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Online Proctoring System

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Abstract: As digital education continues to rise, the demand for reliable online exam monitoring has grown significantly. Conventional in-person invigilation methods are not feasible in remote settings, highlighting the need for automated proctoring solutions. This paper presents a web-based proctoring system that utilizes real-time webcam monitoring through WebCam.js and server-side functionality powered by Node.js. Instead of relying on artificial intelligence or machine learning, the system adopts a straightforward rule-based approach to identify suspicious behaviors such as switching browser tabs, inconsistent facial presence, and unusual eye movements. A tiered warning system is implemented, where repeated violations lead to automatic termination of the examination session. Built on the MERN stack, the platform emphasizes scalability, user accessibility, and exam integrity. System evaluations indicate high reliability in detecting anomalies, making it an effective alternative to manual supervision.

Keywords: Remote Proctoring, Online Exams, WebCam.js, Node.js, Eye Tracking, Academic Honesty, Cheating Detection.

I. INTRODUCTION

The rapid expansion of online education has revolutionized learning methodologies, providing students with greater flexi- bility and accessibility to academic resources. However, main- taining academic integrity in virtual environments remains a significant challenge. Unlike traditional physical classrooms where invigilators monitor students in real-time, online exam- inations lack direct supervision, increasing the risk of mal- practices such as unauthorized assistance, resource usage, and content sharing. To address these concerns, online proctoring systems have been developed to enforce examination integrity through automated monitoring mechanisms.

Existing proctoring solutions often incorporate machine learning algorithms, artificial intelligence (AI), and secure browsers to detect and prevent cheating. However, these ap- proaches may raise concerns regarding privacy, system com- plexity, and resource consumption. To provide a lightweight yet effective alternative, this research proposes an Online Proctoring System that does not rely on machine learning models or secure browser restrictions but instead implements a tab-switching warning mechanism to discourage unauthorized behavior.

The proposed system is built using the MERN stack (Mon- goDB, Express.js, React.js, Node.js), ensuring a scalable, responsive, and user-friendly experience for both examiners and students. The core functionality revolves around detecting tab switching during an examination and issuing immediate warnings to the user. This feature prevents test- takers from accessing external resources, such as search engines, online documents, or unauthorized communication platforms, thereby reinforcing academic integrity. The system provides real-time alerts and maintains a record of tab violations, which can be reviewed by exam administrators for post-exam analysis.

By leveraging modern web technologies and an efficient monitoring approach, the proposed system balances security, simplicity, and user privacy. Unlike AI-driven proctoring so- lutions that require extensive data processing and may lead to ethical concerns, this system ensures a non-intrusive yet effective examination environment. The subsequent sections of this paper provide an in-depth analysis of the system architecture, implementation methodology, and its impact on maintaining academic fairness in online assessments.

II. LITERATURE SURVEY

As online learning platforms continue to expand, ensuring examination integrity has become a priority for academic institutions. To address the risks of cheating and miscon- duct, numerous online proctoring tools have been developed. These systems commonly integrate technologies such as face recognition, audio surveillance, and user behavior tracking to supervise candidates in real-time.

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Despite their technological strengths, many of these solutions face key challenges such as high operational complexity, privacy intrusions, hardware dependencies, and algorithmic inaccuracies.

Yousef Atoum et al. [3] investigated a vision-based proc- toring system using face authentication and gaze tracking to identify suspicious activity. Although effective to a degree, their solution frequently triggered false positives, especially in cases of natural eye movement or minor distractions. Even a quick glance to the side could be interpreted as an attempt to cheat. Moreover, persistent facial scanning raised ethical concerns around privacy and continuous surveillance. In our proposed system, we apply eye movement tracking with adaptive thresholds, allowing for natural behavior without raising unnecessary alarms, thus ensuring fairness without compromising privacy.

Kulshrestha et al. [4] proposed an artificial intelligence- based exam surveillance system that utilized facial recognition and object detection through computer vision. Their method was capable of identifying when a candidate left the web- cam frame or introduced unauthorized items. However, the system was heavily reliant on facial data, which could easily misinterpret lighting changes or facial shifts as threats. Our work enhances reliability by adding multiface detection that specifically looks for more than one face within the webcam frame. It is paired with smart threshold-based eye tracking, minimizing false detections from routine eye shifts or subtle head movements.

Prathish et al. [1] involved a rule-driven inference engine that detected voice, tab changes, and movement patterns using both video and system event logs. Although the rule-based approach worked well under certain conditions, it lacked the contextual intelligence to distinguish between legitimate and suspicious behavior. For instance, harmless background noise often led to false voice alerts. To overcome this, our system utilizes voice detection with noise filtering algorithms, allowing it to suppress ambient sounds while focusing on speech patterns indicative of communication. Additionally, we have added tab-switch and mobile phone usage detection, which were absent in their framework, resulting in more robust monitoring coverage.

Mendez, Sheela, and Solomon [9] explored an AI-enhanced browser-based proctoring system that operated within a secure exam environment. Their model was tailored for real-time detection of cheating behaviors such as unauthorized browsing or the presence of additional individuals. However, it lacked features for tracking mobile devices or capturing nuanced facial behavior. Also, its dependency on secure browsers limited its accessibility on open platforms. Our proposed system introduces cross-platform compatibility and focuses on essential rule-based checks including tab switching, face visibility, and mobile object identification, offering greater flexibility with fewer hardware or software constraints.

Motwani et al. [6] leveraged a combination of machine learning, behavioral analysis, and facial tracking to build an automated proctoring platform. While their work con- tributed to the advancement of remote supervision, the re- liance on computationally heavy AI models made the system unsuitable for users with limited system resources or slow internet connectivity. Furthermore, critical aspects such as browser focus detection and voice activity alerts were missing. In our approach, we've specifically designed a low-latency, hardware-light system that can operate smoothly even on standard devices. Our tool includes all necessary monitoring layers—voice, tab-switch, mobile detection, multiface recog- nition, face movement, and eye tracking—without requiring GPU-intensive processing.

Research by Kumar et al. [2] focused on a machine learning- based surveillance model that analyzed real-time facial expres- sions to assess candidate attention. While innovative, such a system can be intrusive and overly sensitive, leading to over- flagging due to stress-induced facial gestures during exams. Our solution avoids facial emotion classification entirely and instead applies movement thresholds to define what constitutes a suspicious action, preserving user comfort and reducing bias in detection.

III. PROPOSED SYSTEM

The proposed system ensures exam integrity by detecting tab switching and issuing real-time warnings. It does not use machine learning or secure browsers but monitors browser activity to prevent misconduct. Repeated violations are logged for examiner review.

A user authentication system restricts access to authorized can- didates, while activity logs track session details and violations. Built on the MERN stack, the system offers a user-friendly interface and generates reports for post-exam review, ensuring fair evaluation.

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This scalable solution maintains exam security while respect- ing student privacy.

A. System Architecture

The system is structured using a modular design for easy maintenance and scalability. It is developed using the MERN stack: *MongoDB* handles data storage, *Express.js* and *Node.js* form the backend infrastructure, while *React.js* delivers a dynamic frontend user interface.

Each exam begins with user verification. Candidates must log in using secure credentials validated against a registered database. Upon successful authentication, multiple monitoring modules are activated in parallel. These include video surveil- lance, audio monitoring, and browser event tracking.

At its core, the system uses a rule-based engine to identify violations. This approach eliminates the need for machine learning models and reduces hardware requirements. The rule- based logic makes the system faster and more lightweight, allowing it to operate efficiently on devices with limited processing power or slow internet connections.

B. Monitoring Modules

Once logged in, the monitoring process continues until the session ends or is forcibly terminated due to violations. The system operates through three major observation channels:

1) **Webcam Monitoring:** The candidate's face is tracked continuously. Presence, head position, and facial direc- tion are monitored to detect distraction or absence. If multiple faces are detected in the frame, it triggers a warning.
2) **Microphone Analysis:** Background audio is analyzed for voices or potential communication. If speech is identified that suggests interaction with another person, the system flags it.
3) **Browser Tab Tracking:** The system listens for tab switches or window minimization. Every time the test interface loses focus, an event is logged and evaluated.

Each module has predefined thresholds to distinguish between normal and suspicious behavior. The combination of these modules ensures comprehensive supervision.

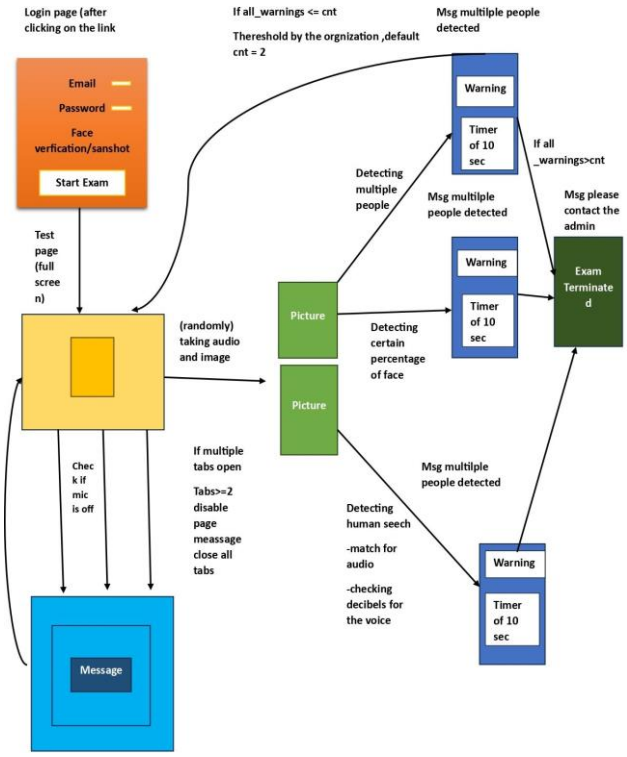

Fig. 1. System Architecture

C. Preprocessing and Signal Refinement

To improve accuracy, the raw data is cleaned and structured before detection. This preprocessing step removes irrelevant noise and prevents misclassification:

- **Visual Processing:** The webcam feed undergoes contrast normalization and brightness adjustment. The candidate's face is isolated to ensure the system only focuses on relevant features.

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- **Audio Processing:** Common background noise is filtered out. Voice detection is triggered only when human speech surpasses a specific decibel threshold.
- **Event Debouncing:** For browser tracking, short-lived focus losses due to pop-ups or accidental clicks are filtered out to prevent false alerts.

This refined data is passed to the monitoring engine for behavior evaluation.

D. Behavior Analysis and Pattern Detection

The system establishes a behavior baseline when the test begins. Initial face orientation, noise levels, and screen interaction patterns are recorded. These benchmarks help the system identify deviations that may indicate misconduct.

As the exam progresses, the live stream is compared against these references. Multiple or prolonged deviations are treated as red flags. For instance, if the candidate frequently disap- pears from the frame or repeatedly looks away, the system issues warnings. Similarly, unexpected speech after long si- lence periods is flagged.

This adaptive detection approach minimizes false positives by focusing on actual anomalies rather than isolated events.

E. Violation Classification and Response Mechanism

Violations are categorized based on severity, and the system responds accordingly:

- **Minor Violations (Level 1):** These include brief glances away from the screen or a single instance of tab switching. A soft on-screen warning is issued.
- **Moderate Violations (Level 2):** Repeated distractions, partial face disappearance, or low-level background speech trigger stronger alerts. The candidate is informed that continued behavior will result in exam termination.
- **Severe Violations (Level 3):** Major infractions include clear cheating attempts—visible phones, multiple individuals in frame, or consistent speech patterns suggesting collaboration. The system terminates the session and records a detailed log for administrative review.

All responses are logged, including timestamps and descrip- tions, to allow examiners to verify system actions.

F. Privacy and Ethical Safeguards

The system is developed with privacy as a core principle. No continuous recording is saved. Only when a policy breach is detected does the system store a brief video or audio clip for evidence. This ensures student rights are respected.

Unlike many AI-based tools, this platform avoids facial recog- nition, emotional analysis, or biometric profiling. All monitor- ing is strictly limited to what is necessary for exam integrity. Candidates are informed about what will be monitored, and consent is obtained before the session begins.

G. Performance and Accessibility

A major strength of the platform is its lightweight design. Because it does not require intensive computation or special hardware, it runs efficiently on standard laptops and desktops. This accessibility makes it suitable for use in rural areas or developing regions where device and bandwidth limitations are common.

The system runs directly within the browser, requiring no software installations. This not only simplifies deployment for institutions but also enhances compatibility across operating systems.

Real-time performance optimization ensures that monitoring is not delayed or lagged, even under moderate system loads.

The use of asynchronous operations in the backend improves system responsiveness and helps manage large volumes of concurrent users.

IV. RESULTS AND EVALUATION

The online proctoring system, built using the MERN stack, ensures secure and efficient remote exam monitoring. The frontend offers an intuitive interface, while the backend han- dles authentication, data processing, and anomaly detection. Key security features include full-screen enforcement, random audio/image capture, and real-time detection of suspicious activities like tab switching, multiple faces, and background noise. If violations exceed a set threshold, the system automatically terminates the exam, ensuring academic integrity.

The system provides instant alerts to both candidates and proctors, minimizing misconduct. A secure logging mechanism records all flagged activities, enabling post-exam review. The scalable architecture ensures smooth operation, even under high traffic, and customizable security settings allow institutions to tailor monitoring policies.

A proctoring dashboard offers live exam tracking, instant reporting, and user-friendly controls for real-time intervention. Students receive immediate warnings upon detection of any violations, helping them adhere to exam rules. Designed for cross-device compatibility, the system ensures accessibility for all users.

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A. Login

The login page ensures secure authentication by verifying user credentials against the database. It supports role-based access for students and administrators. Secure password en- cryption and session management prevent unauthorized access. Error messages guide users in case of incorrect credentials, ensuring a seamless and protected login process.

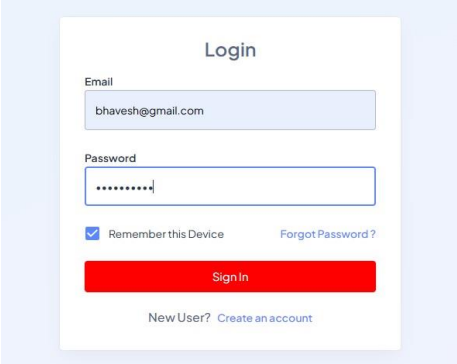

Fig. 2. Login Page

After successful authentication, users are redirected to the dashboard, where they can access their respective functionalities based on their roles.

B. Dashboard

The dashboard is the central interface of the Online Proc- toring System, providing users with essential functionalities based on their roles. Students can view upcoming exams, access guidelines, and enter the exam portal, while administrators can manage exams, monitor sessions, and analyze system activity. It also displays real-time exam status and active users, ensuring smooth navigation and efficient management of remote assessments.

Additionally, the dashboard includes notifications for impor- tant updates and exam reminders. User activity logs are also maintained to enhance security and ensure compliance with examination policies.

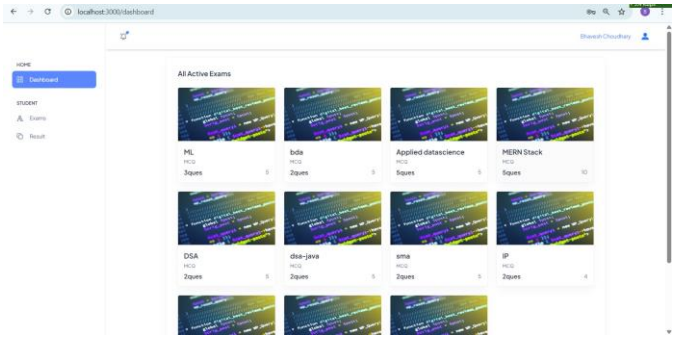

Fig. 3. Dashboard

C. Face Movement Detection

To ensure exam integrity, the system continuously tracks the candidate's face position using the webcam. If the user frequently looks away to the left or right beyond a predefined threshold, the system generates an automated warning. Multi- ple warnings may lead to further action based on the exam policy. This feature helps prevent unauthorized assistance while maintaining a fair examination environment.

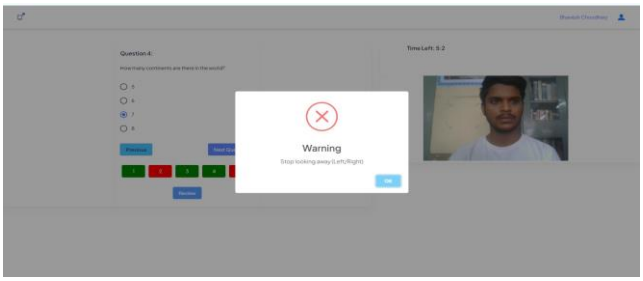

Fig. 4. Face Movement Detection

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D. Tab Switching Detection

The system detects tab switches, issuing warnings for vio- lations. Repeated offenses may lead to penalties. All incidents are logged for review, ensuring candidates stay focused and preventing unauthorized access, maintaining a fair and secure exam environment through real-time monitoring.

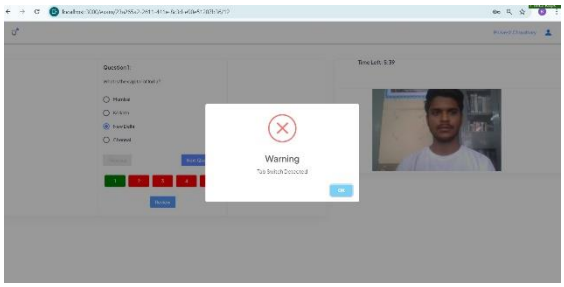

Fig. 5. Tab Switching Detection

E. Voice detection

The system detects unauthorized voices, issues warnings, and logs violations. Repeated offenses may lead to penalties. Background noise filtering reduces false alerts, ensuring fair- ness and security in exams through real-time monitoring and post-exam review.

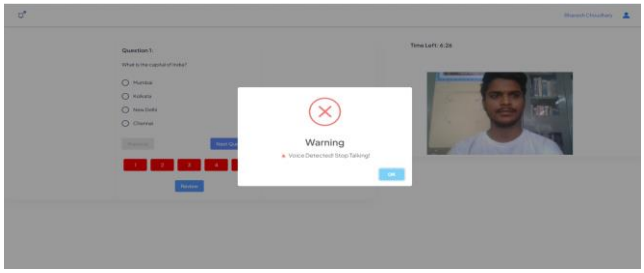

Fig. 6. Voice detection

F. Cell Phone Detection

The system detects mobile phone usage via webcam moni- toring. If a candidate is seen with a phone, a warning is issued. Repeated violations may result in penalties, ensuring exam security and preventing unauthorized assistance.

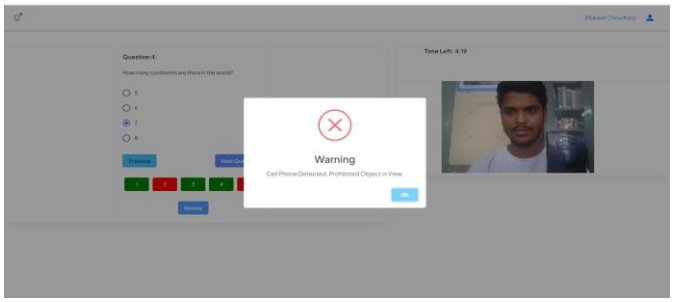

Fig. 7. Cell Phone Detection

G. Review Of Question and Answer

Before submitting, candidates can review their responses, view answered and unanswered questions, and modify answers if needed, ensuring accuracy and completeness before final submission.

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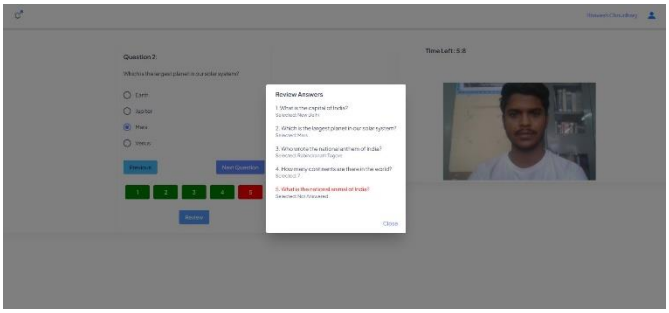

Fig. 8. Review

H. Result

After successfully submitting the exam without violations, the system generates the result instantly. The result page displays the total score along with the number of correct and incorrect answers. This feature provides candidates with im- mediate feedback on their performance, ensuring transparency and efficiency in the evaluation process.

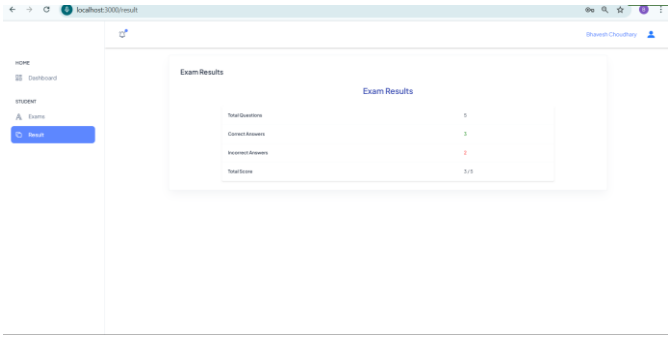

Fig. 9. Result

V. CONCLUSION

The development of the Online Proctoring System has established a reliable and efficient method for conducting remote examinations while ensuring academic integrity. By implementing real-time tab-switch detection and warning mechanisms, the system effectively discourages unauthorized activities during exams. The use of the MERN stack provides scalability, security, and a seamless user experience.

Future enhancements may include additional monitoring features, such as automated reporting and session review functionalities, to further strengthen examination security. This system serves as a valuable solution for institutions seeking to maintain the credibility of online assessments while balancing student privacy and usability.

VI. FUTURE WORK

Future enhancements will focus on improving AI-driven behavioral analysis to reduce false detections and enhance security. Multi-factor authentication (MFA) using facial and voice recognition can strengthen identity verification. Multi- camera support via external webcams or mobile devices will help eliminate blind spots. Real-time examiner intervention and cloud-based proctoring dashboards can provide better monitoring and post-exam analytics. Optimizing the system for low-bandwidth environments and ensuring privacy-focused proctoring will enhance accessibility and security. These ad- vancements will make the system more intelligent, secure, and scalable for future online assessments.

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