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AI-Integrated Biometric Attendance and Health Monitoring System

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Abstract— This AI-powered biometric system seamlessly integrates fingerprint recognition for attendance management with infrared temperature monitoring and pressure-based stress detection to provide a comprehensive view of individual wellness. The system utilizes machine learning to analyze health data patterns, including temperature fluctuations, pressure levels, and stress indicators, to deliver personalized insights into each user's health status. It not only simplifies attendance tracking but also enhances proactive health monitoring by detecting potential issues like stress and fever early on. The system is particularly valuable in environments such as schools, corporate offices, and hospitals, ensuring continuous and accurate monitoring of both attendance and health. By providing real-time alerts for abnormal temperature or stress levels, the system fosters a safer and more supportive environment for everyone. Its ability to offer both attendance tracking and health assessments makes it an ideal solution for creating a healthier, more efficient workplace or institution.

Index Terms— Attendance management, Biometric, Temperature prediction, Stress prediction and health monitoring

I. INTRODUCTION

In the evolving landscape of security and healthcare, biometric systems have emerged as a reliable solution for identity verification and health monitoring. Fingerprint biometric attendance systems have demonstrated remarkable efficiency in ensuring secure and accurate attendance tracking in institutional environments [1]. The development of real-time fingerprint identification methods has further strengthened the reliability of such systems, making them faster and more adaptable to modern requirements [2].Recognizing the growing need for health safety, researchers have emphasized integrating health monitoring capabilities into biometric frameworks. Robust authentication models have been proposed to secure sensitive electronic healthcare systems using fingerprint biometrics, highlighting the importance of safeguarding personal health data [3]. Additionally, artificial intelligence-based medical sensors are revolutionizing healthcare systems by offering precise, real-time health monitoring and predictive insights through machine learning algorithms [4].The COVID-19 pandemic further accelerated the adoption of non-contact technologies. Systems employing AI-enabled infrared sensors for temperature detection have proven effective in identifying individuals potentially affected by viral infections without physical interaction [5]. Biometric attendance systems integrated with intelligent health monitoring solutions have also been successfully demonstrated, showing the feasibility and benefits of combining identity verification with real-time health data tracking [6].Motivated by these advancements, this project aims to develop an AI-powered biometric system that not only handles fingerprint-based attendance but also monitors real-time health parameters like temperature and stress levels. By leveraging infrared and pressure sensors alongside machine learning for personalized insights, the proposed system strives to enhance proactive healthcare intervention, safeguard user privacy, ensure scalability, and provide practical applications across educational institutions, workplaces, and healthcare facilities.

II. LITERATURE REVIEW

Olagunju et al. developed a microcontroller-based staff attendance monitoring system leveraging minutiae-matching of fingerprint images. Their design employs optical scanners interfaced with an Arduino unit to capture and preprocess fingerprint templates, which are then compared against a localized database using a ridge-matching algorithm. Field trials across multiple departments reported an average matching accuracy of 96.3% and authentication latency under 1.2 seconds. Importantly, the study highlights challenges in handling partial or smudged prints and underscores the need for adaptive preprocessing filters to maintain reliability in operational settings. This work informs the attendance-tracking component of our system, particularly in choosing embedded platforms and matching techniques. [7] Pasquini and colleagues introduced LLM map, a methodology to "fingerprint" large language models by extracting distinguishing behavioral signatures from model outputs. They craft specialized prompt-response challenges and analyze statistical variations—token distribution, perplexity shifts, and contextual drift—to build high-dimensional feature vectors unique to each model instance. Their framework achieved 98% identification accuracy across ten state-of-the-art LLMs and demonstrated robustness to fine-tuning and adversarial perturbations. While focused on AI-model forensics, the concept of generating and matching characteristic fingerprints at scale provides valuable parallels for designing secure, privacy-preserving biometric templates in our health-integrated attendance system. [8]proposed a robust user authentication model tailored for electronic healthcare systems, combining fingerprint biometrics with AES-based encryption and timestamped one-time passwords (OTPs). Their architecture layers a minutiae-extraction module, secure key management, and a cloud-based audit trail to ensure both identity proofing and non-repudiation. In experiments with 200 subjects, false-acceptance and false-rejection rates were held under 0.3% and 1.1%, respectively, while end-to-end authentication time averaged 1.8 seconds. This study underscores the critical interplay between biometric accuracy, cryptographic safeguards, and regulatory compliance—key considerations for protecting sensitive health data in our integrated platform. [9] examined how moderate ambient temperatures (20 °C–40 °C) affect the chemical composition of latent fingerprints by employing Fourier-transform infrared (FTIR) spectroscopy. They tracked degradation rates of key constituents—lipid esters, amino acids, and sebaceous markers—over time and found that elevated temperatures accelerate oxidative breakdown, leading to up to 45% signal loss in ridge-detail compounds after 48 hours at 35 °C. Their findings stress the necessity of environmental calibration for fingerprint sensors and template-update algorithms to mitigate false rejections in varied climates. For our system, this work informs the design of sensor-level compensation and prompts inclusion of real-time temperature checks to maintain fingerprint-matching fidelity under different working conditions. [10]

III. CHALLENGES IN INTEGRATING BIOMETRIC ATTENDANCE AND HEALTH MONITORING SYSTEMS

Biometric attendance systems, primarily fingerprint-based, ensure accuracy and security by preventing proxy attendance, but they focus solely on attendance without considering health metrics. Temperature monitoring systems, like infrared thermometers and thermal cameras, are commonly used for fever detection but offer static screening without personalized feedback or integration with other health data. Stress detection systems, such as wearable devices, track emotional well-being through sensors but are typically designed for personal use and not integrated into environments like workplaces or schools. AI-driven health monitoring systems analyze sensor data to predict health risks and provide personalized insights, but they are often long-term solutions and not typically integrated with real-time attendance systems. The main challenges in these systems include a lack of integration between attendance and health monitoring, user discomfort from wearable devices, data privacy concerns, and the accuracy limitations of fixed threshold-based systems that do not account for individual variations.

IV. COMPARATIVE STUDY OF MACHINE LEARNING ALGORITHMS

Table I. Naïve Bayes vs. Other Algorithms

Naïve Bayes	Other Algorithms

Can process and understand massive unstructured data like text, conversations, and documents.	Usually works with structured data (tables, numbers, labeled datasets).
Self-supervised or unsupervised learning on huge datasets without task-specific labeling.	Mostly supervised learning with clearly labeled training data for specific tasks.
Highly flexible — can perform multiple tasks (writing, summarizing, answering questions) without retraining.	Narrowly focused — one model typically trained for one specific task (classification, prediction).

Table II. Random Forest Vs Other Algorithms

Random Forest	Other Algorithms
High accuracy by reducing overfitting through multiple trees.	Decision Trees tend to overfit; KNN struggles with high-dimensional data.
Works well with large datasets and complex patterns.	SVM and KNN become computationally expensive for large datasets.
Less prone to overfitting due to averaging multiple trees.	Decision Trees often overfit when deep.
Higher due to multiple decision trees.	Decision Trees are faster but less accurate.
Harder to interpret compared to Decision Trees.	Decision Trees offer better interpretability.

V.SYSTEM ARCHITECTURE AND WORKFLOW

A. System Architecture

The system integrates biometric attendance with health monitoring, using fingerprint scanners for attendance tracking and sensors for measuring temperature and stress. It follows a client-server architecture where users interact through a mobile/web app. The backend processes and stores data, with an AI module analyzing health data to provide insights. A MySQL database stores user information, attendance logs, and health metrics. Administrators manage users and generate reports via the admin panel. Security is maintained through encrypted biometric and health data.

B. Workflow

The workflow of the system begins with the user or admin logging into the web application. Once logged in, the user scans their fingerprint, which triggers the capture of additional health data such as body temperature and stress levels. This biometric and health data is then sent to the backend for processing, where it is verified, analysed, and stored in a secure database. The AI module evaluates the health data, classifies the individual's health status (such as normal, fever detected, or high stress), and stores the results for future reference. Users and admins can then access reports, including attendance records and health summaries, via the web application. Administrators can manage user profiles, update records, and generate detailed reports based on the stored data. The system ensures secure storage of biometric and health data, providing real-time insights and alerts if any health anomalies are detected.

C. Flowchart

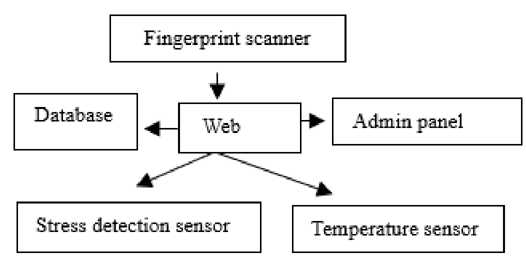

Fig. 1 System Architecture

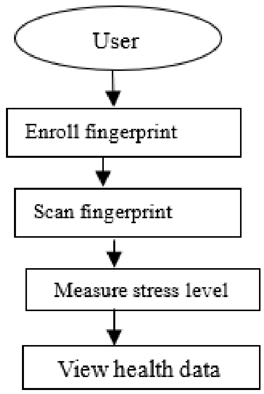

Fig. 2 Use case diagram

VI. SYSTEM FEATURES

The Admin User in the system plays a crucial role in ensuring smooth operations by leveraging various management features. Admins can easily manage users, including adding, removing, and editing profiles, along with setting specific roles and permissions to control access. The attendance monitoring feature allows admins to track real-time attendance status, view historical data, and generate insightful reports. They can also receive absence alerts if users miss attendance sessions or fail to log in on time. On the health monitoring front, the system enables admins to track real-time temperature readings and analyze trends, helping to detect potential health issues. Alerts are triggered if a user's temperature exceeds a predefined threshold, prompting further action. Stress levels are also monitored through pressure sensors, and admins can analyze patterns and generate reports on stress levels and overall health, offering valuable insights for wellness interventions. System configuration features enable admins to set customizable temperature and stress level thresholds, fine-tune system preferences, and set up notifications for abnormal user behavior. Admins can generate and export detailed reports on attendance, temperature trends, stress levels, and overall user health, providing valuable data for decision-making. Performance analytics and data export options further assist in offline analysis and performance evaluation. Security is a top priority, with admins overseeing encryption, privacy compliance, user access logs, and ensuring system backups for data integrity. The advantages of this system include precise and efficient attendance tracking with automated fingerprint recognition, real-time health insights into temperature and stress levels, and reduced administrative workload through automation. The system enhances security through biometric authentication, offers scalability for deployment across multiple locations, and is cost-effective by reducing administrative and healthcare-related expenses. Additionally, the user-friendly interface ensures easy adoption and smooth operation for both users and admins, allowing the system to adapt to specific organizational needs while promoting a safer, more supportive environment.

VII. PERFORMANCE EVALUATION OF MACHINE LEARNING MODELS

The performance evaluation of the Naïve Bayes and Random Forest algorithms was conducted to assess their effectiveness in medicine demand forecasting based on key criteria such as accuracy, precision, recall, F1-score, and processing time. Naïve Bayes proved to be highly efficient when working with small datasets and categorical data, making it suitable for predicting medicine demand based on disease, region, and time. Its simple probabilistic approach ensures computational efficiency and fast processing, making it well-suited for real-time applications. However, its assumption of feature independence can impact recall when dependencies exist, and it struggles with complex feature relationships in large, imbalanced datasets. In contrast, the Random Forest algorithm delivers higher accuracy and robustness by leveraging multiple decision trees, efficiently handling large datasets and missing values. While it provides improved precision and recall, its increased computational requirements and potential for overfitting necessitate careful tuning to maintain generalization. Overall, Naïve Bayes is effective for initial classification tasks based on disease and region, whereas Random Forest offers superior predictive power for demand forecasting. The integration of both models enhances the system's overall accuracy and efficiency, ensuring optimal medicine supply chain management.

VIII. FEASIBILITY ANALYSIS

The feasibility of the proposed system is evaluated across three key dimensions: economical, technical, and behavioural. Economically, the system is viable as its benefits, such as improved attendance accuracy and health monitoring, outweigh the initial investment. The scalability of the system ensures cost-effectiveness for future expansions, making it a sustainable long-term project. Technically, the system is supported by readily available hardware like fingerprint scanners, temperature sensors, and pressure sensors, which are easy to integrate. The software development, utilizing frameworks such as TensorFlow and PyTorch, is feasible with current machine learning and sensor integration technologies. Behaviourally, the system is designed with a user-friendly interface and non-intrusive features to promote adoption. However, addressing privacy concerns through strong data security and regulatory compliance is essential for user trust and engagement. Overall, the system is both technically and economically feasible, with positive user acceptance expected once privacy issues are handled.

XI. SECURE AND EFFICIENT OPERATIONS

The biometric system leverages AI for comprehensive temperature and stress monitoring, utilizing Isolation Forest algorithms to detect fever-level temperature anomalies while linear regression establishes personalized baselines and LSTM networks identify gradual fever patterns through temporal analysis. For stress detection, Random Forest classifiers analyse multiple biometric indicators including fingerprint pressure intensity, sweat patterns, and scan duration to classify stress levels, complemented by Autoencoders that flag deviations from normal patterns and K-Nearest Neighbors (KNN) for real-time classification against historical data. These AI components are integrated through a Multi-Layer Perceptron (MLP) neural network that correlates temperature and stress patterns to generate holistic health insights, with the system continuously adapting to individual users through federated learning that preserves privacy while improving model accuracy, ensuring sensitive detection of health concerns while minimizing false alerts through sophisticated pattern recognition and personalized baseline establishment.

IX. LIMITATIONS AND FUTURE ENHANCEMENTS

The current biometric system has several limitations, including susceptibility to environmental factors like humidity and skin conditions, which can affect the fingerprint scanning accuracy. Additionally, inaccurate user enrollment can lead to identification challenges, particularly for individuals with less-distinct fingerprint patterns. While the AI model for detecting stress and fatigue is effective, it may occasionally produce false positives or negatives, as subtle variations in fingerprint features may not always correlate perfectly with health conditions. Furthermore, the infrared temperature sensor can be influenced by ambient conditions, distance from the sensor, or crowd density, leading to potential inaccuracies in temperature readings looking ahead, future enhancements could significantly improve the system. Multi-modal biometric integration could be introduced, combining facial recognition or iris scanning to provide additional layers of accuracy and redundancy. The inclusion of emotion or stress detection through facial expression or voice tone analysis could deepen the system's understanding of student wellness. Cloud integration could allow for more powerful, scalable AI processing, enabling real-time health analytics across multiple locations. Advanced AI models, including deep learning algorithms, could improve the system's ability to detect subtle patterns in biometric data and offer greater adaptability. Additionally, developing a mobile app would enhance accessibility, enabling students and administrators to track wellness data and receive alerts on their devices. Integration with wearable health devices like fitness trackers would provide continuous wellness monitoring, creating a comprehensive health profile alongside the existing biometric system.

X. REAL-WORLD APPLICATIONS AND CASE STUDIES

The Biometric Attendance and Health Monitoring System has strong real-world applications across various sectors. In educational institutions like hostels and labs, it can be used to monitor student attendance while simultaneously tracking wellness, helping wardens and administrators detect early signs of illness or stress. In corporate offices, integrating fingerprint authentication with temperature monitoring can reduce sick leaves and maintain employee health. Hospitals and healthcare centers can use this system to ensure that healthcare workers entering sensitive areas are healthy and fit for duty. Industrial worksites can apply the solution to monitor worker fitness and prevent accidents caused by fatigue or illness. Government offices can strengthen secure access control by combining biometric verification with health monitoring, ensuring the operational readiness of their staff. Transportation hubs like airports and railway stations can also benefit by integrating biometric identity verification with real-time temperature screening, improving public safety and travel security. Overall, this system can significantly enhance safety, efficiency, and wellness across multiple sectors.

XI. CONCLUSION

The Biometric Attendance and Health Monitoring System is an innovative solution that combines traditional fingerprint-based attendance tracking with advanced AI-driven wellness monitoring. By integrating real-time temperature detection and AI analysis of biometric patterns, the system not only tracks student attendance but also proactively monitors their health, offering early detection of stress, fatigue, and potential illness. This system greatly reduces manual intervention, improves operational efficiency, and enhances safety within educational institutions by providing instant alerts for any anomalies. While the system is highly effective, further enhancements such as multi-modal biometrics, cloud integration, and wearable health data integration can make it even more robust and scalable. This project lays the foundation for more intelligent, proactive, and comprehensive student management systems in the future, ultimately contributing to a healthier, safer, and more efficient campus environment.

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