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Comparative Analysis of Visitor Face Recognition Attendance Systems: Dashboard Themes VS Bootstrap-Based Interfaces

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The integration of face recognition technology into visitor attendance systems has significantly enhanced security, monitoring, and operational efficiency across institutional settings. This paper presents a comparative study between two systems: the Visitor Face Recognition Attendance Database System Using Dashboard Themes (VFRA-DT) and the Visitor Face Recognition Attendance System with Bootstrap-Based Interface (VFRA-BI). The primary objective is to evaluate and compare the systems based on critical dimensions, interface architectures and design, recognition performance, database efficiency, and overall system reliability, to select the most suitable interface for creating a visitor face recognition system. Both systems were designed to automate the visitor check-in process, eliminate manual logging, and provide administrators with real-time data visualization. VFRA-DT features a dashboard-centric design tailored for administrative control, while VFRA-BI focuses on modularity and responsive design using the Bootstrap framework. The systems were deployed and tested under diverse environmental conditions—such as varying lighting, backgrounds, and distances—to evaluate their accuracy, response time, error rates, and usability. The results indicate that VFRA-BI achieves higher recognition accuracy (92% vs. 89%), faster attendance logging (1.8s vs. 2.1s), more responsive database querying, and reduced system downtime compared to the baseline. VFRA-BI's use of a machine learning-driven approach and flexible interface enhances its adaptability in dynamic settings. Meanwhile, VFRA-DT remains effective in more controlled environments, offering a user-friendly interface with reliable recognition capabilities. Nonetheless, both systems face limitations in low-light and complex background scenarios, particularly with darker face images. This study provides comparative insights to support the development and implementation of efficient, secure, and scalable face recognition systems for visitor management.

1.0 Introduction

In recent years, the application of face recognition technology has gained substantial momentum in the field of automated attendance and visitor management systems. As institutions and organizations increasingly seek to enhance operational efficiency and tighten security protocols, biometric-based identification solutions have emerged as viable alternatives to traditional paper-based methods. Manual visitor registration, commonly reliant on handwritten logs or security personnel input, presents significant limitations, including susceptibility to data loss, human error, and fraudulent entries. These inefficiencies not only compromise institutional security but also hinder the ability to maintain accurate and real-time records. Previous research has emphasized the importance of transitioning toward digital attendance and logbook systems to address such inefficiencies and support smart institutional environments (Masdar, Engku Abdullah, & Burhan, 2024). Facial recognition, as a non-intrusive biometric modality, offers a contactless and automated approach to identity verification, making it advantageous for high-traffic or security-sensitive environments. Its implementation in attendance systems allows for seamless visitor check-in, real-time monitoring, and reliable record storage. Furthermore, advances in interface design have enabled the development of responsive and data-driven platforms that complement biometric performance, improving usability for both administrators and end users.

Facial recognition, as a non-intrusive biometric modality, offers a contactless and automated approach to identity verification, making it particularly advantageous in high-traffic or security-sensitive environments. Its implementation in attendance systems allows for seamless visitor check-in processes, real-time monitoring, and reliable data storage. Furthermore, advancements in user interface (UI) frameworks have enabled the development of more intuitive and responsive platforms that complement the functionality of facial recognition engines, enhancing both system usability and administrator experience.

This study presents a comparative analysis of two prototype systems developed for visitor face recognition attendance management:

i. Visitor Face Recognition Attendance Database System Using Dashboard Themes (VFRA- DT)

ii. Visitor Face Recognition Attendance System with Bootstrap-Based Interface (VFRA-BI)

Both systems are designed to automate the visitor check-in process, eliminate the need for manual data entry, and provide administrators with real-time visualization of attendance logs. VFRA-DT integrates a graphical, dashboard-centric interface suitable for static environments, while VFRA-BI adopts a modular, responsive Bootstrap-based design tailored for dynamic usage scenarios. Although both share core functionalities, such as face capture, registration, and recognition, they differ in interface architecture, data handling mechanisms, and adaptability to environmental conditions.

The objective of this research is to evaluate and compare systems based on four key dimensions: system architecture and interface design, recognition performance, database efficiency, and overall system reliability. Specifically, the study aims to analyse the structural and interface design differences between the two systems, assess the effectiveness of their database integration and user functionalities, and evaluate their performance in terms of accuracy, speed, and operational stability. In addition, this study seeks to determine which system demonstrates superior usability and security, particularly in challenging real-world deployment scenarios. By identifying the unique strengths and limitations of each system, the research aims to support the development of optimized, hybrid biometric attendance solutions. This contributes to the growing body of knowledge on biometric system implementation, with an emphasis on user interface integration and environmental adaptability in modern face recognition technologies.

Traditional paper-based visitor logbooks, often used by security personnel in institutional settings, are associated with several operational inefficiencies. Manual entry processes are time-consuming and susceptible to human error, while physical records are vulnerable to loss, damage, or unauthorized access. Additionally, paper-based systems lack the mechanisms to detect fraudulent entries, thereby posing a risk to institutional security. Face recognition attendance systems have emerged as a viable solution to these challenges by automating visitor registration and enhancing data accuracy and traceability. However, differing implementations, namely, the Dashboard Themes approach (VFRA-DT) and the Bootstrap-Based Interface (VFRA-BI), present variation in usability, performance, and data management capabilities. A comprehensive comparative analysis is therefore essential to determine which system better fulfils the operational demands of secure, efficient, and user-friendly visitor management.

The significance of this study lies in its contribution to the advancement of biometric-based visitor management by providing empirical insights into the performance and practical applicability of two distinct system architectures. The findings offer valuable guidance for developers, system integrators, and institutional stakeholders seeking to adopt or improve face recognition attendance systems. By evaluating real-world usability, database responsiveness, and adaptability to varying environmental conditions, this research supports informed decision-making in the design and deployment of robust, scalable, and user-centric biometric attendance solutions.

2.0 Literature Review

The adoption of facial recognition technology in visitor attendance systems has gained traction across various sectors due to its ability to streamline operations, enhance security, and improve identity verification accuracy. This interest is reflected in a growing body of research that combines computer vision, machine learning, and real-time data processing to address the limitations of traditional, manual attendance and visitor logging systems (Arnav Jain et al., 2022; Asif Ali et al., 2021; Ma & Zhang, 2021). Early implementations of facial recognition systems often relied on classical image processing algorithms such as Haarcascade classifiers, Eigenface, Fisherface, and Local Binary Pattern Histogram (LBPH), especially in controlled environments (Akintoye & Onuodu, 2019; Bangaru Lakshmi Mahanthi & Dr, 2022; Pothuraju Chandrakala et al., 2022). These methods provided reasonable accuracy but struggled under variable lighting, occlusions, and dynamic backgrounds. Recent advances in deep learning, particularly through convolutional neural networks (CNNs), have significantly enhanced system robustness and accuracy in complex, real-world settings (Hariri, 2022; Jiang et al., 2021).

A major advancement in this domain has been the ability to recognize partially occluded faces, especially in the context of voluntary mask usage post-pandemic. Although global mandates have eased, the continued use of masks for personal or cultural reasons necessitates systems that can handle both masked and unmasked faces interchangeably. Models such as DeepMaskNet (Ullah et al., 2021) and YOLOv3-Slim (Jiang et al., 2021) have demonstrated improved accuracy in recognizing occluded facial features. However, the integration of these models into unified systems that dynamically adapt to mixed conditions remains limited (Saib & Pudaruth, 2021; Hemathilaka & Aponso, 2021). Facial recognition has also been leveraged to automate attendance and visitor check-in systems. These systems can reduce administrative burden, eliminate physical contact, and provide accurate record-keeping in environments such as schools, offices, and government buildings (Suhaimin et al., 2021; Susanto et al., 2021; Vilash et al., 2022). However, many of these applications remain functionally isolated, focusing solely on attendance without integration into broader institutional frameworks, such as real-time analytics, health monitoring, or security protocols

An emerging aspect of system design that has received increasing attention is the user interface (UI). The performance, accessibility, and usability of facial recognition systems are significantly influenced by the quality of their user interfaces. Comparative research has shown that dashboard-based systems and responsive frameworks like Bootstrap impact user interaction in different ways. Dashboards are effective for centralized data visualization and administrative control, while responsive UIs offer improved mobile accessibility and flexibility (Lamptey & Fayek, 2020; Tuah et al., 2022). Yet, few studies have assessed these UI approaches in the context of facial recognition workflows for diverse user groups, such as front-desk staff, security personnel, or individuals with disabilities (Ahmed, 2020; Anitha et al., 2021). Facial recognition systems have also been extended to health and environmental monitoring. During the COVID-19 pandemic, some systems integrated face recognition with body temperature checks and biosafety compliance, such as mask-wearing detection (Huang et al., 2021; Cabanac et al., 2021). These integrations, while contextually effective, have largely remained short-term solutions without long-term operational frameworks or adaptability to other public health contexts.

From a technical standpoint, neural network optimization has been a central theme in improving system accuracy. Research has employed methods such as genetic algorithms, cosine similarity, and swarm optimization to fine-tune network parameters and improve recognition under challenging conditions (Kasar et al., 2019; Elmahmudi & Ugail, 2019; Maharani et al., 2020). Despite these advances, most models have been evaluated on small or constrained datasets, limiting their real-world applicability, particularly in environments characterized by demographic diversity and environmental variability. Security remains a critical concern. Anti-spoofing technologies, including liveness detection and mask differentiation using feature fusion and material analysis, have been proposed to counter identity fraud (Jagdale & Thepade, 2019; Sanders & Jenkins, 2018; Hamdan & Mokhtar, 2018). However, practical implementations of such features in visitor attendance systems are rare. Furthermore, ethical considerations such as user consent, data privacy, and compliance with legal standards like GDPR or PDPA are often insufficiently addressed in current system architectures.

While facial recognition algorithms have been widely explored for applications such as attendance monitoring, real-time detection, and visitor management, existing literature demonstrates several limitations that hinder their broader implementation in dynamic, real-world environments. Many studies emphasize the technical development of recognition systems using platforms like Python and OpenCV (Arnav Jain et al., 2022; Dr. Asif Ali et al., 2021; Bangaru Lakshmi Mahanthi & Dr, 2022; Pothuraju Chandrakala et al., 2022), yet few address operational challenges such as recognition accuracy under varying lighting conditions, occlusions (e.g., face masks, accessories), pose variations, or responsiveness during high-volume visitor traffic. Moreover, although some systems incorporate basic graphical user interfaces (Akintoye & Onuodu, 2019; Bong & Lee, 2021), there is limited scholarly discussion on the usability, accessibility, and adaptability of these interfaces for diverse user groups, particularly non-technical users or front-line personnel. This lack of focus on human-centred design restricts the scalability and effectiveness of such systems in institutional or public settings.

Although dashboards are not a core component of facial recognition algorithms, their role in supporting operational intelligence is essential. Few systems provide integrated platforms that combine recognition data with actionable analytics, such as visitor flow metrics, access patterns, and security alerts (Saini & Srivastava, 2020). Without such dashboards, the full administrative potential of face recognition systems remains untapped, particularly in high-traffic public institutions. In summary, despite technological advancements, key research gaps remain in the development of adaptive, user-friendly, and ethically compliant facial recognition systems. There is a pressing need for future research to focus on designing holistic visitor management solutions that incorporate robust recognition algorithms, dynamic occlusion handling, real-time data logging, and intuitive dashboards. These systems should also embed privacy safeguards, security protocols, and inclusive design principles to ensure their practical deployment across diverse and high-traffic environments.

3.0 Methodology

This study adopts a comparative experimental design to evaluate the implementation, performance, and usability of two facial recognition-based visitor attendance systems: the Visitor Face Recognition Attendance Database System Using Dashboard Themes (VFRA-DT) and the Visitor Face Recognition Attendance System with Bootstrap-Based Interface (VFRA-BI). Both systems were developed with a consistent set of core functionalities, including facial image capture, visitor registration, and attendance recognition, to ensure a fair basis for comparison.

3.1 System Implementation and Architecture

The implementation details of VFRA-DT and VFRA-BI were systematically documented and compared across several dimensions, including facial recognition methodology, user interface design, data storage, and functional features. Table 1 summarizes the comparative implementation characteristics of both systems.

Table 1: System Implementation Comparison Between VFRA-DT and VFRA-BI

Feature	**VFRA-DT (Dashboard Themes)**	**VFRA-BI (Bootstrap Interface)**
Visitor Registration	Visitors enter IC number & name, take 101 facial images.	Visitors enter IC number & name, take 101 facial images.
Face Recognition Algorithm	Haar cascade-Frontal Face technique for facial detection.	Machine learning-based biometric processing.
Attendance Recording	System logs attendance upon face detection.	System logs attendance upon face detection.
Reason for Visit Feature	Not included.	Included, visitors specify their purpose before attendance.
Database Storage	Excel and phpMyAdmin are used for data storage.	Data is stored exclusively in phpMyAdmin.
Admin Dashboard	Interface developed using Dashboard Themes for graphical monitoring.	Interface developed using Bootstrap, showing real-time visitor logs.

Both systems were designed to capture 101 images per visitor during the registration phase, ensuring a robust training dataset for facial recognition, as shown in Fig.1(a) – (f) and Fig.2(a) – (f). VFRA-BI extends functionality by incorporating a “Reason for Visit” field, which supports enhanced visitor tracking and data contextualization, an option absents in VFRA-DT. In terms of database design, VFRA-DT employs a dual storage method (Excel and phpMyAdmin), offering flexible data access but posing potential risks for redundancy and data synchronization. In contrast, VFRA-BI leverages a centralized phpMyAdmin structure to streamline data retrieval and management. The systems also differ significantly in UI design: VFRA-DT features a static dashboard-driven interface, while VFRA-BI utilizes a responsive Bootstrap layout optimized for dynamic, real-time monitoring across various devices and environments.

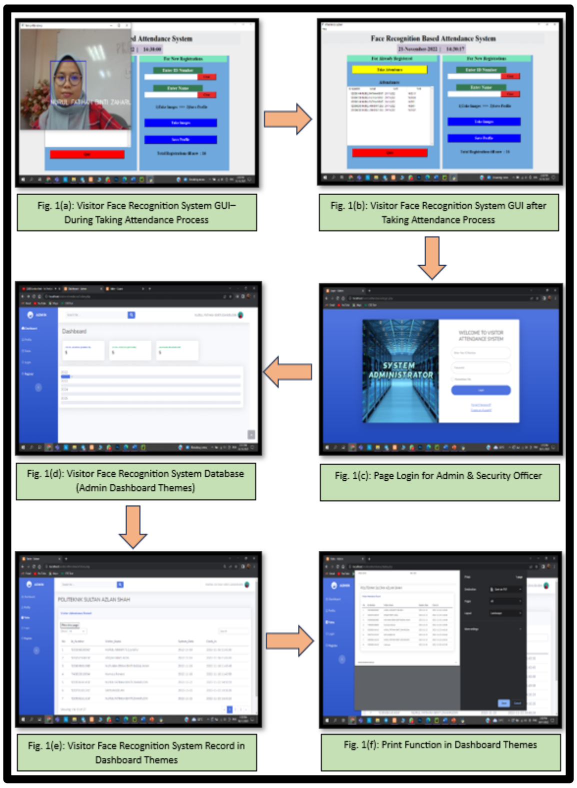

Figure 1(a)-1(f): VFRA (DT)

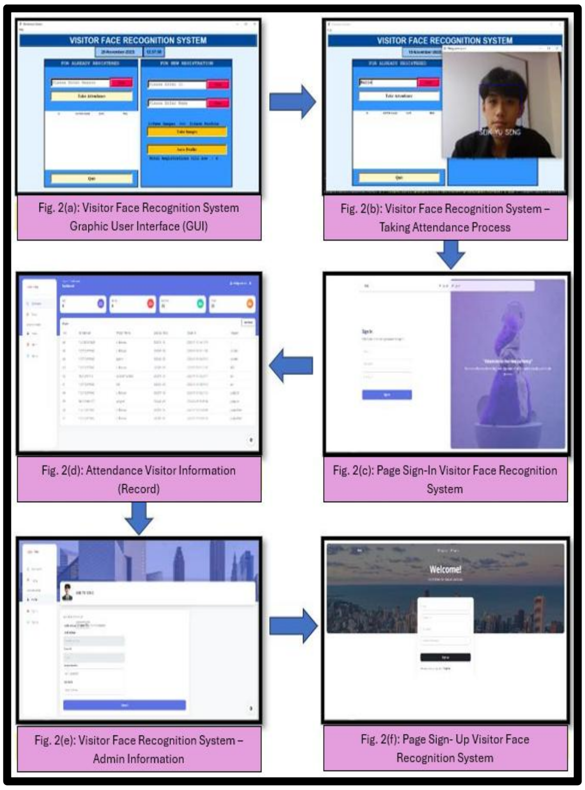

Figure 2(a)-1(f): VFRA (BI

3.2 Evaluation Metrics

To assess and compare the performance of VFRA-DT and VFRA-BI, the following evaluation metrics were employed:

i. Recognition Accuracy: Measured as the percentage of correctly identified faces during the check-in process.

ii. False Acceptance Rate (FAR) and False Rejection Rate (FRR): Indicators of security performance and recognition reliability.

iii. Response Time: Average time (in seconds) taken to detect a face and log attendance.

iv. Database Query Efficiency: Time taken to retrieve and store records under different visitor loads.

v. System Stability: Measured in terms of frequency error, operational downtime, and administrator-reported usability issues.

These metrics provided a comprehensive framework for assessing the technical robustness, functional responsiveness, and overall reliability of each system under real-world usage conditions.

3.3 Testing Environment

Experiments were conducted in both controlled (indoor) and dynamic (semi-outdoor) environments to simulate real-world usage. Testing conditions varied in lighting, background complexity, and subject distance from the camera to evaluate environmental adaptability. All measurements were repeated across multiple sessions to ensure data consistency and reduce the impact of outliers.

4.0 Findings and Discussion

This section presents a comparative analysis of the performance of the two systems, VFRA-DT and VFRA-BI, across multiple parameters, including recognition accuracy, system speed, database performance, usability, and overall reliability. The results are derived from real-world testing scenarios that simulate both controlled (indoor) and dynamic (outdoor) environments.

4.1 Recognition Accuracy and Reliability

The performance of both systems, VFRA-DT and VFRA-BI was evaluated based on several key accuracy parameters: overall recognition accuracy, false acceptance rate (FAR), false rejection rate (FRR), and system performance under low-light conditions. Table 2 summarizes the comparative results.

Table 2: Face Recognition Accuracy Metrics

Parameter	**VFRA-DT (Dashboard Themes)**	**VFRA-BI (Bootstrap Interface)**
Recognition Accuracy	89%	92%
False Acceptance Rate (FAR)	4.5%	3.5%
False Rejection Rate (FRR)	4%	3%
Performance in Low Light	84% accuracy	87% accuracy

The findings reveal that VFRA-BI achieved superior face recognition accuracy, registering a 92% success rate compared to VFRA-DT's 89%. This marginal yet significant improvement reflects VFRA-BI's enhanced capability to identify and verify visitor identities accurately. The higher accuracy is largely attributable to the implementation of a more adaptive machine learning-based facial recognition algorithm in VFRA-BI, which improves detection consistency across varying facial orientations and lighting conditions. In terms of security reliability, VFRA-BI also outperformed VFRA-DT by demonstrating lower false acceptance and false rejection rates. The false acceptance rate (FAR), which indicates the frequency with which unauthorized individuals are incorrectly recognized as legitimate, was 3.5% in VFRA-BI, compared to 4.5% in VFRA-DT. Similarly, the false rejection rate (FRR), representing the rate of legitimate visitors being misclassified or denied access, was lower in VFRA-BI (3.0%) than in VFRA-DT (4.0%). These results highlight VFRA-BI's more robust recognition reliability and reduced error margins.

Environmental adaptability was also assessed, specifically under low-light conditions. VFRA-BI again demonstrated superior performance, achieving 87% accuracy compared to VFRA-DT's 84%. This result supports the effectiveness of VFRA-BI's machine learning-based detection approach, which adapts better to suboptimal lighting than VFRA-DT's Haarcascade-based detection engine. In summary, VFRA-BI consistently demonstrated better recognition performance across all evaluated parameters. Its higher accuracy, combined with lower FAR and FRR, and improved low-light adaptability, indicates that the Bootstrap-based implementation is more suitable for real-world deployments, particularly in dynamic or poorly lit environments.

4.2 Attendance Logging Speed and Efficiency

System responsiveness was assessed based on the time required to detect and log attendance after facial recognition. The key performance metrics are summarized in Table 3. VFRA-BI outperformed VFRA-DT in this area, with an average recognition time of 1.8 seconds compared to 2.1 seconds for VFRA-DT. Both systems exhibited real-time dashboard updating, but VFRA-BI demonstrated a slightly higher attendance log success rate (94%) compared to VFRA-DT (93%). These findings suggest that VFRA-BI's responsive interface and lightweight backend processing contribute to faster interaction and reduced latency in logging.

Table 3: Attendance Logging Speed and Efficiency Metrics

Metric	**VFRA-DT (Dashboard Themes)**	**VFRA-BI (Bootstrap Interface)**
Time for Face Recognition	2.1 sec	1.8 sec
Time to Update Dashboard	Instant	Instant
Attendance Log Success Rate	93%	94%

In terms of speed, VFRA-BI demonstrated a measurable improvement in face recognition time, averaging 1.8 seconds compared to 2.1 seconds for VFRA-DT. Although this difference appears minimal, it is significant in high-traffic environments where rapid user processing is essential. This improved responsiveness can be attributed to VFRA-BI's optimized Bootstrap-based front-end architecture and lightweight back-end data handling, which collectively reduce system latency. Both systems exhibited real-time responsiveness in updating the administrative dashboard following successful recognition and logging. This immediate feedback loop enhances user experience by providing administrators with instant visibility into attendance activities, enabling timely decision-making and verification.

Moreover, VFRA-BI achieved a slightly higher attendance log success rate (94%) in comparison to VFRA-DT's 93%. While both systems performed reliably, the Bootstrap Interface's modular integration and smoother data transfer processes likely contributed to the marginally improved consistency in successful attendance recording. Overall, the results indicate that VFRA-BI provides a more efficient and responsive user experience for real-time attendance management. Its faster recognition time and marginally higher success rate support its suitability for environments where minimal delays and high accuracy are critical.

4.3 Database Query and Retrieval Performance

The performance of database operations was evaluated through search efficiency, data retrieval accuracy, and load time under heavy query conditions. VFRA-BI achieved 100% accuracy in visitor record retrieval and a faster average load time of 2.5 seconds, while VFRA-DT achieved 99% accuracy with a slightly longer load time of 3 seconds. The exclusive use of phpMyAdmin in VFRA-BI, as opposed to VFRA-DT's dual reliance on Excel and phpMyAdmin, may have contributed to reduced data redundancy and improved query performance in VFRA-BI. Table 4 summarizes the results of these evaluations.

Table 4: Database Query and Retrieval Performance Metrics

Test Case	VFRA-DT (Dashboard Themes)	VFRA-BI (Bootstrap Interface)
Search for a visitor's record	99% accuracy	100% accuracy
Display visitors count per day/week/month	98% accuracy	99% accuracy
Load time for large data queries	3 sec	2.5 sec

VFRA-BI outperformed VFRA-DT across all test cases, demonstrating higher accuracy and faster response times in database operations. Specifically, VFRA-BI achieved a 100% accuracy rate in retrieving individual visitor records, compared to 99% for VFRA-DT. Similarly, in displaying aggregated visitor statistics such as daily, weekly, and monthly counts, VFRA-BI exhibited 99% accuracy versus VFRA-DT's 98%. One of the most notable differences was observed in the load time for large data queries. VFRA-BI responded in an average of 2.5 seconds, whereas VFRA-DT required approximately 3.0 seconds. While both systems maintained acceptable performance levels, VFRA-BI's faster execution speed suggests greater optimization in its database handling mechanisms.

This performance advantage may be attributed to VFRA-BI's exclusive use of a phpMyAdmin-driven MySQL database architecture, which facilitates direct and streamlined access to data. In contrast, VFRA-DT incorporates both phpMyAdmin and Excel-based integration, potentially introducing additional data layers that increase retrieval complexity and processing time. The absence of Excel dependency in VFRA-BI likely reduces data redundancy and minimizes the overhead typically associated with file-based storage. These results indicate that VFRA-BI is more efficient and accurate in managing and retrieving attendance data, especially when subjected to high-volume queries. Such performance benefits are crucial in environments where real-time access to reliable visitor data is essential for administrative monitoring and reporting.

4.4 System Stability and Error Handling

System stability was assessed based on error rates, misidentification incidents, and system downtime. VFRA-BI recorded a monthly downtime of 3%, compared to 4% for VFRA-DT. Additionally, VFRA-BI reported fewer misidentification cases (4%) and fewer user complaints (2.5%) than VFRA-DT (5% and 3%, respectively).

These results indicate that VFRA-BI provides a more stable and user-reliable platform, potentially due to better error-handling protocols and a more structured data flow within the Bootstrap-based interface.

Table 5: System Stability and Error Handling Metrics

Parameter	VFRA-DT (Dashboard Themes)	VFRA-BI (Bootstrap Interface)
System Downtime	4% monthly	3% monthly
Misidentification Cases	5%	4%
Visitor Complaints on Incorrect Logs	3%	2.5%

As shown in Table 5, VFRA-BI consistently demonstrated superior system stability compared to VFRA-DT. The monthly system downtime for VFRA-BI was recorded at 3%, which is 1% lower than VFRA-DT's 4%. This suggests that VFRA-BI maintained a more continuous and uninterrupted service, an important factor in environments where reliability is crucial. In terms of recognition accuracy from a user experience perspective, VFRA-BI also reported fewer instances of facial misidentification (4%) compared to VFRA-DT (5%). While the difference appears marginal, in high-volume or sensitive use cases, this reduction translates into fewer incorrect logs and improved trust in the system's output. Additionally, the number of visitor complaints related to incorrect logging events was slightly lower for VFRA-BI (2.5%) than VFRA-DT (3%), indicating better end-user satisfaction and fewer manual corrections or disputes.

These findings suggest that VFRA-BI incorporates more effective error-handling mechanisms and offers a more structured and resilient backend infrastructure. The Bootstrap-based architecture likely contributes to a more modular and consistent interface design, which in turn facilitates better control over data validation, exception handling, and real-time feedback during recognition events. VFRA-DT, while functional, may experience slightly higher instability due to its hybrid dependency on both dashboard themes and Excel integration, which introduces more potential points of failure in data processing and system communication. Overall, VFRA-BI demonstrated greater robustness and user dependability, making it a more viable solution for deployment in demanding institutional or organizational settings where minimal downtime and accurate logging are imperative.

4.5 Comparative Summary

To consolidate the findings across all performance dimensions, a comparative summary of the two systems, VFRA-DT and VFRA-BI, is presented in Table 6. This summary evaluates five core criteria: recognition accuracy, attendance logging speed, database accuracy, system usability, and overall system reliability.

Table 6: Comparative Performance Summary of VFRA-DT and VFRA-BI

Criteria	VFRA-DT	VFRA-BI	Superior System
Recognition Accuracy	89%	92%	VFRA-BI
Logging Speed	2.1 sec	1.8 sec	VFRA-BI
Database Accuracy	98–99%	99–100%	VFRA-BI
Usability	Dashboard-centric	Responsive Bootstrap	Context-dependent
Reliability	4% downtime	3% downtime	VFRA-BI

As shown in the table, VFRA-BI consistently outperformed VFRA-DT in most categories. The VFRA-BI system achieved higher recognition accuracy (92% vs. 89%) and faster average logging speed (1.8 seconds vs. 2.1 seconds), both of which are critical for seamless real-time visitor processing. In terms of database performance, VFRA-BI recorded slightly higher retrieval accuracy and reduced latency, supported by its streamlined database architecture using phpMyAdmin exclusively. This contrasts with VFRA-DT, which relies on a hybrid data handling approach involving both Excel and phpMyAdmin, potentially contributing to minor inefficiencies.

The usability of both systems depends on the deployment context. VFRA-DT, with its dashboard-centric design, may be better suited for static environments such as reception desks or control rooms, offering centralized visualization. In contrast, VFRA-BI leverages a responsive Bootstrap framework, making it more adaptive to dynamic environments such as mobile checkpoints or kiosks, where flexibility and modularity are prioritized. From a reliability perspective, VFRA-BI showed marginally lower system downtime (3%) and fewer error-related incidents, indicating better error-handling and operational resilience. This improved stability can be attributed to its structured interface design, lighter backend load, and more robust system architecture. In summary, while both systems effectively fulfilled the goal of automating visitor attendance and improving security, VFRA-BI demonstrates superior performance across recognition, speed, database handling, and reliability. These advantages position VFRA-BI as the more viable solution for institutions seeking a robust, efficient, and adaptable face recognition attendance system.

5.0 Conclusion and Recommendations

The comparative analysis of the Visitor Face Recognition Attendance Database System Using Dashboard Themes (VFRA-DT) and the Visitor Face Recognition Attendance System with Bootstrap-Based Interface (VFRA-BI) reveals key insights into the design, usability, and performance of biometric visitor management systems. Both systems significantly improve upon traditional paper-based visitor logs by offering automation, real-time monitoring, and enhanced security. However, measurable differences in system architecture and user interface design result in distinct operational outcomes.

VFRA-BI demonstrates superior performance across most evaluation metrics. Its machine learning-based face recognition algorithm enables higher accuracy (92%) and better adaptability in low-light and complex environments compared to the Haarcascade-based VFRA-DT (89%). Furthermore, VFRA-BI achieves faster attendance logging, lower system downtime, and improved database query performance due to its modular Bootstrap interface and structured phpMyAdmin storage. Despite VFRA-BI's overall efficiency, VFRA-DT remains a viable solution for controlled environments where visual dashboards are prioritized. Its graphical interface offers intuitive monitoring for administrators who may favour static and visually rich data representations.

To further improve the effectiveness of face recognition-based visitor attendance systems, the following recommendations are proposed:

i. Algorithm Enhancement: Upgrade the recognition engine in both systems with deep learning models such as convolutional neural networks (CNNs) or pretrained models like FaceNet to improve accuracy, particularly under poor lighting or with occluded faces.

ii. Low-Light Optimization: Integrate infrared imaging or adaptive exposure techniques to enhance recognition reliability in low-light or shadowed environments.

iii. Mobile Integration: Extend system accessibility through mobile-responsive dashboards or dedicated mobile apps for real-time remote monitoring by administrators.

iv. Unified Interface Design: Combine the best features of both interfaces, such as VFRA-DT's graphical visualization and VFRA-BI's modular responsiveness, into a hybrid UI to improve overall user experience.

v. Security Audits: Implement routine security checks and encryption protocols to safeguard sensitive biometric and visitor data.

In conclusion, this study underscores the importance of aligning system design with the intended operational context. While face recognition technology provides a robust foundation for automated attendance, the choice of user interface framework, algorithmic model, and database architecture significantly influences system efficiency and user satisfaction. Future research may explore the integration of multimodal biometrics (e.g., voice or fingerprint) and AI-driven anomaly detection to further advance intelligent visitor management solutions.

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Author Contributions

Rahmat N.: Conceptualization, Methodology, Supervision, Data Curation, Validation, Writing- Original Draft Preparation; **Ahmad H.**: Writing Review, Editing**; Seng S. Y.**: Methodology, Hardware Setup, Software, Data Curation; **Zaharuddin N. F.**: Methodology, Software, Data Curation; **Ismail:** Writing-Reviewing.

Conflicts of Interest

The manuscript has not been published elsewhere and is not being considered by other journals. All authors have approved the review, agree with its Submission and declare no conflict of interest in the manuscript.

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