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Design and Implementation of an Intelligent Assistant for Emotion-Based Student Readiness Assessment Using Embedded Systems

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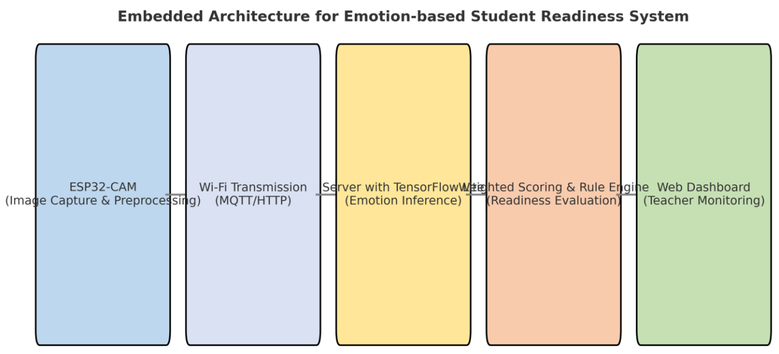
INTRODUCTION & AIM

Recent advances in **affective computing** and **embedded artificial intelligence** have enabled the creation of systems capable of interpreting human emotions to improve learning environments. This work presents the design and implementation of an **intelligent assistant** for student readiness assessment that integrates **emotion recognition** with **embedded system technology**. The primary goal is to create a low-cost and portable platform capable of analyzing students' emotional states during exams. The assistant aims to support teachers in evaluating readiness by combining **concentration** and **nervousness** metrics derived from facial expressions. This project bridges **AI**, **psychology**, and **education**, providing a practical example of how embedded deep learning can enhance classroom analytics and emotional awareness in real time.

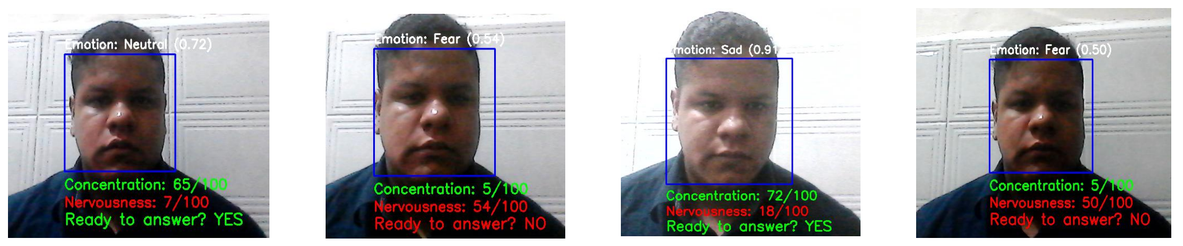
METHOD

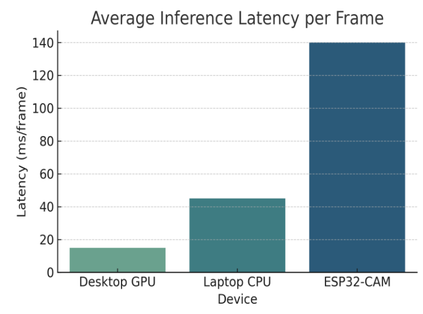
The intelligent assistant was implemented on an **ESP32 microcontroller** integrated with an **ESP32-CAM module**, enabling low-cost, real-time facial emotion analysis. The camera captures video frames, which are preprocessed locally to reduce image size and noise before being transmitted via Wi-Fi to a remote server for inference. A **TensorFlow Lite CNN**, trained on the **FER2013 dataset**, performs facial emotion recognition across seven categories: *anger, disgust, fear, happiness, neutrality, sadness,* and *surprise.* Each emotion is translated into quantitative **concentration** and **nervousness** indicators through weighted mappings, generating scores from 0–100. A **rule-based evaluation** determines readiness: students are classified as *ready* when concentration ≥ 60 and nervousness ≤ 50. The system continuously updates these scores, displaying real-time readiness states on an **interactive web dashboard** accessible to educators. This embedded configuration demonstrates how emotion-based assessment can operate in **resource-constrained environments**, combining **edge computing** efficiency with **cloud-based AI analysis**, ensuring responsiveness and accessibility in educational settings.

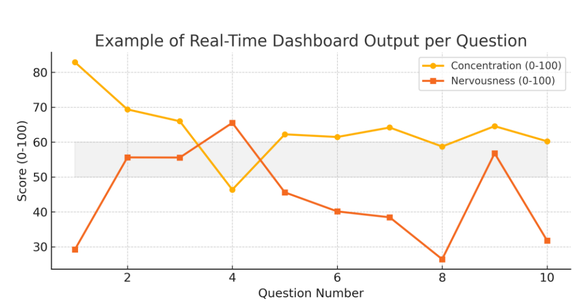


RESULTS & DISCUSSION

The implemented system successfully achieved **real-time emotion recognition** with an average inference latency of **under 0.5 seconds per frame**. The CNN model maintained approximately **70% accuracy** on validation data, balancing efficiency and speed for embedded deployment. Experiments conducted with simulated student sessions demonstrated the feasibility of using **low-cost hardware** for emotion-based assessment. The ESP32-CAM efficiently captured facial expressions, and the TensorFlow Lite inference produced consistent concentration and nervousness estimations. The dashboard visualization allowed teachers to observe emotional trends over time, enhancing understanding of student engagement and anxiety levels. These results confirm that **edge–cloud hybrid architectures** can provide reliable and interpretable emotional analytics for education.







CONCLUSION

This research demonstrates the viability of integrating **embedded systems** and **neural networks** to assess student readiness in real time. The intelligent assistant effectively combines affective computing and educational analytics within a **low-cost, scalable platform**. By quantifying emotions into measurable indicators of concentration and nervousness, the system assists teachers in identifying emotional readiness during exams. The combination of **ESP32 hardware**, **TensorFlow Lite inference**, and a **web dashboard** provides both portability and accessibility. The approach enhances fairness and personalization in assessment environments while promoting emotional awareness as a key component of academic performance evaluation.

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