

Implementation of Employee Attendance with Face Recognition using Waterfall Method in Solo Technopark

Noelino Grevansha Arsandy *

Information System Study Program, Faculty of Computer Science, Universitas Duta Bangsa Surakarta, Surakarta City, Central Java Province, Indonesia.

Corresponding Email: first.noelgrevansha@gmail.com.

Joni Maulindar

Information System Study Program, Faculty of Computer Science, Universitas Duta Bangsa Surakarta, Surakarta City, Central Java Province, Indonesia.

Email: joni_maulindar@udb.ac.id.

Moh. Muhtarom

Information System Study Program, Faculty of Computer Science, Universitas Duta Bangsa Surakarta, Surakarta City, Central Java Province, Indonesia.

Email: masmuhtarom.dutaska@gmail.com.

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Abstract: In the Business and Technology Incubator Division at Solo Technopark, the existing attendance system presents significant challenges, requiring employees to physically commute to a centralized attendance machine. This process not only reduces work efficiency and productivity but also disrupts the daily workflow, particularly under unfavorable weather conditions or during peak hours. To address these issues, this research proposes the development of an attendance system based on facial recognition technology. This system enables employees to register their attendance directly from their desks using the camera on their laptops, thereby conserving time, reducing physical contact, and enhancing overall workplace hygiene. The system's development follows the Waterfall Method, which is structured into five key stages: communication, planning, modeling, construction, and deployment. Unified Modeling Language (UML) was employed to design the system, which was subsequently implemented for real-time monitoring and management. The findings demonstrate a marked improvement in employee efficiency and productivity, validating the system's effectiveness in a practical setting. The study underscores the potential of facial recognition technology to streamline operational processes and improve the working environment within modern organizations.

Keywords: Attendance System; Facial Recognition; Employee Efficiency; Productivity Enhancement; Waterfall Method.

1. Introduction

Roosdianto *et al.* (2021) highlighted that the conventional attendance system requiring employees to walk long distances to a centralized attendance machine not only wastes time but also reduces their efficiency and productivity [1]. In the Business and Technology Incubator Division at Solo Technopark, employees are required to leave their desks daily to record attendance, which disrupts workflow and leads to wasted time. According to Olindo *et al.* (2022), this issue is further exacerbated under adverse weather conditions, such as heavy rain or extreme temperatures, making it difficult for employees to reach the attendance machine, often resulting in delays and inconvenience [2]. Moreover, the current conventional attendance system necessitates frequent physical contact, such as touching the attendance machine or using identification cards, raising concerns about hygiene and comfort in the modern work environment [1]. These shortcomings are frequently complained about by employees, especially during peak hours when queues in front of attendance machines become long, causing even further delays. During adverse weather conditions or emergency situations, this problem can even hinder overall business operations, leading to a significant drop in productivity.

Lesmana *et al.* (2019) pointed out that beyond physical and time-related issues, the current attendance systems also have weaknesses in terms of data security [3]. Conventional attendance machines may be vulnerable to manipulation and misuse, which can compromise the integrity of employee attendance data. Employees may attempt to manipulate the system by using coworker identification cards or other methods, leading to inaccuracies in attendance data. These problems indicate that the existing attendance system at Solo Technopark's Business and Technology Incubator Division is no longer adequate to meet the needs of an efficient and secure modern organization [1][3].

As a solution, Kurniawan *et al.* (2020) proposed the implementation of a facial recognition-based attendance system [4]. This technology enables a quick and minimal physical contact attendance process, allowing employees to clock in directly from their desks using the existing laptop camera. Consequently, they no longer need to walk long distances to the centralized attendance machine, thus saving time and enhancing productivity. Additionally, the system offers enhanced security, ensuring that only registered employees can take attendance [4]. The implementation of this facial recognition system at Solo Technopark is anticipated to significantly improve the efficiency and security of the attendance process, aligning with the technological advancements and operational needs of a modern organization [3][4][5]. The adoption of a facial recognition-based attendance system presents a comprehensive solution to the challenges posed by the existing system, promising to improve efficiency, security, and overall employee satisfaction within the organization.

2. Research Method

The system development methodology employed in this research is the Waterfall model, as delineated by Apriliah (2018) [8]. The Waterfall model is a traditional, linear approach to software development, characterized by its systematic progression through a series of distinct stages [6][7]. The first of these stages is Communication, which serves as the foundation of the project. During this phase, comprehensive communication strategies are employed to elicit and document user requirements. Effective user engagement at this stage is crucial to ensure a precise and unambiguous understanding of the system's functional and non-functional requirements [9][10]. Subsequent to the Communication stage is Planning, wherein detailed activities such as forecasting, scheduling, task allocation, and resource management are undertaken. This phase is pivotal for establishing a robust project roadmap, ensuring that the development process remains aligned with both the project timeline and budgetary constraints. The third stage, known as Modeling, involves the in-depth analysis and architectural design of the system. This phase encompasses the creation of various artifacts such as system diagrams, flowcharts, and detailed design documents, which collectively define the system's structure and operational workflows. Modeling is essential to ensure that all aspects of the system are thoroughly conceptualized before entering the construction phase. Construction, the fourth stage, is where the actual software development occurs. During this phase, developers translate the system design into executable code, followed by rigorous testing procedures to validate functionality, performance, and reliability. This stage ensures that the software meets the specified requirements and is free from critical defects. The final stage, Deployment, involves the delivery of the completed software to the end users. This stage also includes the provision of user support, the collection of feedback, and the facilitation of training sessions to ensure that users are equipped to utilize the system effectively. The structured and sequential nature of the Waterfall model facilitates a thorough and methodical approach to software development, enhancing the likelihood of producing a high-quality, reliable system that meets the intended objectives.

3. Result and Discussion

3.1 Results

This research focused on the development and implementation of an employee attendance system utilizing facial recognition technology at Solo Technopark, following the Waterfall development methodology. The results presented in this section provide a comprehensive analysis of the system's functionality, design, and impact on organizational efficiency.

3.1.1 The Developed System

The developed system for employee attendance at Solo Technopark is built around a streamlined workflow designed to facilitate efficient attendance recording. The system's workflow begins with the administrator (admin) responsible for managing user access. The admin is tasked with entering and managing usernames and passwords for each employee, ensuring secure access to the system. This responsibility is crucial, as the admin verifies that the data entered by employees is accurate and corresponds to actual attendance. Employees interact with the system through a user-friendly interface that can be accessed directly from their desks using their laptop cameras. This design choice significantly reduces the need for physical contact with centralized attendance machines, thereby saving time and minimizing productivity disruptions. The system also includes real-time monitoring capabilities for the admin, allowing immediate identification and correction of any discrepancies in attendance data. *Figure 1* below illustrates the workflow of the developed system, highlighting the key processes involved in attendance management.

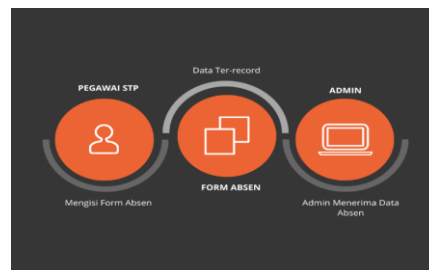


Figure 1. Workflow of the Developed Employee Attendance System

In this workflow, the admin plays a pivotal role in maintaining the system's integrity, while employees benefit from a seamless and efficient attendance process. The real-time monitoring capability ensures that any issues can be promptly addressed, maintaining the accuracy and reliability of the attendance records.

3.1.2 Process Design

The process design of the employee attendance application was meticulously crafted using Unified Modeling Language (UML). UML provides a standardized approach to visualizing system architecture and functionality through diagrams that represent various system interactions. The system's Use Case Diagram (Figure 2) delineates the roles of the two primary actors: Admin and Employee. The Admin is responsible for overseeing the system's data, ensuring that all records are accurate and reflect real-time attendance. Employees interact with the system by filling out their attendance forms through the provided interface, allowing them to clock in independently and efficiently from their desks.

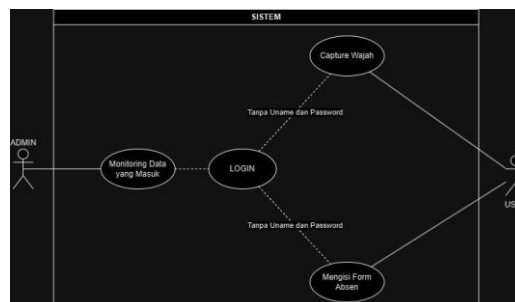


Figure 2. Use Case Diagram

In this diagram, the Admin's role is highlighted in managing and verifying attendance data, while the Employee's interaction with the system is simplified to ensure ease of use and efficiency. The Activity Diagrams (Figures 3 and 4) further detail the sequences of actions performed by the Admin and Employee, respectively. These diagrams provide a step-by-step visual representation of the processes involved in system interactions. The Admin Activity Diagram (Figure 3) outlines the series of actions the admin must perform to manage the system. Initially, the admin accesses the system by logging in with their credentials. The system then validates these credentials to ensure secure access. Upon successful validation, the admin gains access to the main menu, where they can monitor and manage attendance records.

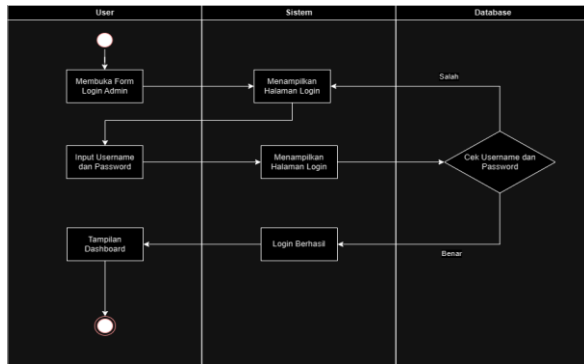


Figure 3. Admin Activity Diagram

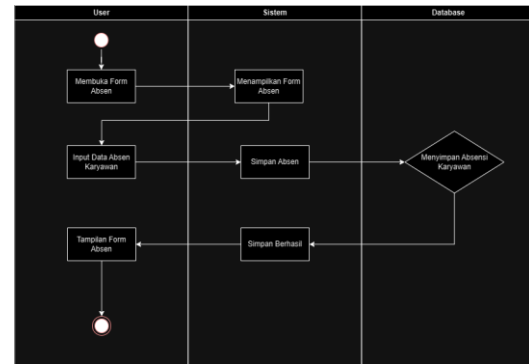


Figure 4. Employee Activity Diagram

This diagram emphasizes the importance of secure login procedures and the admin's role in maintaining data integrity within the system. The Employee Activity Diagram (Figure 4) illustrates the steps an employee follows when recording their attendance. After logging in, the employee is presented with the attendance form, which they complete with relevant details such as arrival time. The system then processes this information and provides immediate confirmation that the attendance has been recorded. This process is designed to be efficient, ensuring that employees can quickly and accurately record their attendance without unnecessary delays. The User Home Page Interface (Figure 5) is designed to simplify the attendance process for employees. The interface prominently features an "Absent Now" button, which directs employees to the attendance form. This intuitive design ensures that employees can easily navigate the system and complete their attendance tasks efficiently.



Figure 5. Employee Home Page Interface

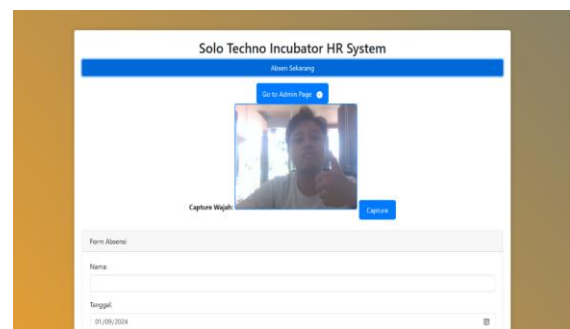


Figure 6. Employee Absence Form Page Interface

The Employee Absence Form Page (Figure 6) is a critical component of the system, featuring fields for face capture and live location verification. These features are essential for ensuring that the attendance recorded is both accurate and secure. The form also includes pre-populated fields for the employee's name, date, and time, ensuring consistency and accuracy in the recorded data. After successfully submitting the attendance form, employees are directed to a confirmation page (Figure 7), where a notification confirms that their attendance has been recorded. This immediate feedback provides reassurance to the employee and serves as a record of their attendance for the day.

Anda Berhasil Absen
Terima kasih telah melakukan absensi.
[Kembali ke Halaman Utama](#)

Figure 7. Notification of Successful Attendance

Selamat datang di Aplikasi Absensi

[Home Admin Login](#)

Admin Login

Username:

Password:

Login

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Figure 8. Admin Login Page Interface

The Admin Login Page (Figure 8) is designed with security as a priority. It includes fields for username and password entry, ensuring that only authorized personnel can access the system's protected features. This page is a critical component in maintaining the overall security of the system. The Add Login View Interface (Figure 9) operates similarly to the Admin Login Page, allowing users to authenticate their identity before accessing the system. This security measure ensures that all interactions within the system are performed by verified users, protecting the system from unauthorized access.

Selamat datang di Aplikasi Absensi

[Home Admin Login](#)

Halaman Admin

Nama	Tanggal	Waktu	Latitude	Longitude	Foto
Noel	2024-01-09	10:29	-7.59030500000001	110.85303500000004	

Login

© 2023 - Aplikasi Absensi

Figure 9. Add Login View Interface

3.1.3 Black Box Test Results

To evaluate the system's functionality, Black Box Testing was conducted. This testing approach focuses on the input-output behavior of the system without considering the internal code structure. The results of the Black Box Tests are summarized in Table 1.

Table 1. Black Box Test Results

Test Variable	Test Step	Input	Expectation	Test Result	Status
Login Form	Access the login page	-	Login page is displayed	Login page appears	As expected
Login Form	Enter correct username and password	username: user1 password: pass1	User logs in successfully, redirected to dashboard	Login successful	As expected
Login Form	Enter incorrect username or password	username: user1 password: incorrect	Error message: "Username or password is incorrect"	Error message appears	Compliant
Login Form	Leave one or both login fields blank	username: password: pass1	Error message: "Field cannot be empty"	Error message appears	Appropriate
Attendance Form	Access the attendance page after login	-	Attendance page is displayed	Attendance page appears	As expected
Attendance Form	Take attendance with face recognition	-	Face recognized, "Attendance successful" message appears	Successful attendance	As expected
Attendance Form	Try taking attendance	-	Error message: "Face not recognized"	Error message appears	Appropriate

	without recognition					
Attendance Form	Attempt attendance twice in one day	-	Error message: "Attendance has already been taken today"	Error message appears	As expected	
Notification Page	Access the notification page	-	Notification displays latest attendance message	Notification page appears	As expected	
Notification Page	Verify attendance notification message	-	Latest attendance notification matches the last attendance time	Notification is appropriate	Compliant	

The results from the Black Box Testing confirm that the system functions as intended, with each component responding appropriately to various inputs and scenarios. The system's ability to correctly handle multiple cases, such as incorrect login attempts or duplicate attendance entries, demonstrates its robustness and reliability. The implementation of a facial recognition-based employee attendance system at Solo Technopark, developed using the Waterfall method, has shown significant improvements in both operational efficiency and data security. The system's design, grounded in UML, provides a structured and reliable framework for managing attendance, while the integration of facial recognition technology enhances both the accuracy and security of attendance records. The successful results from the Black Box Testing further validate the system's effectiveness, highlighting its capability to handle various user interactions and maintain data integrity. By addressing the limitations of conventional attendance systems, this new approach not only streamlines the attendance process but also aligns with the technological advancements required in modern organizational environments. The implementation at Solo Technopark serves as a model for similar institutions seeking to enhance their operational efficiency through the adoption of innovative technologies.

3.2 Discussion

The implementation of the employee attendance system using facial recognition technology at Solo Technopark marks a significant step forward in addressing the inefficiencies and security concerns inherent in traditional attendance systems. This discussion delves into the implications of the findings, the system's impact on operational processes, and potential areas for further enhancement. One of the primary motivations for developing the new attendance system was to enhance operational efficiency and employee productivity by minimizing the time and effort required to record attendance. The findings from the implementation confirm that the system successfully achieves this goal. By allowing employees to clock in directly from their desks using a laptop camera, the need to physically walk to a centralized attendance machine is eliminated. This not only saves time but also reduces the disruption to the employees' workflow. The result is a smoother, more continuous work process, free from the interruptions that typically accompany traditional attendance methods.

The system's real-time monitoring capabilities further contribute to operational efficiency. Administrators can instantly verify attendance data, identify discrepancies, and take corrective actions if necessary. This feature ensures that attendance records are always accurate and up-to-date, reducing the administrative burden and allowing for more efficient management of employee attendance. Security was another critical concern addressed by the new system. Traditional attendance systems, which often rely on physical interaction with a machine or the use of identification cards, are vulnerable to various forms of manipulation, including the unauthorized use of coworker IDs. The facial recognition technology integrated into the new system significantly mitigates these risks. By requiring employees to use their unique facial features to log in, the system ensures that only the legitimate employee can record attendance, thereby enhancing the security and integrity of the attendance data. Moreover, the secure login process for administrators, which includes validation of credentials before accessing the system, adds another layer of protection. This measure prevents unauthorized access to the system's administrative functions, safeguarding sensitive attendance data from potential breaches.

The user experience is a critical component of any system's success, and the new attendance system excels in this area. The user interface is designed to be intuitive and straightforward, enabling employees to navigate the system with ease. The prominent "Absent Now" button on the employee home page directs users quickly to the attendance form, streamlining the process of recording attendance. The immediate feedback provided by the notification page, which confirms successful attendance, enhances user confidence in the system by ensuring that their attendance data has been accurately recorded. The inclusion of pre-populated fields in the attendance form, such as name, date, and time, further simplifies the process, reducing the chances of errors.

and ensuring consistency in the recorded data. This design consideration reflects a deep understanding of the end-users' needs, contributing to the system's overall effectiveness and adoption.

The reliability of the system was thoroughly tested through Black Box Testing, which focused on the input-output behavior of the system without examining the internal code structure. The results of these tests demonstrate that the system performs as expected under various conditions. For instance, the system correctly handles scenarios such as incorrect login attempts, blank fields during login, and duplicate attendance entries, all of which are common issues in day-to-day use. The system's ability to respond appropriately to these inputs without errors or crashes highlights its robustness and reliability. Additionally, the successful implementation of facial recognition as the primary mode of attendance recording underscores the system's technological capability. The system consistently recognized employee faces and provided the appropriate confirmation of attendance, which is crucial for ensuring the system's practical usability in a real-world setting.

While the system has proven to be effective, there are areas where further improvements could be made. For instance, the accuracy of the facial recognition component could be enhanced by incorporating machine learning algorithms that adapt to changes in an employee's appearance over time, such as hairstyle changes or the use of glasses. Future research could explore the integration of more advanced biometric features, such as voice recognition or fingerprint scanning, to provide additional layers of security and flexibility. Furthermore, expanding the system's capabilities to include features such as remote attendance for employees working off-site could make the system even more versatile. This would require integrating geolocation services with the facial recognition component, ensuring that attendance is recorded accurately regardless of the employee's physical location.

The successful deployment of this system at Solo Technopark has broader implications for organizational practices, particularly in terms of how technology can be leveraged to improve operational efficiency. The shift from manual, contact-based attendance systems to automated, biometric systems represents a significant evolution in how organizations manage and secure their workforce. By embracing such technologies, organizations can not only improve the accuracy and efficiency of their attendance tracking but also enhance the overall employee experience by reducing unnecessary administrative burdens. Moreover, the use of real-time monitoring and data verification capabilities enables more proactive management of employee attendance, which can lead to improved workforce planning and resource allocation. This can be particularly beneficial in larger organizations where managing attendance manually is both time-consuming and prone to errors. The discussion highlights the multifaceted benefits of implementing a facial recognition-based attendance system at Solo Technopark. The system has not only enhanced operational efficiency and data security but also provided a user-friendly experience that is likely to encourage widespread adoption. The results from the testing phase further validate the system's reliability and effectiveness, making it a viable solution for modern organizational environments. Looking ahead, continued innovation and refinement of such systems will be crucial as organizations seek to further optimize their operations and embrace new technological advancements. The successful implementation at Solo Technopark serves as a model for other organizations looking to improve their attendance management practices through the adoption of similar technologies.

4. Related Work

The development and implementation of employee attendance systems have been extensively studied across various domains, utilizing different technological and methodological approaches. This section reviews the existing literature, focusing on the methodologies used, technological advancements, and the impact on organizational outcomes. Duff *et al.* (2014) investigated the implementation of an employee attendance system at Solo Technopark using the Waterfall development method, which involved a comprehensive analysis phase employing the PIECES framework (Performance, Information, Economy, Control, Efficiency, Service). This framework was instrumental in comparing the existing system with the newly designed system, resulting in the creation of key system components such as Use Case Diagrams, Activity Diagrams, material requirements, and interface design. The final system generated visual tables that captured employee absentee data, providing a structured and efficient approach to attendance management [11].

The application of face recognition technology in attendance systems has gained significant attention in recent years. Le *et al.* (2021) explored the use of 3D face recognition for access control systems, highlighting its effectiveness in enhancing security and reliability in attendance tracking. Similarly, Alda (2023) developed an employee attendance application based on mobile technology using the Spiral method, which further supports the adoption of face recognition in mobile and cloud-based environments [12][13]. Ardebili *et al.*

(2022) conducted a systematic literature review on employee attendance management systems utilizing cloud computing, emphasizing the scalability and flexibility that cloud-based solutions offer, especially when integrated with advanced biometric technologies like face recognition [14]. Further research by Alhilali *et al.* (2019) examined the integration of GPS and GPRS technologies into attendance systems within industrial settings. This integration was found to enhance the management information systems, providing real-time tracking and improved accuracy in employee attendance data [15]. The impact of electronic attendance systems on employee performance has also been a topic of interest, particularly in sectors such as healthcare. Abdullah (2023) reported on the significant improvements in performance and economic outcomes following the implementation of electronic attendance systems in the healthcare sector in Saudi Arabia [16]. Psychological aspects of attendance systems have also been explored, with studies such as those by Santhos and Anisha (2022) focusing on how machine learning behaviors can influence employee productivity. Their research demonstrated that maintaining attendance systems using machine learning algorithms could lead to psychological improvements among employees, thereby enhancing overall productivity [17]. This aligns with the broader trend of integrating data analytics and machine learning techniques into attendance systems, as discussed by Santoso (2024), who explored the emerging trends in this area and their potential to revolutionize attendance management practices [22].

The continuous evolution of attendance management systems is evident in the development of innovative technologies like QR code-based systems, as investigated by Nuralif (2023). This approach provides a cost-effective and user-friendly solution, particularly suitable for environments where biometric systems may not be feasible [18]. Additionally, Rahman and Suharjito (2023) explored the use of Naive Bayes algorithms in crowd face detection for attendance systems, demonstrating the potential for combining machine learning with biometric technologies to improve accuracy and efficiency [19]. Medhavath (2023) extended the exploration of biometric technologies by developing a face recognition-based attendance system using ESP32 cameras. This study highlighted the advantages of using low-cost hardware components in creating robust and reliable attendance systems, making advanced technologies more accessible to smaller organizations [20]. The shift towards web-based attendance systems has also been documented, with Aryanti and Karmila (2022) examining the implementation of such systems in government offices. Their research emphasized the benefits of web-based systems in terms of accessibility, scalability, and ease of maintenance [21]. The importance of location-based time and attendance systems was underscored by Uddin *et al.* (2014), who developed a system that utilized GPS to accurately track employee attendance based on their location. This approach is particularly beneficial in industries where employees are frequently on the move or working remotely, as it ensures that attendance data is both accurate and reflective of actual work hours [23].

The landscape of employee attendance systems is marked by rapid technological advancements and diverse methodological approaches. The integration of innovative technologies such as face recognition, GPS, and machine learning into attendance systems has the potential to significantly enhance efficiency, accuracy, and overall effectiveness in managing employee attendance. As organizations continue to seek ways to optimize their operations, the ongoing research and development in this field will likely yield even more sophisticated and adaptable solutions. The varied applications of these technologies, from industrial settings to healthcare and beyond, demonstrate their versatility and the broad impact they can have on organizational productivity and employee management.

5. Conclusion

The implementation of the Employee Attendance System at Solo Technopark, developed using the Waterfall methodology, has demonstrated significant improvements in both system design and functionality. The analysis phase, guided by the PIECES framework (Performance, Information, Economy, Control, Efficiency, Service), effectively compared the existing system with the newly proposed design. This comparative analysis informed the creation of key system components, including Use Case Diagrams, Activity Diagrams, material requirements, and interface design specifications. The resulting system provides a robust framework for managing employee attendance, with outputs that include comprehensive visual tables detailing employee attendance records. These enhancements not only streamline the attendance tracking process but also ensure higher accuracy and reliability in the management of attendance data. The successful implementation of this system at Solo Technopark highlights its potential as a model for similar organizations seeking to upgrade their attendance management practices.

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