INTELLIGAZE AI: AN ADVANCED REAL-TIME MULTIMODAL SYSTEM FOR ADAPTIVE ATTENTION AND INTEGRITY MONITORING IN DIGITAL LEARNING ENVIRONMENTS USING INTEGRATED GAZE DYNAMICS, HEAD POSE ESTIMATION, AND CUSTOMIZABLE BIOMETRIC SCORING ALGORITHMS

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ABSTRACT

The shift towards online education has highlighted the need for effective student engagement monitoring. Unlike traditional classrooms, online environments often lack mechanisms to track attentiveness, resulting in increased instances of student inattention. IntelliGaze AI addresses this issue by integrating gaze tracking, head pose estimation, and a specialized attention scoring algorithm to quantify student engagement in real time. This paper outlines the development, implementation, and testing of IntelliGaze AI, emphasizing its unique contribution to digital education. The system's personalized scoring algorithm adapts to individual behavioral nuances, providing dynamic feedback on user attention. Initial testing demonstrates IntelliGaze AI's potential to offer non-intrusive, scalable, and accessible monitoring of student engagement.

1. INTRODUCTION

With the widespread adoption of online learning, ensuring student engagement has become a critical challenge. Traditional proctoring solutions, which rely on either human oversight or automated monitoring of singular behavioral aspects, often fail to capture the complexity of student behavior during online assessments. Most existing technologies lack real-time feedback mechanisms, individual adaptability, and a holistic approach to analyzing student engagement. IntelliGaze AI presents a novel solution by combining gaze tracking, head pose estimation, and an adaptive scoring algorithm to provide a nuanced and personalized assessment of student attention during online learning. By analyzing head movements, gaze direction, and hand positions, IntelliGaze AI not only detects potential cheating behaviors but also provides educators with an ongoing measure of student engagement. This paper outlines the development, implementation, and initial testing of IntelliGaze AI, showcasing its innovative approach to transforming the online learning experience.

2. METHODOLOGY

IntelliGaze AI employs advanced computer vision techniques, leveraging the capabilities of MediaPipe and OpenCV for real-time tracking and analysis of the student's movements. The methodology is designed to offer a dynamic scoring system that adapts to each student's unique behaviors, reducing false positives commonly associated with traditional proctoring methods. Head Pose Estimation: The system first identifies key facial landmarks, such as the nose tip, chin, and eyes, to estimate the head's orientation. By utilizing the Perspective-n-Point (PnP) problem-solving technique, the model calculates rotation angles (yaw, pitch, and roll) in real time. The inclusion of angular thresholds allows IntelliGaze AI to detect deviations from a "straight-ahead" posture, indicative of potential distractions or dishonest behavior. Unlike other systems that flag any movement as suspicious, IntelliGaze AI's thresholds are adaptable, taking into account individual movement patterns over time to distinguish between natural and abnormal behavior. Gaze Direction Analysis: IntelliGaze AI performs a detailed analysis of both eyes' landmarks to estimate the user's gaze direction. The average x-coordinates of the eye landmarks determine whether the user is looking straight, left, or right. By monitoring the gaze direction in tandem with head pose, the system creates a more complete picture of student attention, reducing false alerts due to natural movements such as reading or shifting focus on the screen. Hand Movement Tracking: The system further integrates hand landmark detection to identify hand movements that could indicate dishonest behavior, such as reaching for unauthorized devices or notes. This feature is a significant departure from many current solutions that overlook hand movements, thus providing a more comprehensive proctoring approach. Scoring Mechanism and Personalization: A core innovation of IntelliGaze AI is its dynamic scoring algorithm, which calculates an "engagement score" ranging from 0 to 100. Starting at a full score of 100, the system adjusts this score in real time based on detected behaviors. When the user maintains a straight gaze, the score gradually increases or remains stable, whereas deviations in head orientation, gaze direction, or suspicious hand movements cause the score to decrease. The score is averaged over 10-second intervals to capture a snapshot of engagement, accounting for natural variations in behavior. The system's adaptability sets it apart from existing tools. IntelliGaze AI dynamically adjusts its thresholds and feedback based on the user's unique facial structure, movement patterns, and interaction tendencies. This personalization reduces the likelihood of false positives and provides a more accurate assessment of student engagement.

3. RESULTS

Preliminary testing of IntelliGaze AI involved monitoring participants during controlled online learning sessions. The system recorded head movements, gaze direction, and hand movements while participants engaged with reading material. The resulting scores were averaged over 10-second intervals, providing a dynamic measure of engagement throughout the session. Engagement Scoring Accuracy: Initial findings indicate that IntelliGaze AI successfully captured nuanced behaviors. Participants who exhibited consistent focus, maintaining a straight gaze and steady

head posture, retained high engagement scores throughout the session. Conversely, participants who frequently looked away or moved their hands towards potential unauthorized materials exhibited lower scores, suggesting potential distractions or dishonest behavior. Personalized Feedback Mechanism: A unique strength of IntelliGaze AI is its individualized analysis. By tailoring its scoring mechanism to each participant's natural behavior, the system minimized false positives. For example, a participant with a natural tendency to glance sideways while thinking was not penalized excessively due to the system's adaptive thresholds. This level of customization distinguishes IntelliGaze AI from one-size-fits-all proctoring solutions, emphasizing its ability to deliver accurate, user-specific assessments. Multi-Modal Analysis: By integrating head pose estimation, gaze direction analysis, and hand tracking, IntelliGaze AI provided a multi-layered approach to engagement assessment. This integration reduced the likelihood of misclassification, as the system cross-referenced multiple behavioral indicators before adjusting the engagement score. IntelliGaze AI introduces several key innovations to the field of online proctoring and engagement monitoring. Unlike traditional systems that rely solely on static thresholds or focus on a single aspect of student behavior, IntelliGaze AI employs a multi-modal analysis framework. This approach enables the system to cross-check head pose, gaze direction, and hand movements, significantly enhancing detection accuracy. The adaptive scoring mechanism represents another novel contribution. By dynamically adjusting to the user's unique patterns, IntelliGaze AI provides a personalized measure of engagement, reducing the risk of false positives. This level of customization is rarely found in current proctoring solutions, which typically apply uniform criteria to all users. Furthermore, IntelliGaze AI's non-intrusive and accessible design distinguishes it from competitors. Operating solely with a standard webcam and leveraging open-source tools, the system is scalable and easy to implement in various educational settings. This accessibility democratizes advanced proctoring technology, extending its benefits to institutions with limited resources.

4. CONCLUSION

This paper presented IntelliGaze AI, a groundbreaking application for real-time engagement scoring and cheating detection in online education. By combining head pose estimation, gaze tracking, and a unique scoring algorithm, IntelliGaze AI offers a multi-modal, individualized approach to student monitoring. Preliminary testing shows its potential in accurately identifying student engagement, paving the way for future developments in digital education. Future work will focus on expanding the dataset, refining detection algorithms, and incorporating additional behavioral parameters to further enhance the system's capabilities.

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