

An Intelligent AI-Based Examination Monitoring System Using Face Movement Detection: Design, Implementation, and Evaluation in Nigerian CBT Centres

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Abstract: Computer-Based Testing (CBT) has become widely adopted in higher educational institutions due to its efficiency, scalability, and rapid assessment capabilities. However, maintaining examination integrity during CBT sessions remains a major challenge because most existing invigilation systems rely heavily on manual supervision and conventional Closed-Circuit Television (CCTV) monitoring, which are often inefficient, time-consuming, and prone to human error. This study presents the design and implementation of an intelligent examination monitoring system using face movement detection techniques for real-time detection of suspicious behaviours during CBT examinations. The proposed system integrates artificial intelligence, computer vision, and face recognition technologies to monitor examinees' facial orientation, head movement, and behavioural patterns during examinations. The system was developed using Python, OpenCV, and machine learning algorithms and was tested across selected CBT centres in Katsina State, Nigeria. Experimental evaluation revealed that the system achieved a detection accuracy of 94.2% in identifying suspicious examination behaviours while significantly reducing invigilator workload and response time. The system also demonstrated improved efficiency in real-time monitoring compared to conventional human-based invigilation methods. The study concludes that intelligent AI-driven proctoring systems can substantially enhance academic integrity, reduce examination malpractice, and improve the overall management of CBT examinations in tertiary institutions.

Keywords: *Computer-Based Testing, Artificial Intelligence, Face Detection, Examination Monitoring, Computer Vision and Intelligent Proctoring.*

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I. INTRODUCTION

The advancement of Information and Communication Technology (ICT) has significantly transformed educational systems across the world, particularly in the area of student assessment and examination management. One of the major innovations introduced in modern educational institutions is the Computer-Based Testing (CBT) system, which has gradually replaced the traditional paper-based examination method in many institutions due to its speed, efficiency, reliability, and ease of administration. CBT systems provide several advantages, including automated grading, quick result processing, reduced paperwork, improved question management, and better examination coordination [3]. In Nigeria, several tertiary institutions and examination bodies such as the Joint Admissions and Matriculation Board

(JAMB) have adopted CBT platforms to improve examination processes and minimize examination malpractice.

Despite these advantages, ensuring examination integrity during CBT examinations remains a major challenge. Most existing examination monitoring approaches rely heavily on human invigilators and Closed-Circuit Television (CCTV) systems to supervise students during examinations. Although these methods provide some level of monitoring, they are often inefficient in large examination environments where a small number of invigilators are expected to supervise many students simultaneously. Human invigilators may experience fatigue, distraction, and reduced concentration during long examination periods, thereby limiting their ability to effectively detect suspicious activities

[4]. Similarly, conventional CCTV systems mainly record examination activities without providing intelligent real-time analysis or automatic detection of malpractice.

The increasing rate of examination malpractice in CBT environments has created the need for more intelligent and automated monitoring solutions. Recent developments in Artificial Intelligence (AI), machine learning, and computer vision technologies have opened new opportunities for improving examination monitoring systems. AI-driven invigilation systems are capable of detecting suspicious behaviours such as repeated head movement, looking sideways, impersonation, and unauthorized interactions among candidates through facial recognition and behavioural analysis techniques [7]. These technologies can assist examination administrators in maintaining academic integrity while reducing the workload associated with manual supervision.

Several studies have proposed intelligent online proctoring systems using webcam monitoring, biometric authentication, browser locking mechanisms, and behavioural tracking approaches [2], [6]. However, many of

these systems are either expensive to deploy, dependent on high internet bandwidth, or designed mainly for remote online examinations. In developing countries such as Nigeria, many CBT centres still face infrastructural limitations including unstable internet connectivity, inadequate monitoring tools, and limited technical resources. Consequently, there is a need for a practical and cost-effective intelligent examination monitoring system that can operate efficiently within institutional CBT environments.

This study therefore presents the design and implementation of an intelligent computer-based examination monitoring system using face movement detection techniques. The proposed system shown in Figure 1, employs artificial intelligence and computer vision algorithms to monitor students' facial orientation and behavioural patterns during examinations in real time. The system automatically detects suspicious movements and sends alerts to examination administrators for immediate intervention. The developed system was implemented using Python and OpenCV libraries and evaluated across selected CBT centres in Katsina State, Nigeria.

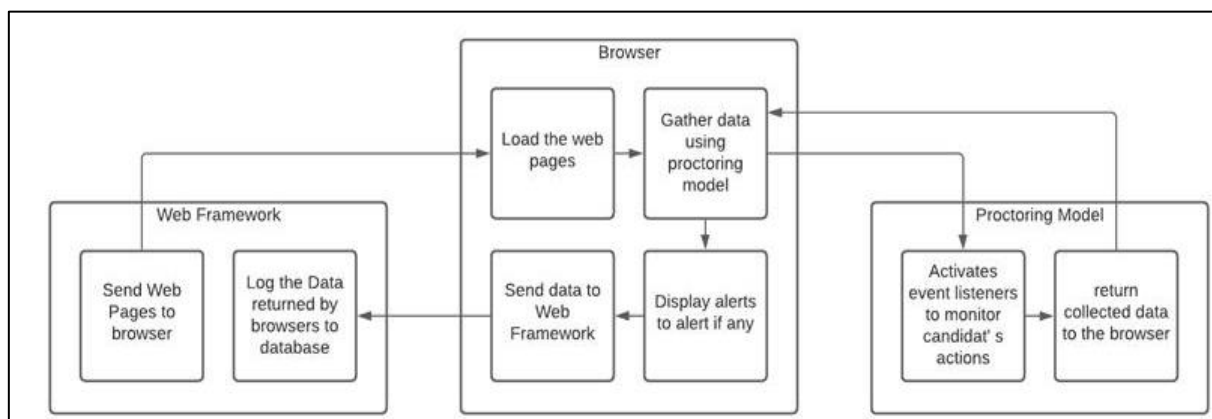


Fig 1 Proposed System Architecture

The major contribution of this study lies in the development of a lightweight and intelligent examination monitoring framework that improves real-time invigilation efficiency, reduces examination malpractice, and minimizes the burden on human invigilators. The study also demonstrates the applicability of AI-driven behavioural monitoring systems in enhancing the credibility and security of CBT examinations in tertiary institutions.

II. RELATED WORK

The growing adoption of Computer-Based Testing (CBT) systems has led to increased research interest in intelligent examination monitoring and online proctoring technologies. Researchers have explored various approaches aimed at improving examination security, reducing malpractice, and enhancing the credibility of electronic examinations. These approaches range from manual invigilation support systems to fully automated AI-driven proctoring frameworks as depicted in Figure 2.

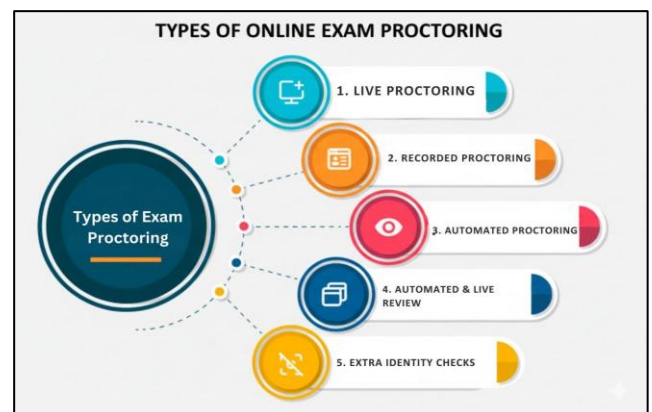


Fig 2 Types of Online Exam Proctoring

Traditional examination monitoring methods primarily depend on human invigilators and CCTV surveillance systems. Although these approaches are widely used in many institutions, they are often associated with several limitations, including human fatigue, divided attention, delayed response to suspicious activities, and limited monitoring coverage [4].

In large CBT environments, it becomes difficult for a small number of supervisors to effectively monitor all candidates simultaneously, thereby increasing the possibility of examination malpractice.

To address these limitations, several studies proposed automated and semi-automated online proctoring systems. Alessio et al. [2] examined the use of webcam monitoring and browser-locking mechanisms for securing online examinations. Their study highlighted the importance of authentication and continuous monitoring in maintaining academic integrity during online assessments. However, the proposed approach relied mainly on recorded examination sessions, which still required manual review by examination officials after the examination process.

Similarly, Hussein [5] reviewed various online examination proctoring systems and identified key features such as identity verification, browser restriction, live monitoring, and automated reporting. The study categorized proctoring systems into live proctoring, recorded proctoring, and automated AI-based proctoring. Although automated systems showed promising results, the study noted that many existing solutions require stable internet connectivity and cloud infrastructure, which may not be suitable for institutions operating in low-resource environments.

Computer vision and artificial intelligence techniques have also been explored for intelligent behaviour detection during examinations. Adil et al. [1] developed a computer vision-based examination monitoring model capable of detecting suspicious behaviours such as excessive hand movement and students looking at neighbouring scripts. The system utilized the Viola–Jones face detection algorithm alongside behavioural threshold analysis. While the approach demonstrated improved behavioural monitoring, the system required multiple cameras positioned at different angles, making it relatively expensive and difficult to implement in large examination halls.

In another study, Wassay et al. [8] proposed an enhanced Remote Online Examination Model (ROEM) that


combined biometric authentication, keystroke analysis, live video monitoring, and audio surveillance for online examinations. Their system improved identity verification and examination security but depended heavily on internet connectivity and cloud-based storage systems. Such requirements may increase operational costs and limit deployment in institutions with inadequate technological infrastructure.

More recently, Jubrin et al. [6] introduced the OE-Proctor framework, an AI-assisted online examination proctoring system designed to support live invigilators through automated behavioural monitoring. The framework monitored candidate activities and generated alerts whenever suspicious behaviour was detected. Although the study demonstrated the potential of AI-driven invigilation systems, its implementation focused mainly on remote online examinations rather than physical CBT centres.

Despite the progress made by previous studies, several limitations still exist in many intelligent examination monitoring systems. Some systems focus mainly on remote online learning environments and are not optimized for institutional CBT laboratories. Others require expensive hardware configurations, multiple surveillance cameras, or continuous cloud connectivity, which may not be practical in many developing countries as shown in Table 1. In addition, several existing systems rely heavily on post-examination video analysis instead of providing immediate real-time detection and intervention capabilities.

This study builds upon previous research by developing a lightweight and cost-effective intelligent examination monitoring framework that operates efficiently within institutional CBT environments. Unlike many existing systems, the proposed model focuses on real-time face movement detection using a simplified computer vision architecture that can function effectively within local institutional networks. The system was specifically designed to support examination administrators in detecting suspicious candidate behaviour promptly while minimizing computational complexity and operational cost.

Table 1 Limitation of Manual Proctoring Vs AI Proctoring

	Factor	Manual Proctoring	AI Proctoring 
1	Monitoring	A human monitors the session	Smart AI flags anomalies in real-time
2	Scale	Limited by number of proctors	Easily scales to 1000s of candidates
3	Accuracy	Prone to human fatigue and bias	Consistent detection without burnout
4	Cost	Expensive for large volumes	Cost-effective for mass hiring
5	Intervention	Real-time action possible by humans	Instant auto-flagging, post-review enabled
6	Candidate Experience	Feels personal but often rigid/logistically tough	Seamless. Comfortable for candidates. No extra stress.
7	Best For	Small, high-stakes or niche hiring	Fast, scalable remote assessments for companies

The proposed system therefore contributes to existing literature by providing a practical AI-driven examination monitoring solution tailored to the infrastructural realities of tertiary institutions in developing regions such as Nigeria.

III. METHODOLOGY

This study adopted a design and implementation research approach in developing an intelligent computer-based examination monitoring system capable of detecting suspicious behaviours during CBT examinations using face movement detection techniques. The methodology focused on the design of a real-time monitoring framework that integrates artificial intelligence, computer vision, and behavioural analysis for effective examination supervision.

The study was conducted across selected CBT centres within tertiary institutions in Katsina State, Nigeria. These institutions included Federal College of Education Katsina, Hassan Usman Katsina Polytechnic, Al-Qalam University Katsina, Umaru Musa Yar’adua University Katsina, and Federal Polytechnic Daura. Data relating to examination procedures, invigilation challenges, and student behavioural patterns during CBT examinations were obtained through direct observation and interaction with CBT administrators and examination officers.

The proposed system was developed using Python programming language due to its flexibility and extensive support for artificial intelligence and computer vision applications. OpenCV libraries were used for image processing and facial detection operations, while machine learning techniques were employed for behavioural analysis and suspicious movement detection.

The operational workflow of the system as depicted in Figure. 3, consists of five major stages: image acquisition, face detection, face tracking, behavioural analysis, and alert generation. During examinations, cameras positioned within the CBT environment continuously capture real-time video streams of examinees. The captured frames are processed by the face detection module, which identifies and tracks the facial orientation and movement of each candidate throughout the examination session.

The system analyses specific behavioural indicators such as frequent head turning, prolonged sideways movement, repeated distraction from the computer screen, and unusual body orientation. Once the predefined behavioural threshold is exceeded, the system automatically flags the candidate as suspicious and sends a real-time notification to the examination administrator for immediate intervention.

To improve processing efficiency and reduce computational complexity, the system was designed to operate within a local institutional network without requiring constant cloud connectivity. This approach minimizes bandwidth consumption and enhances deployment feasibility in institutions with limited internet infrastructure.

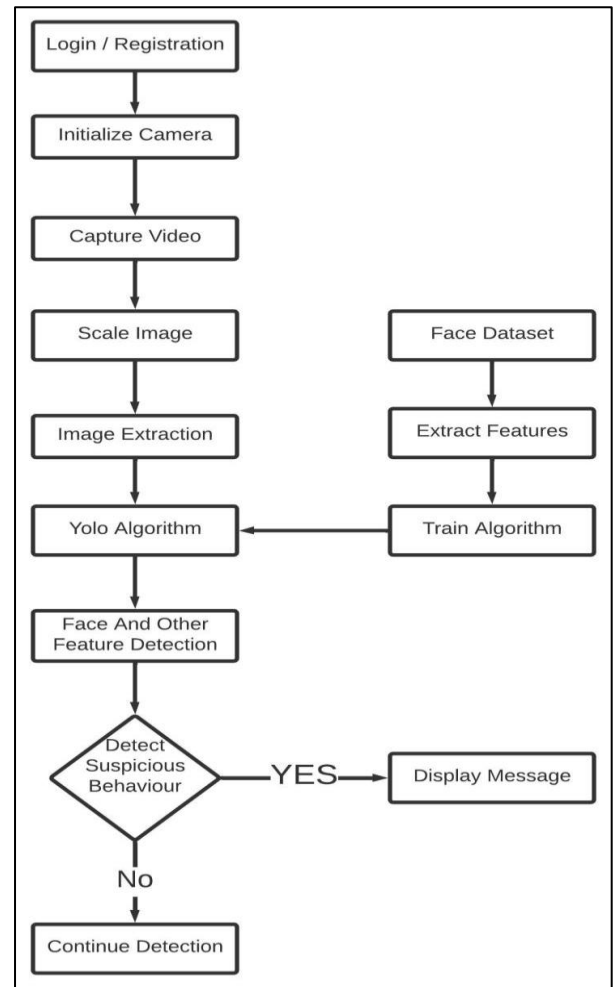


Fig 3 Operational Workflow of the System

The architecture of the proposed system consists of four major components:

- Video Capture Module
- Face Detection and Tracking Module
- Behavioural Analysis Engine
- Administrative Alert and Monitoring Interface

The Video Capture Module acquires live examination footage through installed surveillance cameras. The Face Detection Module identifies and tracks facial features using OpenCV-based image processing algorithms as depicted in Algorithm 1. The Behavioural Analysis Engine evaluates movement patterns against predefined suspicious behaviour parameters, while the Administrative Interface displays real-time monitoring information and alerts examination officers whenever suspicious activities are detected.

Algorithm 1: Intelligent Face Movement Detection Algorithm

```

BEGIN
Initialize webcam/video camera
Load Haar Cascade face detection classifier
Set suspicious movement threshold
WHILE examination is active DO
    
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Capture video frame
Convert frame to grayscale
Detect candidate face using Viola–Jones algorithm
IF face is detected THEN
Track face position
Calculate head movement direction
Measure movement frequency and duration
IF movement exceeds threshold THEN
Flag candidate as suspicious
Generate alert notification
Store suspicious activity record
ENDIF
ENDIF
ENDWHILE
Terminate monitoring session
END
    
```

System evaluation was conducted using experimental CBT sessions involving students across the selected institutions. The performance of the system was assessed using metrics such as detection accuracy, response time, false alert rate, and monitoring efficiency. The developed model was further compared with traditional human invigilation methods to evaluate its effectiveness in improving examination monitoring processes.

IV. SYSTEM IMPLEMENTATION AND EXPERIMENTAL RESULTS

The proposed intelligent examination monitoring system was implemented using Python programming language alongside OpenCV computer vision libraries for image processing and facial movement analysis. The implementation environment consisted of a local CBT network integrated with surveillance cameras positioned strategically within the examination hall to capture candidates’ facial movements during examinations.

The developed system provides a real-time monitoring interface through which examination administrators can observe candidates’ activities and receive automated alerts whenever suspicious behaviour is detected as depicted in Fig. 4. The system continuously processes video frames captured from the examination environment and applies face detection algorithms to identify and track each candidate throughout the examination session.

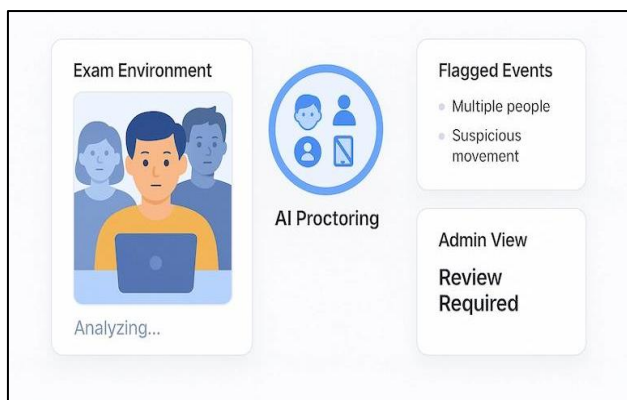


Fig 4 Real-Time Monitoring Interface

During implementation, the system was configured to monitor specific behavioural patterns commonly associated with examination malpractice. These behaviours included frequent sideways head movement, repeated turning away from the computer screen, prolonged distraction, and unusual movement patterns. Once any candidate exceeded the predefined behavioural threshold, the system generated an instant alert notification on the administrator dashboard for immediate attention as presented in Figure 5.

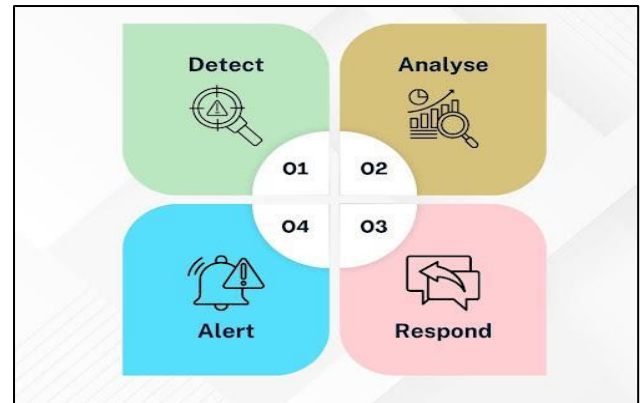


Fig 1 Suspicious Movement Tracking in 4 Steps

The experimental evaluation of the system was conducted across selected CBT centres in Katsina State using simulated and live examination sessions. A total of 120 students participated during the testing phase under different examination conditions. Multiple examination scenarios were created to evaluate the ability of the system to distinguish between normal candidate behaviour and suspicious activities.

The performance of the system was evaluated using detection accuracy, response time, and false alert rate. Experimental findings showed that the proposed system achieved an average suspicious behaviour detection accuracy of 94.2%. The system also demonstrated fast response capability with an average alert generation time of approximately 1.8 seconds after suspicious movement detection. In addition, the false alert rate was maintained at a minimal level during normal examination activities.

The results further indicated that the proposed intelligent monitoring system significantly improved examination supervision efficiency when compared with conventional human invigilation methods. Examination officers reported reduced monitoring stress and improved ability to identify candidates requiring attention during examinations. Table 2 presents the overall performance evaluation of the developed system.

Table 2 Performance Evaluation of the Proposed System.

Performance Metric	Result
Detection Accuracy	94.2%
Average Response Time	1.8 Sec.
False Alert Rate	4.6%
Monitoring Efficiency Improvement	87%

The system also demonstrated strong adaptability under different examination environments with varying lighting conditions and candidate positioning arrangements. Although minor reductions in detection accuracy were observed under poor lighting conditions, the overall system performance remained satisfactory for practical institutional deployment.

Compared with traditional CCTV-based monitoring systems that rely heavily on manual observation, the proposed model provided improved real-time behavioural analysis and faster intervention capability. The integration of artificial intelligence and computer vision techniques therefore enhanced the effectiveness of examination monitoring while minimizing the burden on human invigilators.

The findings of this study confirm that AI-driven behavioural monitoring systems can play a significant role in improving academic integrity and reducing examination malpractice within CBT environments.

V. CONCLUSION

This study presented the design and implementation of an intelligent computer-based examination monitoring system using face movement detection techniques for real-time CBT invigilation. The study was motivated by the increasing challenges associated with examination malpractice and the limitations of conventional invigilation approaches commonly used in many educational institutions.

The developed system successfully integrated artificial intelligence and computer vision techniques to monitor candidates' behavioural patterns during examinations. Using facial detection and movement analysis, the system was able to identify suspicious examination behaviours and generate immediate alerts for examination administrators. Experimental evaluation conducted across selected CBT centres demonstrated that the system achieved high detection accuracy with minimal false alerts and improved monitoring efficiency compared to traditional human-based supervision methods.

The findings further revealed that the proposed system can significantly reduce invigilator workload, improve examination security, and enhance academic integrity within CBT environments. The lightweight architecture of the system also makes it suitable for deployment in institutions with limited technological infrastructure and unstable internet connectivity.

Although the system performed effectively under most testing conditions, certain environmental factors such as poor lighting conditions and camera positioning slightly affected detection performance. Future improvements may therefore focus on integrating deep learning techniques, multi-camera synchronization, and advanced behavioural prediction models to further improve detection accuracy and scalability.

Overall, this study demonstrates the practical relevance of AI-driven intelligent monitoring systems in modern

examination management and contributes to ongoing efforts toward improving the credibility, reliability, and security of computer-based examinations in tertiary institutions.

RECOMMENDATIONS AND FUTURE WORK

Based on the findings of this study, the following recommendations are proposed:

Educational institutions should consider adopting intelligent AI-based monitoring systems to strengthen the credibility and integrity of CBT examinations.

CBT centres should improve surveillance infrastructure and examination hall arrangements to support effective deployment of intelligent monitoring technologies.

Institutions should provide adequate technical training for examination administrators and ICT personnel responsible for managing intelligent invigilation systems.

Future research should explore the integration of deep learning and advanced behavioural analytics for improved suspicious activity prediction and reduced false alert rates.

Further studies may also investigate cloud-based and hybrid monitoring architectures capable of supporting large-scale national examinations.

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➤ Conflict of Interest

The Authors declared that there is no conflict of interest.

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