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Expression Aware Intelligent Learning System for Enhanced Student Engagement

M. Shenbaga Devi[1], Aswin M A[2], Hariharan S[3], Lakshmi Narayana M[4]

[1]*Assistant Professor, Department of Computer Science and Engineering,Sri Venkateswara College of Engineering, Sriperumbudur, Chennai, India*

[2,3,4]*Department of Computer Science and Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, Chennai, India*

***Abstract*— The majority of contemporary online learning systems rely on static methods of instructional delivery that don't adapt to the changing needs of their learners. This restriction makes it more difficult to identify disengagement, perplexity, or irritation during learning sessions. The Expression Aware Intelligent Learning System presented in this research combines adaptive teaching methods with real-time facial expression recognition. By integrating behavioural markers like quiz tries, time spent, and repeat frequency with facial expression probabilities, the method generates a composite engagement score. The technology automatically starts contextual interventions, such as guided tips, micro-quizzes, streamlined explanations, or controlled content playback, when user interest levels start to drop. The architecture is based on a scalable three-tier paradigm that uses Python with OpenCV-based deep learning models for emotion detection, Node.js and Express for backend services, and React for the frontend. Raw video data is not stored, and opt-in camera usage is guaranteed by a privacy-first framework. In comparison to non-adaptive modules, experimental evaluation shows increased consistency in learner interactions and shorter durations of disengagement.**

***Keywords*— adaptive learning, facial expression recognition, affective computing, student engagement, machine learning, intelligent tutoring systems**

I. Introduction

The availability of education across regional borders has been revolutionized by e-learning platforms. The majority of platforms continue to use uniform teaching methods that do not take individual cognitive and emotional differences into account, despite technological developments. Teachers in actual classrooms constantly monitor student responses and adjust their pedagogical approaches. In digital surroundings, this adaptive feedback loop is mostly lacking.

Inadequate real-time detection of learner confusion frequently leads to accumulated knowledge gaps and delayed support. In order to overcome this difficulty, the suggested system incorporates affective computing methods to dynamically track engagement. Replicating instructor-like responsiveness in a scalable digital infrastructure is the aim.

II. Related Work

Recent studies in affective computing have shown that facial expressions can be accurate markers of cognitive states like boredom, confusion, and attentiveness. Under controlled conditions, landmark-based models and convolutional neural networks (CNNs) have greatly increased the accuracy of facial emotion classification.

However, there is still little real-world use in live learning systems. Most of the research fails to incorporate adaptive pedagogical responses, instead focusing on detection performance. These methods are expanded in the current study by combining real-time instructional choice processes with detection outputs.

III. System Architecture

Three levels make up the suggested architecture: intelligence, application, and display. React is used by the presentation layer to create dynamic dashboards, engaging visualizations, and video courses. Developed with Node.js and Express, the application layer controls adaptive rule processing, lesson APIs, and authentication.

OpenCV-implemented Python-based emotion recognition models are used in the intelligence layer. Emotional states are identified by classifying facial structures. To provide consistent engagement trends, a smoothing technique lowers noise in frame-by-frame forecasts.

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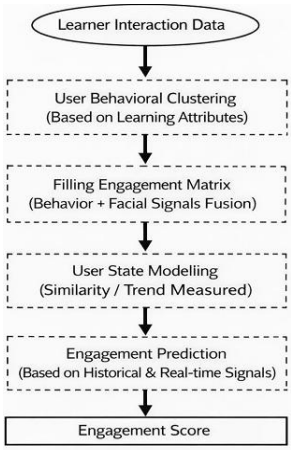


Fig 1. System Design (Prediction)

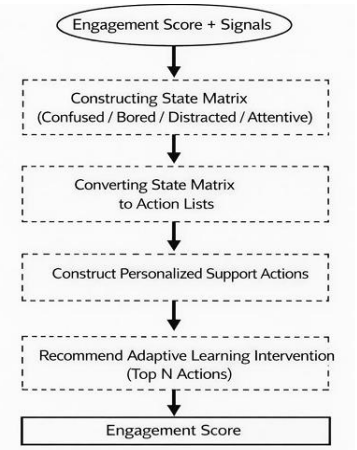
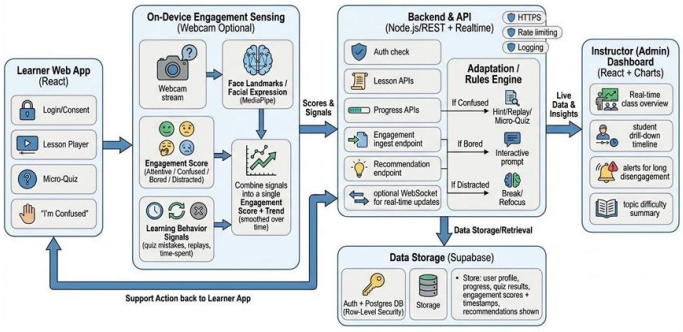


Fig 2. System Design (Adaptive Recommendation



IV. Methodology

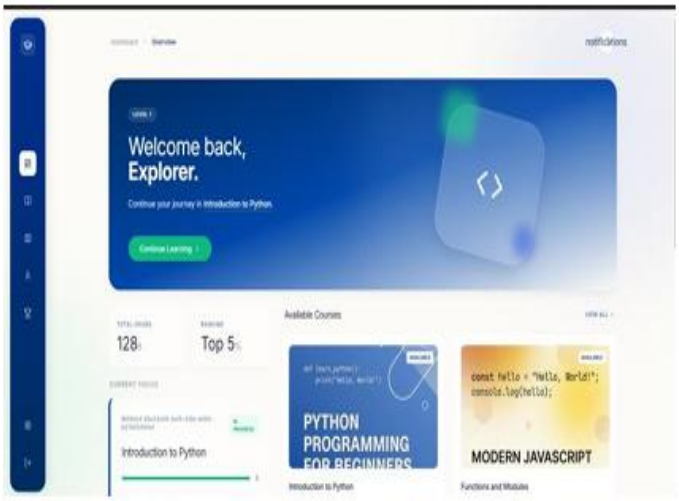
A weighted method that combines behavioural signals and emotion confidence levels is used to get the engagement score. Response latency, frequency of material replay, and quiz accuracy are examples of behavioural parameters.

Adaptive rules are activated when the engagement score falls below a predetermined threshold. These guidelines specify what kinds of support actions are appropriate, like giving hints, making summary recommendations, doing micro-assessments, or taking brief cognitive pauses. Timely intervention and ongoing monitoring are guaranteed by the closed-loop system.

V. Implementation

Progress dashboards, engagement metrics, and lesson streaming are all supported via the frontend interface. Real-time communication channels and secure REST APIs are managed by the backend. Only academic performance indicators, timestamps, and engagement scores are stored in the data.

While teachers read aggregated summary, learners can only access their own personal records via role-based access control. Every webcam-based monitoring system only functions with the user's permission.



VI. Results And Discussion

Engagement retention has improved noticeably, according to pilot testing done on a few course units. Higher course completion rates and better quiz performance were shown by students who received adaptive interventions.

The accuracy of detection is influenced by environmental conditions including lighting and camera angles. Preprocessing methods like noise filtering and normalization were used to reduce these impacts.

VII. Conclusion

The Expression Aware Intelligent Learning System uses adaptive support techniques and emotion-aware analytics to improve online learning. Scalability is maintained while ethical compliance is guaranteed by the privacy-centric architecture. Future improvements will include eye tracking and speech tone analysis to determine multimodal participation.

References

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