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Online Examination & Proctoring System

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Abstract: ***The increasing adoption of online education has created a strong demand for secure and reliable examination systems, while simultaneously raising concerns regarding academic integrity in remote environments. This paper presents an enhanced AI-based Online Examination Proctoring System (OEPS) that incorporates role-based access control, biometric identity verification, and realtime behavioral analysis to ensure fair and transparent online assessments. The system is designed using a full-stack architecture consisting of a React-based frontend, a Node.js and Express backend, Supabase database integration, and a FastAPI-based AI microservice. During student registration, facial data is captured and stored, which is later used for identity verification before theexamination begins. Real-time monitoring is performed using computer vision techniques through libraries such as face-api.js and MediaPipe to detect cheating behaviors including head movement, absence of face, and multiple face detection. All suspicious activities are logged as violations and made accessible to teachers via a dedicated dashboard for analysis. Additionally, the system supports exam creation, publishing, OCR-based question extraction using Tesseract.js, and performance analytics. The admin module provides complete system oversight by allowing accessto both teacher and student dashboards. Experimental observations indicate that the systemeffectively minimizes cheating, enhances examsecurity, andreduces reliance onmanualinvigilation, making it a scalable and efficient solution for modern digital education platforms.***
Keywords: Online Proctoring, Artificial Intelligence, Computer Vision, Facial Recognition, Behavior Monitoring, OCR, Cloud Computing, Academic Integrity

I. INTRODUCTION

Therapidexpansionofonlineeducationanddigitallearningplatforms hassignificantlytransformedthe wayexaminations are conducted. Remote assessments provide flexibility, accessibility, and scalability, allowing students to participate from any location. However, this shift has introduced seriouschallenges in maintaining academic integrity, as the absence of physical supervision creates opportunities for cheating, impersonation, and unauthorized assistance. Traditional online examination methods, such as manual invigilation and browser restrictions, are often inefficient, difficult to scale, and unable to detect sophisticated malpractice. Therefore, there is a growing need for intelligent and automated systems that can ensure secure and fair examination processes.

Advancements in artificial intelligence (AI), machine learning (ML), and computer vision have enabled thedevelopment ofsmart proctoringsystemscapableofanalyzingreal-timeuser behavior. Inthispaper, we propose an enhanced AI-based Online Examination Proctoring System (OEPS)that integrates role-based systemdesign, biometric authentication, and real-time monitoring. The system is built usinga full-stack architecture consisting of a React-based frontend, a Node.js and Express backend, a Supabase database, and a FastAPI-based AI microservice. It supports three primaryroles—Admin, Teacher, and Student—where the admin has full control over the system, teachers can create andmanage exams, and students can register, verifytheir identity, and participate in examinations. During registration, the systemcaptures and stores the student's facialdata, which is later used for identity verification before the exam begins.

II. LITERATURE SURVEY

Nigam (2021) presented a comprehensive review of AI-based online proctoring systems, highlighting the use of facial recognition, eye tracking, and behavioral analysis to detect cheating during online examinations. The study emphasized that AI-driven systems significantly improve monitoring efficiency compared to traditional invigilation methods, while also raising concerns regarding privacy and ethical implications. Similarly, Tweissi (2022) examined the effectiveness of automated proctoring systems in online education and demonstrated that AI-based video analysis can help maintain academic integrity by identifying suspicious behaviors. The research concluded that such systems are scalable and reduce reliance on manual invigilation, although their performance largely depends on the accuracy of the underlying algorithms.

Erdem (2025) explored the application of machine learning and deep learning techniques for detecting cheating behavior in online examinations.

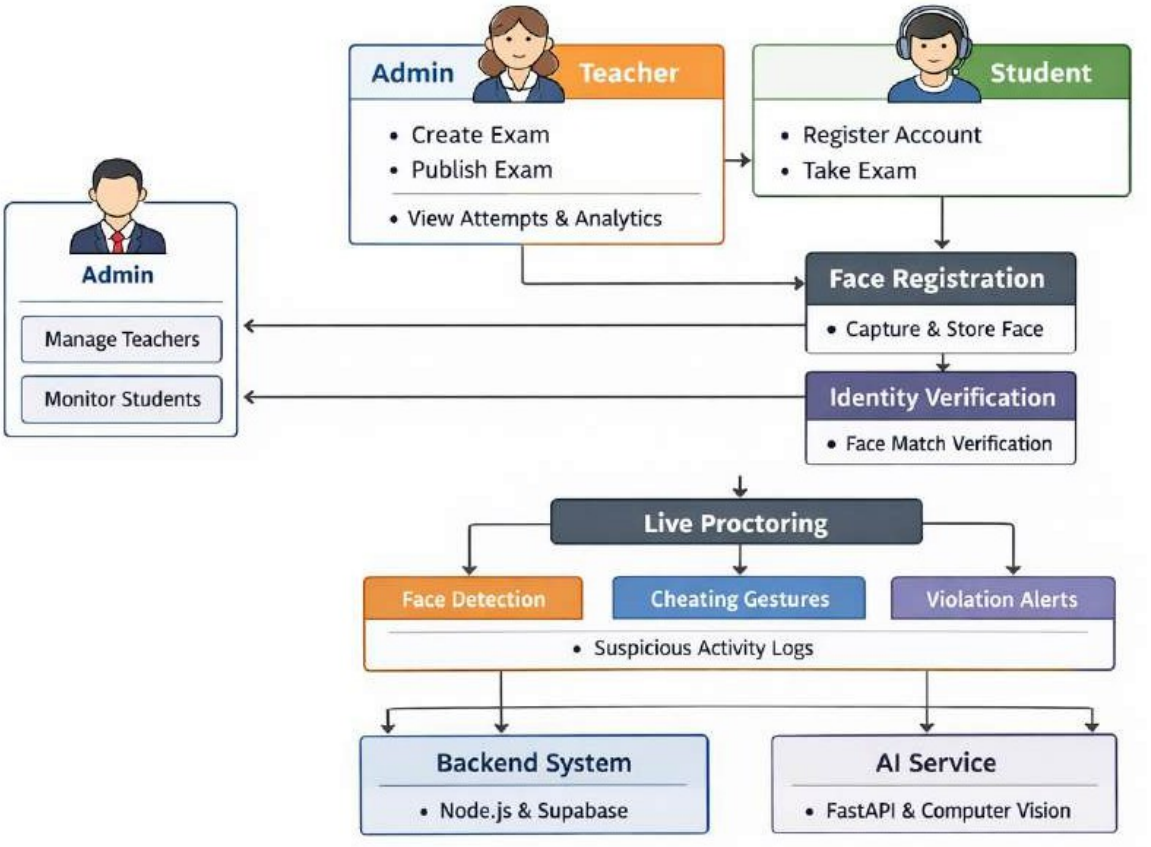
The study compared various models, including Support Vector Machines (SVM), Random Forest, and Deep Neural Networks (DNN), and found that deep learning approaches achieved the highest accuracy in behavior classification and anomaly detection. In addition, Singh (2024) proposed a multi-modal proctoring system that integrates computer vision and audio analysis techniques. Their approach utilizes facial detection, head pose estimation, and sound monitoring to identify malpractice, with results indicating that combining multiple data sources improves detection accuracy and overall system reliability.

Furthermore, Heinrich (2025) conducted a systematic review focusing on both the technical and ethical aspects of online proctoring technologies. The study highlighted that modern systems heavily rely on artificial intelligence and biometric data for monitoring purposes, but also raised significant concerns regarding data security, transparency, and user trust. It emphasized the need for incorporating ethical frameworks and privacy-preserving techniques in the design of such systems to ensure responsible deployment.

III. METHODOLOGY

The proposed Online Examination Proctoring System (OEPS)is designed as an AI-driven, role-based platform that ensures secure and reliable online assessments through continuous monitoring, identity verification, and behavioral analysis. The system integrates three primary user roles—Admin, Teacher, and Student—along witha backend server, database, and AI-based microservice to deliver a complete examination ecosystem. The methodology follows a structured workflow starting from user registration to exam completion and result analysis.

Flow Chart 3.1



A. Role-Based System Design

The system is structured around three keyroles. The Adminhas complete controlover the platform, including managingteachersandstudentsandaccessingtheirdashboardsformonitoringpurposes.The Teacher is responsible for creating, managing, and publishing examinations, as well as analyzing student attempts and violation reports. The Studentregisters onthe platform, completes identity verification, and participates in examinations. This role-based architecture ensures proper access control and efficient system management.

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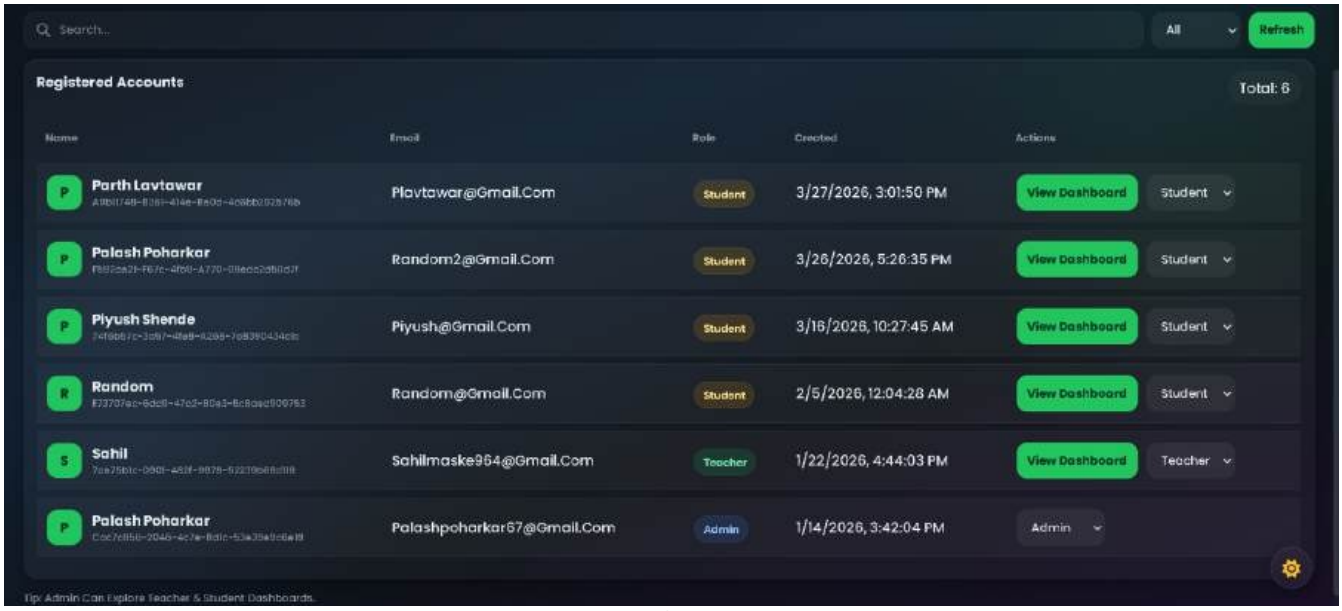

Fig 3.1

B. Student Registration and Face Enrollment

Duringregistration, thesystemcapturesthestudent'sfacialimageusingthedevicecamera. This image isprocessed and stored securely inthe database as a reference for future identityverification. Thisstep establishes a biometric profile for each student, which is later used to authenticate the user before and during the examination process.

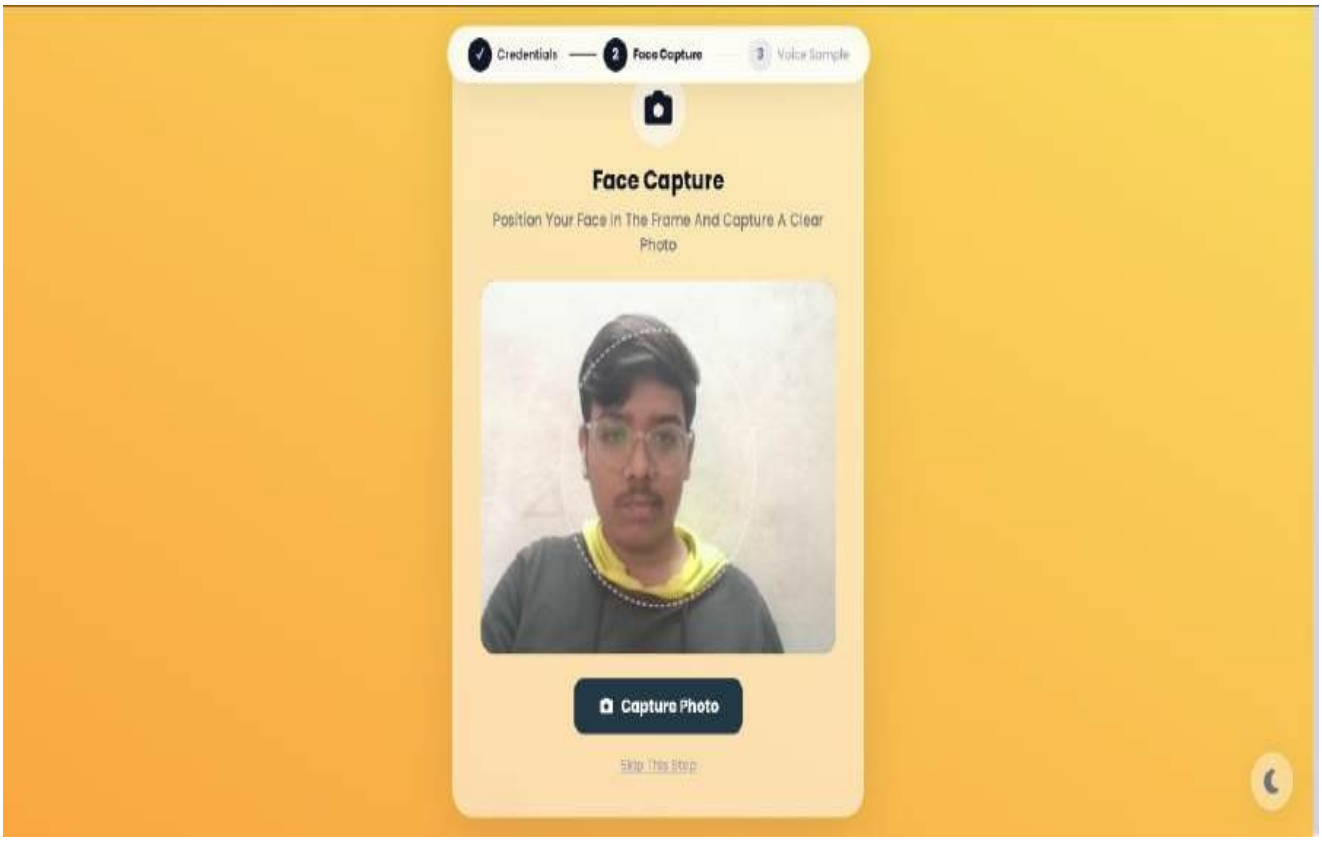

Fig 3.2

C. IdentityVerificationBeforeExamination

Before starting an exam, the system performs real-time identity verification by capturing live video frames fromthe student's webcam. The captured image is compared with the stored facialdata using computer visiontechniquesto ensurethattheregistereduser isthesamepersonattemptingtheexam. If the verification fails, the systemrestricts access to the examination, therebypreventing impersonation.

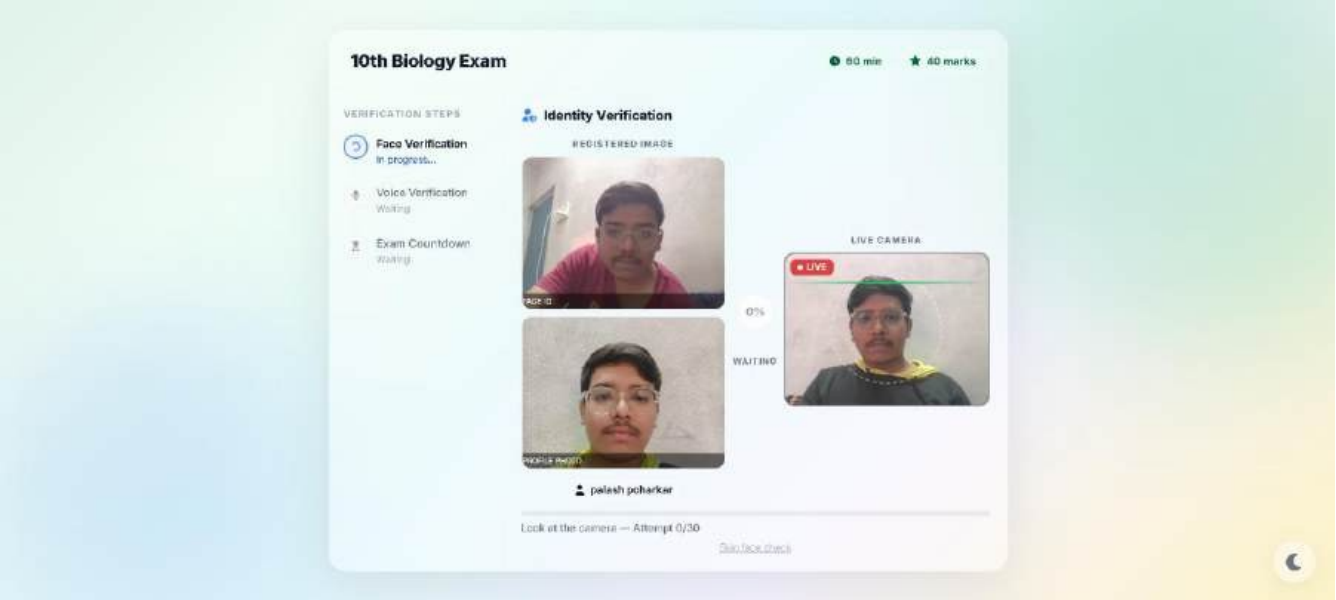

Fig 3.3

D. ExamCreation andPublishing

Teachers can create and manage multiple-choice question (MCQ) based examinations through the system interface. Questions can be added manually or extracted using Optical Character Recognition (OCR)fromimagesanddocuments. Oncefinalized, theteacherpublishestheexam, makingit available to students. The systemalso allows teachers to track attempts, view performance metrics, and analyze examination data.

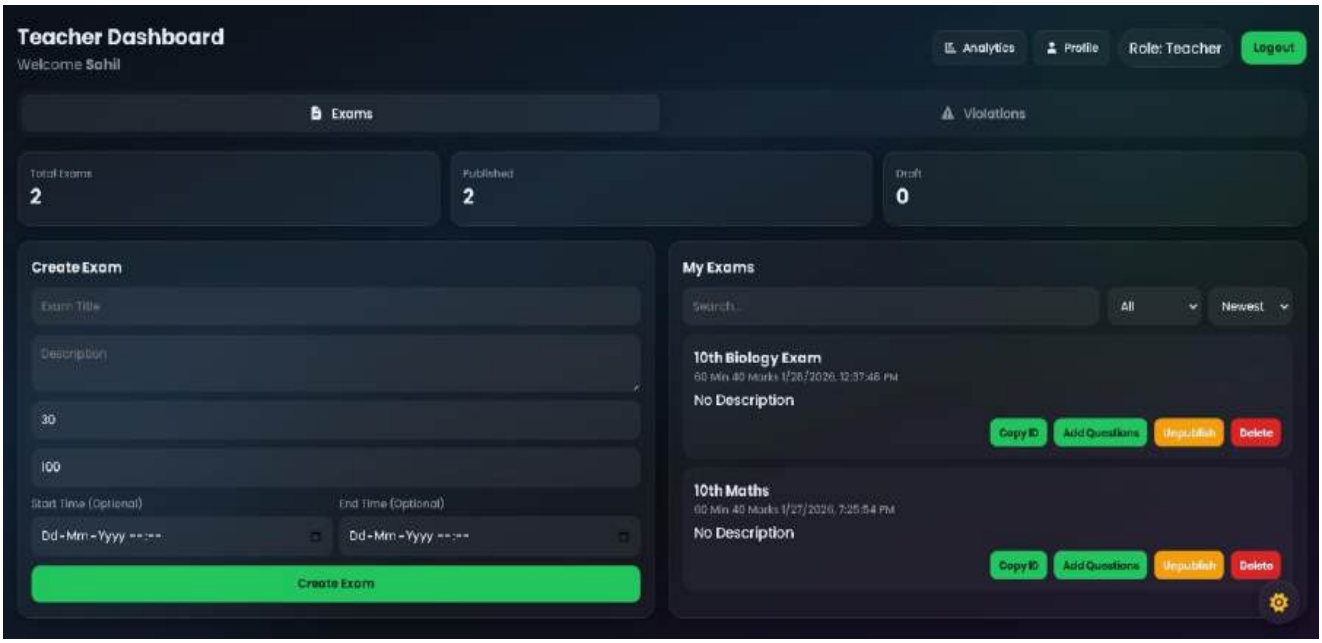

Fig 3.4

E. Real-TimeProctoringandMonitoring

During theexamination, thesystemactivatescontinuous monitoring using thestudent'swebcam. Realtimevideo framesare processedusingcomputervisionlibraries suchasface-api.jsandMediaPipe.The systemdetects facialpresence, head orientation, and eye movement to ensure that the student remains attentive and follows examination rules. These frames are sent to the AI microservice, implemented using FastAPI, for further analysis.

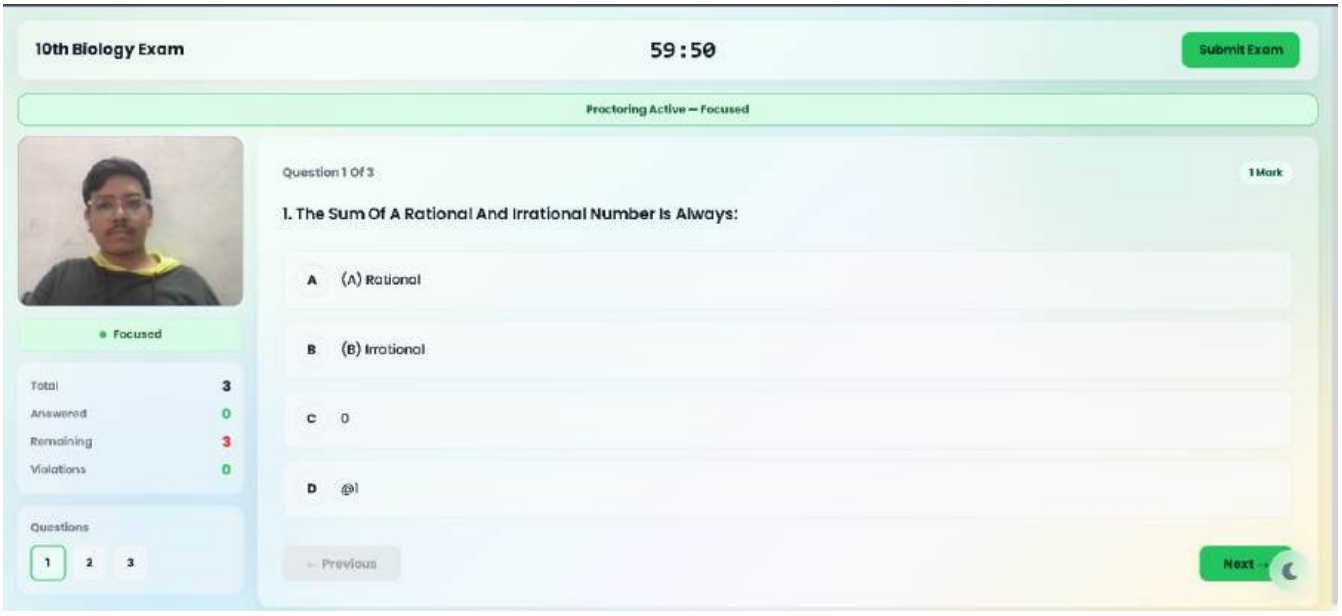

Fig 3.5

F. CheatingDetectionandViolationLogging

The AI module identifies multiple cheating gestures and suspicious behaviors, such as looking away from the screen, absence of face, presence of multiple faces, or unusual movements. Each detected anomalyisrecordedasa**violation**andstoredinthedatabase.These violationlogsare madeaccessible to teachers through their dashboard, allowing them to review student behavior during the exam.

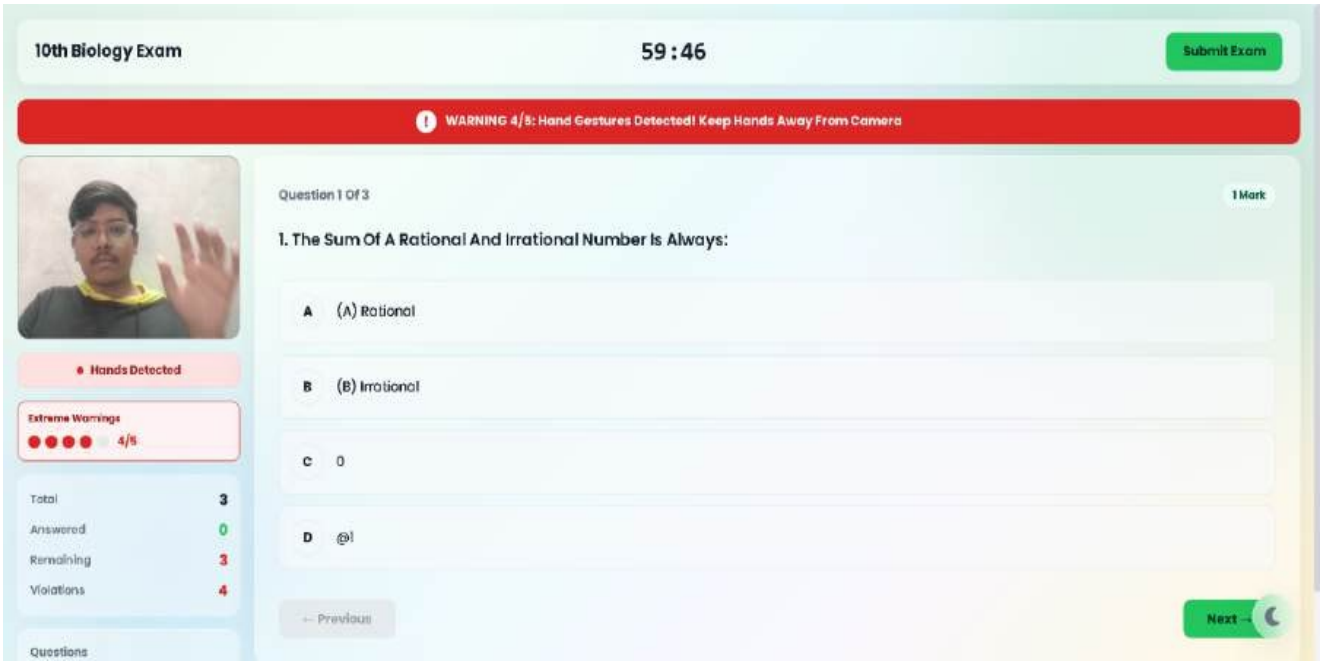

Fig 3.6

G. BackendProcessingandDataManagement

The backend system, developed using Node.js and Express, handles all core functionalities including authentication, exam management, data storage, and communication with the AI service. Supabase is used as the database for storing user profiles, facial data, examdetails, responses, and violation logs. SecureauthenticationisimplementedusingJ SONWebTokens (JWT), ensuring safeaccesstosystem resources.

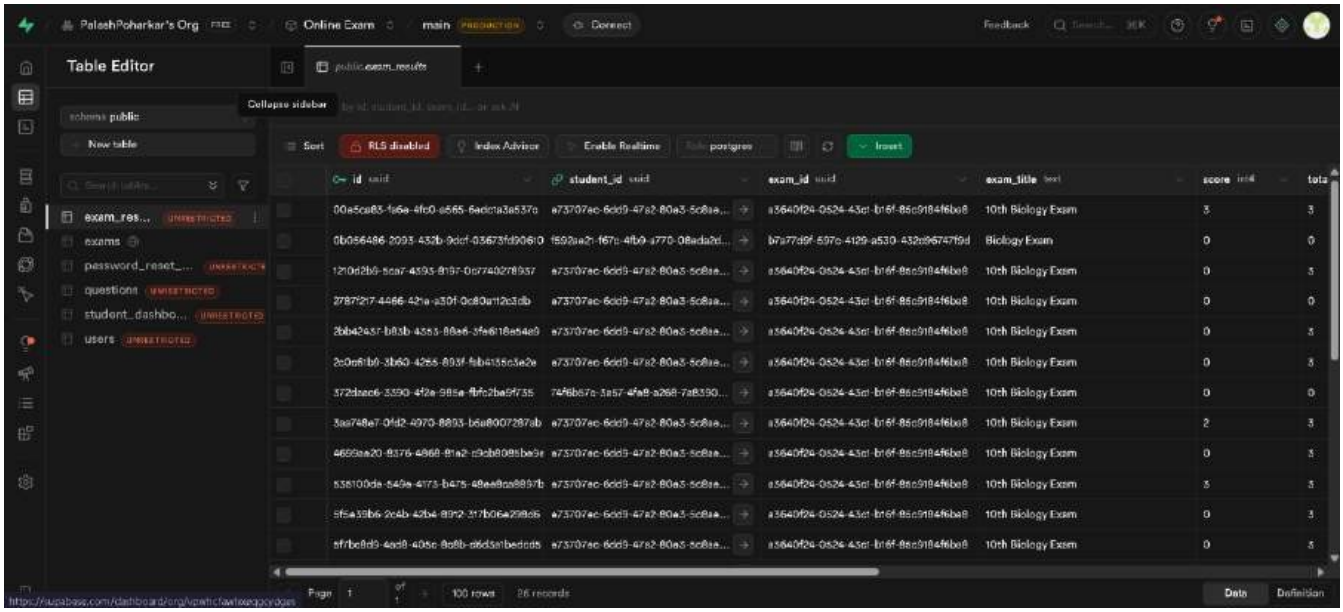

Fig 3.7

H. ResultEvaluationandAnalytics

After the completion of the examination, the system automatically evaluates student responses and generatesresults.Teacherscanaccessdetailedanalytics, includingscores,attempt data,andviolation reports. These insights help in assessing both student performance and exam integrity.

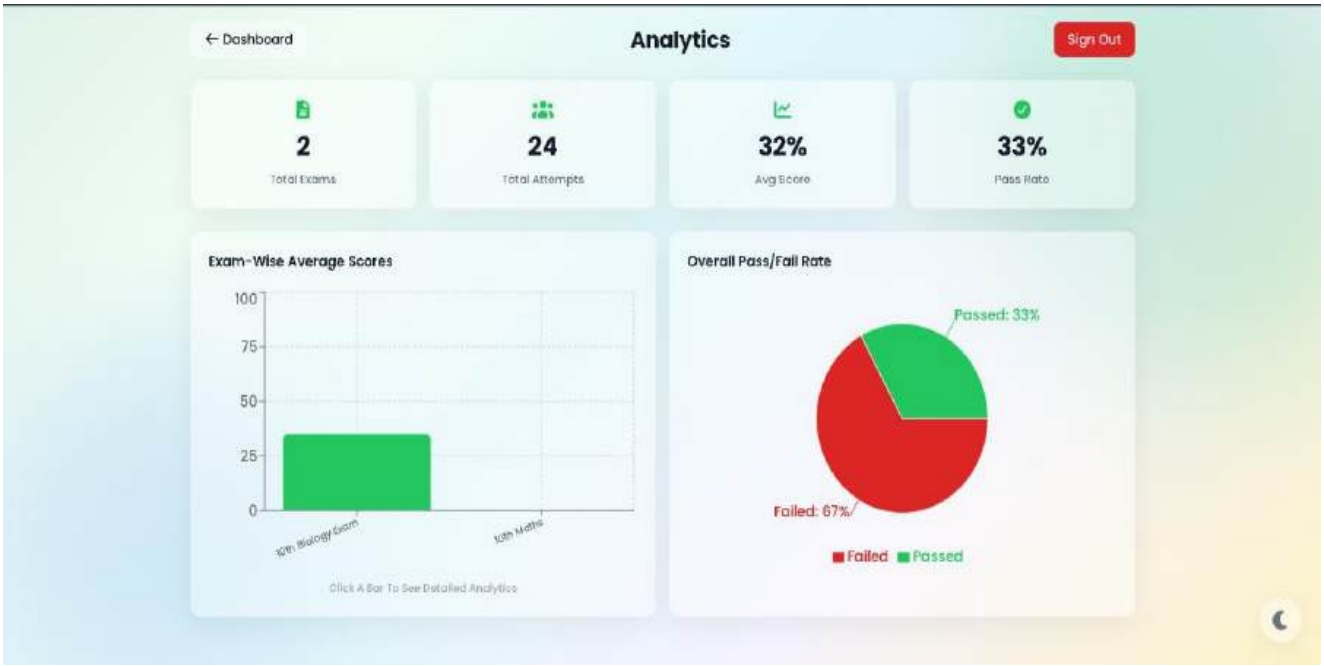

Fig 3.8

I. SystemSecurityandIntegrity

Toensurereliability,thesystemincorporatesmultiplesecuritymechanismssuchasencryptedpassword storage, secure API communication, and rate limiting. Continuous monitoring and AI-based validation enhance the integrity of the examination process by minimizing the chances of malpractice.

Overall, the proposed methodology integrates biometric authentication, real-time AI monitoring, and role-basedsystemdesigntocreateasecure, scalable, and intelligentonlineexaminationplatform. The combination of automation and advanced analytics ensures both efficiency and credibility in digital assessments.

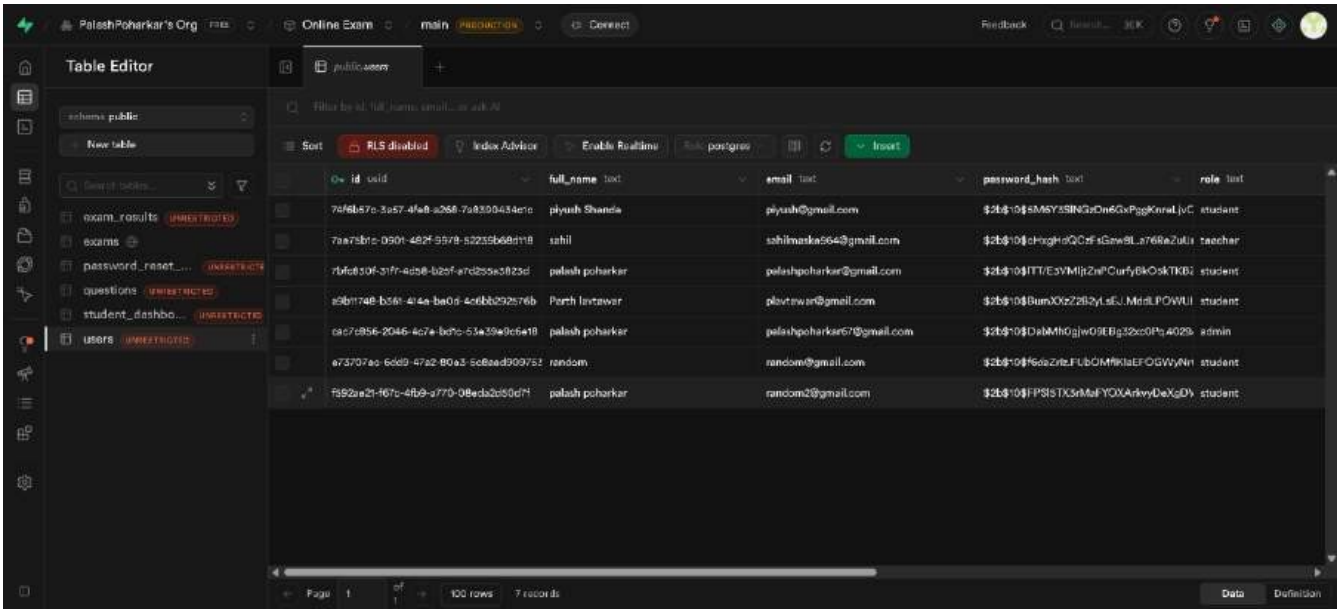

Fig 3.9

IV. RESULTS AND ANALYSIS

Inthisstudy, theproposed OnlineExamination Proctoring System(OEPS) wasevaluated based on its abilityto ensure secure online examinations, accuratelydetect suspicious activities, and efficiently manageexaminationworkflows.ThesystemintegratesAI-based monitoring, identityverification,and role-based access control, and its performance was analyzed through functional testing and simulated examination scenarios.

A. System Performance

The system successfully handled core functionalities including user authentication, exam creation, examparticipation, andresultgeneration.Theintegrationoffrontend,backend,andAI microservice demonstrated smooth communication and real-time processing. The platform was able to support multiple users simultaneously, indicating good scalability and stability for practical deployment.

B. IdentityVerificationAccuracy

The facial recognition mechanismused during student registration and pre-exam verification showed reliable performance in validating user identity. In most test cases, the systemcorrectly matched the live webcam image with the stored facial data, effectively preventing unauthorized access and impersonationattempts. Minorvariationsinlighting andcamera quality affected performances lightly but did not significantly impact overall verification accuracy.

C. Real-Time Proctoring and Behavior Detection

The AI-based monitoring system demonstrated effective detection of various cheating behaviors. Activities such as looking away fromthe screen, absence of face, and presence of multiple faces were successfullyidentifiedduringthe examination. Theuseofcomputervisionlibrariesenabledcontinuoustrackingoffacialmovementsanduserattention.Thesystemmaintainedconsistent monitoring throughout the exam without significant latency.

D. ViolationLoggingandReporting

All detected suspicious activities were recorded as violations and stored in the database. These logs wereaccuratelyreflected intheteacherdashboard,allowing instructorsto reviewstudent behavior in detail. The violation reporting mechanismprovided clear insights into the frequency and type of anomalies, helping teachers make informed decisions regarding exam integrity.

E. ExamManagement andAnalytics

The exam management module allowed teachers to create, publish, and monitor examinations efficiently. The systemgenerated detailed analytics, including student scores, attempt history, and violation data. Visual representations such as charts and reports improved the readability of performancedata.TheintegrationofOCRalso reducedthetimerequired forquestioninput andexam preparation.

F. OverallSystemEffectiveness

The combined use of AI-based monitoring and secure backend processing resulted in a robust and reliableexaminationsystem. Theplatformsignificantlyreducedtheneed formanualinvigilationwhile maintaining high levels of security. The role-based access ensured proper system control, with administrators having complete oversight of both teacher and student activities.

G. LimitationsandObservations

Although the system performed effectively, certain limitations were observed. The accuracyof face detectionandbehavioranalysis dependsoncameraquality, lightingconditions,andinternetstability. Additionally, some subtle cheating behaviors may not always be detectedwith highprecision. These challenges highlight the need for further improvements using advanced deep learning models and multi-modal analysis techniques.

In summary, the experimental evaluation demonstrates that the proposed OEPS system provides a secure,scalable,andefficient solutionforonlineexaminations.The integrationofartificialintelligence enhances monitoring capabilities, ensures academic integrity, and offers a practical alternative to traditional invigilation methods.

V. CONCLUSION

In this paper, an AI-based Online Examination Proctoring System (OEPS) has been proposed and developed to address the challenges of maintaining academic integrity in remote assessment environments. The system integrates modern web technologies with artificial intelligence to provide a secure, scalable, and automated platform for conducting online examinations. By incorporating role-basedaccesscontrol,thesystemeffectivelymanagesinteractionsbetweenadministrators,teachers,and students, ensuring smooth operation and centralized monitoring.

The implementationoffacialrecognitionfor identityverification, alongwithreal-timeproctoringusing computer vision techniques, significantly enhances the reliability of the examination process. The systemsuccessfullydetectsvariouscheatingbehaviorsand logsviolations, whichare madeavailable to teachers for further analysis. Additionally, features such as automated exam management, OCR-based question extraction, and performance analytics contribute to improved efficiency and usability.

Theresultsdemonstratethattheproposed systemreducesthedependencyonmanualinvigilationwhile maintaining high levels ofsecurityand accuracy. Althoughcertain limitations exist, suchas sensitivity to environmental conditions and the need for more advanced detection models, the system provides a strong foundation for intelligent online examination platforms. Future work can focus on improving detectionaccuracyusingdeep learningtechniques,integrating multi-modalanalysis(audio and video), and implementing real-time alert systems for enhanced responsiveness.

Overall, the OEPS systemhighlights the potentialofcombining artificialintelligence with full-stack development tocreatearobust andeffectivesolutionformoderndigitaleducation,ensuring fairness, transparency, and scalability in online assessments.

VI. FUTURE SCOPE

The proposed AI-based Online Examination Proctoring System (OEPS) establishes a strong foundation for secure and intelligent online assessments; however, there is significant scope for further enhancement. Future work can focus on integrating advanced deep learning techniques such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) to improve the accuracy of behavioral analysis and anomaly detection. These models can help identify subtle cheating patterns more effectively while reducing false positives and enhancing the overall reliability of the system.

The system can also be expanded by incorporating multi-modal monitoring techniques, including audio analysis, keystroke dynamics, and screen activity tracking, to provide a more comprehensive evaluation of student behavior during examinations. Additionally, real-time alert mechanisms can be implemented to notify teachers or administrators instantly when suspicious activities are detected, allowing immediate intervention. Improvements in facial recognition, such as liveness detection and robust verification under varying environmental conditions, can further strengthen the system's security and prevent impersonation attempts.

Furthermore, the scalability and usability of the system can be enhanced by deploying it on cloud-based infrastructure to support a larger number of concurrent users. Integration with Learning Management Systems (LMS) and the development of mobile-based applications can increase accessibility and adoption. Future developments should also focus on ensuring data privacy and ethical compliance through secure encryption, user consent mechanisms, and transparent data handling policies, thereby making the system more trustworthy, efficient, and adaptable to modern digital education requirements.

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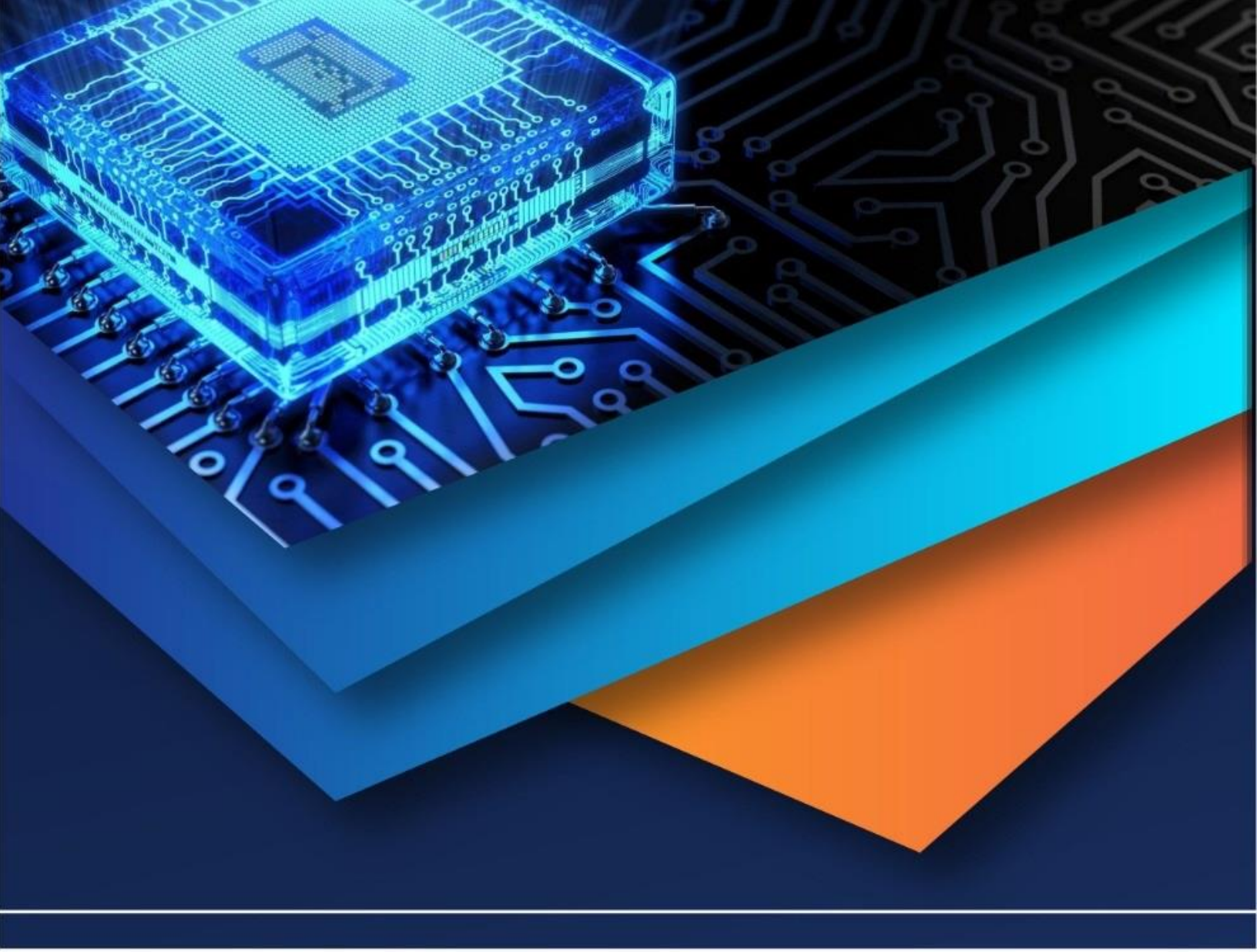

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