execution and client encounter.

In outline, the proposed framework offers a comprehensive arrangement for real-time feeling acknowledgment in virtual instruction, combining frontend web advances, profound learning calculations, intelligently dashboards, and PDF announcing capabilities to improve educators' understanding of students' passionate states and encourage data-driven educating procedures. Advance advancement and optimization endeavors will center on refining execution, client involvement, and adaptability to meet the advancing needs of virtual instruction situations.

V. SYSTEM ARCHITECTURE

A. Frontend Interface

1. Webcam Integration:

The framework coordinating the react-webcam bundle to capture live video streams from users' webcams. This includes getting to the user's webcam gadget utilizing WebRTC (Web Real-Time Communication) APIs.

2. Face Detection and Landmark Detection:

Utilizing the face-api.js library, the framework performs real-time confront discovery and facial point of interest detection. Convolutional neural systems (CNNs) inside face-api.js analyze webcam previews, recognizing faces and key facial points of interest (e.g., eyes, nose, mouth).

3. Emotion Recognition:

Deep learning models inside face-api.js classify facial expressions to induce enthusiastic states (e.g., bliss, pity, anger). Emotion acknowledgment is based on highlights extricated from facial points of interest and facial expressions.

B. Data Management

1. Client-Side Data Processing:

Data for facial points of interest, facial expressions, and enthusiastic states is handled locally inside the user's browser. In-memory information structures (e.g., clusters, objects) store transitory data related to facial highlights and feelings.

2. Temporary Storage:

The framework utilizes brief capacity components inside the browser's memory for proficient information taking care of amid real-time processing. This temporal information capacity guarantees protection and security whereas keeping up real-time responsiveness.

C. Working Principle

1. Webcam Snapshot Capture:
   Users give authorization for webcam get to, permitting the framework to capture webcam previews at a tall recurrence (e.g., 2-3 times per moment).

2. *Face Detection and Landmark Detection:*
   Face-api.js forms each webcam preview, recognizing faces and extricating facial points of interest utilizing CNN-based algorithms. Detected facial points of interest (e.g., facilitates of eyes, nose) are extricated and utilized as input for feeling acknowledgment.

3. *Emotion Recognition and Analysis:*
   Deep learning models analyze facial expressions based on identified points of interest, classifying feelings in genuine time. Emotion acknowledgment calculations induce enthusiastic states (e.g., bliss, astonish) from facial highlights and expressions.

4. *User Interface Interaction:*
   The frontend dashboard shows real-time feeling examination comes about, giving visualizations of enthusiastic states and engagement levels. Educators can associated with the interface, customize visualization settings, and get to nitty gritty experiences into students' feelings amid virtual classes.

D. Performance Considerations

1. *Real-Time Responsiveness:*
   The framework prioritizes real-time responsiveness through a combination of productive calculations and optimized information dealing with. By minimizing idleness between webcam depictions, information preparing, and result visualization, the framework guarantees fast criticism to clients. Profound learning calculations inserted in face-api.js are particularly chosen for their capacity to perform quick deduction, permitting for quick examination of facial expressions and feeling acknowledgment. Client-side information dealing with strategies, counting transitory information structures and in-memory caching, encourage upgrade real-time responsiveness by diminishing disk I/O and arrange overhead.

2. *Scalability and Resource Management:*
   The design of the framework is outlined to be adaptable, able of taking care of numerous clients and concurrent webcam streams without compromising execution. Asset administration strategies are executed to optimize memory utilization and computational assets, guaranteeing proficient real-time handling indeed beneath tall client loads. Stack adjusting techniques disperse approaching demands over different server occurrences, whereas offbeat preparing strategies empower the framework to handle errands concurrently, upgrading adaptability and responsiveness. Persistent observing and optimization forms are coordinates to recognize and address execution bottlenecks, encourage upgrading the system's versatility and asset utilization.

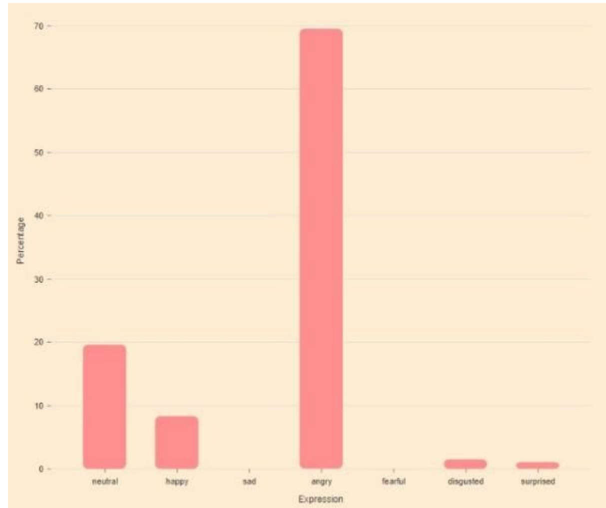

Fig. 1. Real Time Emotion Recognition

In the above figure (Fig. 1) the x-axis represents the Emotions or the expression that are captured from the student's face during the class hours, whereas the Y-axis represents the percentage at which the expressions that are conveyed by the students face during the class. Here, the faces are detected from the video stream and the facial landmarks are being recognized, and thus the facial expression is predicted from the landmarks

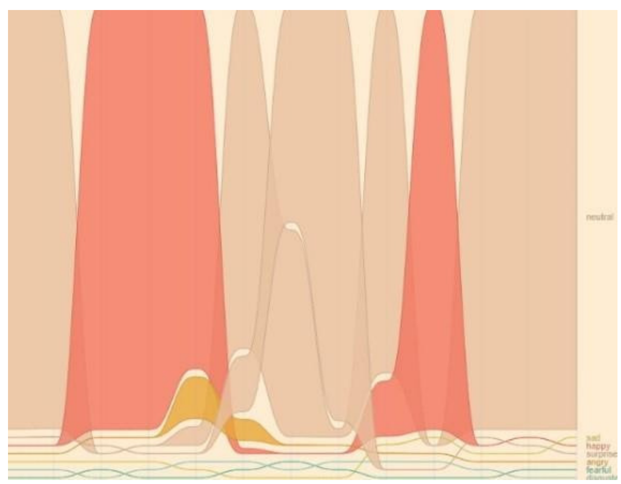

Fig. 2. Overall Emotion Analysis

In the above figure, (Fig. 2) the overall emotions that are expressed by the students are analysed and are plotted in a graph. The various expressions that can be monitored by the system are Neutral, Sad, Happy, Surprised, Angry, Fearful and Disgusted.
While the webcam is on, the expressions detected will be recorded. When the webcam is turned off (for example when

the video call is completed), the recorded expressions will be plotted on a Area Chart.

It is an interactive Area Chart, which is also downloadable and this analysis helps teacher, analyse the student's expressions,mood for one whole video call.

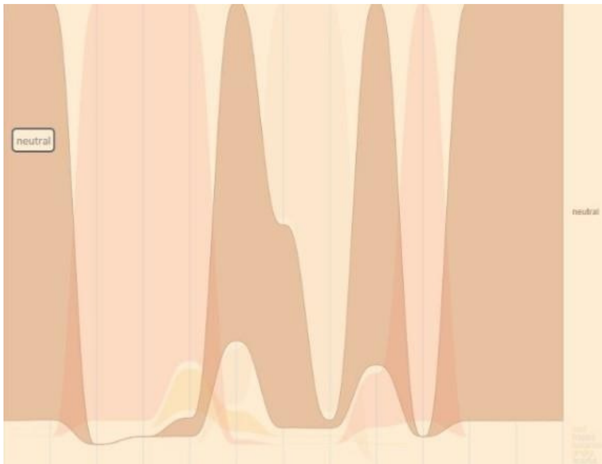

Fig. 3. Emotion Recognition – Neutral

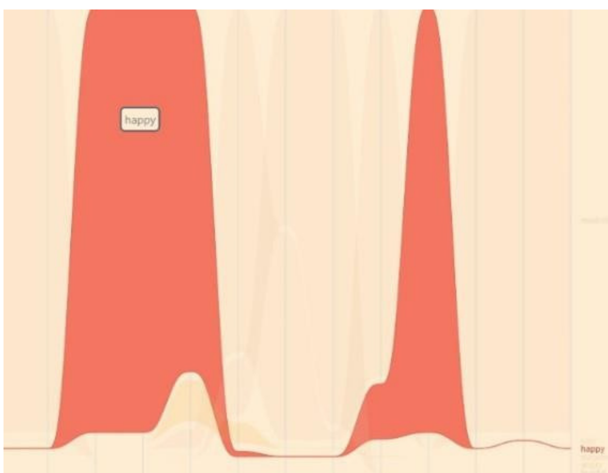

Fig. 4. Emotion Recognition – Happy

The Fig. 3 and Fig. 4 plots the emotions such as Neutral and Happy, which has been highlighted in the above area charts. Each of the emotions are color coded for the better understandability of the teachers.

The Fig. 5 gives the detailed flow of the process that is involved in developing the system, in other words the sequence diagram.

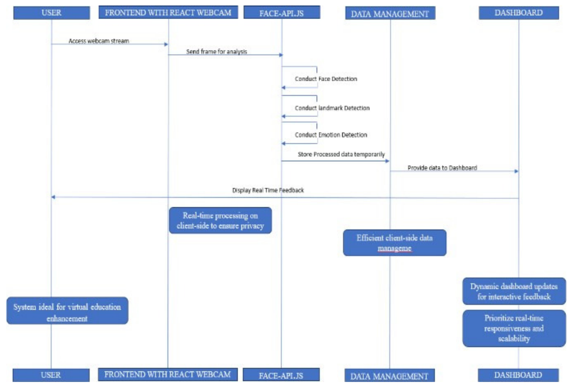

Fig. 5. Sequence diagram

VI. CONCLUSION

To sum up, the suggested system is the result of a synthesis of cutting-edge technologies and approaches meant to provide a smooth and interesting user interface for real-time face identification and emotion recognition. By carefully combining state-of-the-art frontend tools such as TailwindCSS, Framer Motion, and React's ContextAPI with the reliable face-api.js library, the system strikes a nice compromise between functionality and usability. The technology ensures real-time responsiveness and improved user engagement by utilising machine learning models directly within the browser environment. This allows for quick and precise facial expression analysis without requiring server-side processing.

In addition, camera integration, interactive chart rendering, and PDF generating features increase the system's usefulness in a variety of settings, from online learning environments to virtual chat rooms. The lightweight Home page and asynchronous ML model loading, as examples of the iterative loading method, highlight a dedication to maximising user experience and reducing wait times. Though the system demonstrates notable progress in client-side facial analysis, there are still opportunities for improvement and growth.

Subsequent versions of the system may investigate methods to enhance mobile efficiency, tackling any detected lag in user interfaces and animations on mobile gadgets. Furthermore, scalability improvements might be necessary to support more extensive installations and a rise in user volume. Through continuous iteration and refinement in response to user feedback and new developments in technology, the system might potentially become a foundational tool for the creation of accessible and interactive facial analysis applications in a variety of disciplines.

In summary, the proposed system stands as a testament to the transformative capabilities of web-based technologies in delivering immersive and impactful user experiences. Through its fusion of state-of-the-art frontend tools, machine learning models, and user-centric design principles, it sets a precedent for the seamless integration of facial analysis functionalities into web applications, paving the way for enhanced communication, education, and interaction in the digital age.

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