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A systematic literature review of web-based employee attendance information systems

Mutia Raysha [a,1,*], Yusuf Durachman [a,2]
[a] Department of Information Systems, Syarif Hidayatullah State Islamic University, Jakarta, Indonesia
mutia.raysha23@mhs.uinjkt.ac.id [1], [2] yusuf_durachman@uinjkt.ac.id
* corresponding author

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Abstract

Web-based employee attendance systems have increasingly replaced manual recording and dedicated attendance devices, yet challenges related to proxy attendance, identity verification, and location manipulation remain. This study aims to examine publication trends, technological implementations, and technical limitations in web-based employee attendance information systems through a Systematic Literature Review (SLR). Following the PRISMA framework, 6,283 records were retrieved from Scopus and screened based on publication year, subject area, document type, language, and open-access availability, resulting in 71 journal articles for full-text analysis. The findings show that publications peaked at 18 articles in both 2023 and 2024, with Indonesia contributing the highest number of publications (19). Regarding technological implementations, Python-based frameworks, including TensorFlow, Keras, and PyTorch, are frequently used alongside web frameworks such as Flask, Laravel, and ASP.NET, while MySQL is the most frequently reported database technology. Single-factor validation remains dominant, with face recognition reported in 37 studies. Hybrid validation was identified in 12 of 66 studies with identifiable validation technologies. The review also identifies recurring limitations involving environmental sensitivity, limited evaluation datasets, inadequate spoofing protection, unreliable location validation, scalability, and privacy concerns. Within the reviewed studies, no hybrid system was identified that integrates face recognition, liveness detection, and device-level GPS validation within a single web-based attendance workflow. This gap highlights the need for practical multi-factor attendance architectures that jointly verify user identity and physical location. Future research should focus on lightweight web-based systems integrating face recognition, GPS geofencing, and liveness detection, supported by explicit validation rules and evaluation against realistic spoofing scenarios.

1. Introduction

Accurate and timely attendance tracking forms the backbone of payroll calculation and regulatory compliance. As institutional digitalization accelerates, conventional manual record-keeping has increasingly transitioned toward automated and IoT-driven platforms [1], [2]. Manual recording is slow and error-prone. Reported weaknesses include low accuracy in recording time, potential data manipulation, inefficient data collection, and the absence of real-time notification. In a four-week school experiment, replacing manual recording with an RFID and fingerprint IoT system raised the average attendance rate from 72 percent to 87 percent and made tardiness measurable for the first time [1]. Proxy attendance is a further concern. Police officers interviewed in one field study reported that colleagues punched in or out for one another and falsified records to show more hours than they had worked [3].

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A range of technologies has been adopted to automate attendance. RFID-based IoT applications raise security and privacy concerns that have prompted dedicated guidelines [4], and RFID is often combined with fingerprint authentication [1]. Web-based applications avoid dedicated terminals, and geofencing has been used to confirm that attendance is recorded at the authorized place [5]. Face recognition has attracted particular attention. A bibliometric review of Scopus records from 2019 to 2024 maps its research trends in attendance systems and notes that international collaboration remains limited [6]. Deep-learning pipelines for attendance monitoring [7], hybrid feature-learning methods that raise recognition accuracy [8], and embedded Raspberry Pi implementations of face-based identification [9] illustrate the breadth of approaches.

These technologies are not equally robust. A deployed face-plus-geofence system for field personnel reached 99 percent facial recognition accuracy under optimal conditions, but true-positive rates fell to 92 percent in dim light, 89 percent with glasses, and 85 percent at high camera angles. Its geofence reached 92.18 percent accuracy in open areas but only 71.33 percent in urban settings [3]. Security is a separate issue. Face recognition systems without anti-spoofing verification cannot ensure security against print, replay, 3D-mask, and makeup attacks, and generative AI has added face-swapping fraud to the threat list [9]. Surveys now catalogue presentation attack detection mechanisms [10], deep learning for biometric recognition [11], spoofing on smartphones [12], digital and physical face attacks [13], and digital face manipulation [14]. Location falsification is likewise a route to proxy attendance that isolated technologies fail to prevent [3].

Despite this breadth, knowledge about web-based employee attendance systems is dispersed across studies that examine individual technologies, such as face recognition, RFID, or geofencing, separately. Existing secondary studies tend to concentrate on recognition algorithms or spoofing countermeasures [6], [9], [10]. A consolidated view of how software frameworks, data storage, and validation mechanisms fit together in web-based attendance systems is therefore harder to obtain. A systematic review can bring this evidence together, compare technology choices, and expose the limitations that remain.

This study conducts a Systematic Literature Review of web-based employee attendance information systems published between 2022 and 2026, following the PRISMA protocol. Its objectives are to map publication trends, to identify the software, database, and validation technologies in use, and to synthesize their limitations and research gaps. It addresses three research questions:

- RQ1: How has the literature on web-based attendance systems evolved in publication volume and distribution between 2022 and 2026?
- RQ2: What software engineering frameworks, database architectures, and validation technologies are predominantly utilized in web-based attendance platforms?
- RQ3: What are the primary technical limitations of existing systems, and what research gaps exist regarding hybrid validation architectures?

The remainder of this paper is organized as follows. Section II describes the methodology, Section III presents the results and discussion, and Section IV concludes.

2. Research Methodology

2.1. Research Design and Methodological Approach

To comprehensively analyze and map the research landscape of web-based employee attendance information systems, this study employs a Systematic Literature Review (SLR) protocol to systematically identify, select, analyze, and synthesize relevant studies [15], [16]. In computer science research, SLR provides a structured approach for defining research questions, searching and selecting relevant literature, extracting data, and synthesizing findings in a systematic manner [15]. The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework to support transparent and reproducible reporting of the identification, screening, eligibility, and inclusion processes [16]. Furthermore, the use of predefined review criteria and procedures strengthens the consistency and traceability of the literature selection and analysis process [17]. This methodological approach enables a structured analysis of software engineering frameworks, database technologies, and attendance validation mechanisms reported in existing web-based attendance systems.

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2.2. Inclusion & Exclusion Criteria

To ensure the selection of high-quality, relevant literature, rigorous eligibility criteria were applied during the screening process. The criteria are detailed in Table 1.

Table 1. Inclusion & Exclusion Criteria

Category	Inclusion Criteria	Exclusion Criteria
Publication Year	Articles published between 2022 and 2026.	Articles published before 2022.
Keyword Specificity	Articles containing the exact phrase "Attendance System".	Articles lacking the exact phrase "Attendance System".
Subject Area	Computer Science.	Disciplines outside Computer Science, such as Engineering, Mathematics, Physics, and Medicine.
Document and Source Type	Peer-reviewed primary research articles published in journals.	Non-journal publications and secondary sources, such as Conference Papers, Book Chapters, Reviews, and Erratum.
Language	Full-text articles written in English.	Non-English articles, such as Chinese and Ukrainian.
Accessibility	Open access publications.	Restricted or subscription-based publications.

2.3. Systematic Screening Procedure (PRISMA Pipeline)

The literature selection process followed a structured four-stage PRISMA flow pipeline as illustrated in Figure 1. Out of 6,283 initial records extracted from Scopus, 5,420 documents were excluded during the preliminary screening for lacking the exact phrase "Attendance System" or falling outside relevant subject areas. The remaining 863 records underwent document type filtering, where 764 non-journal publications (e.g., conference papers, book chapters, and reviews) were removed. During the eligibility assessment, 2 non-English studies and 26 non-open-access articles were further excluded. Consequently, a final synthesis dataset of 71 high-quality articles was retained for full-text extraction and qualitative systematic review.

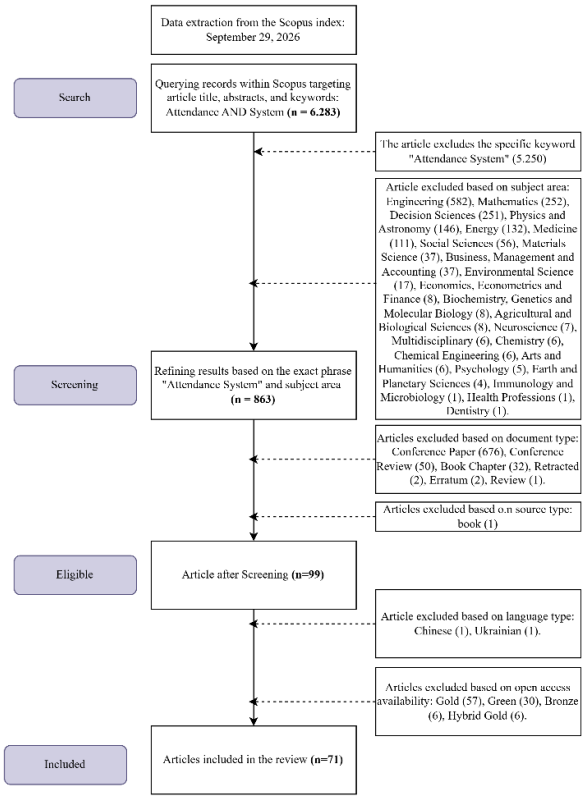


Figure 1. Systematic Literature Review Information Flow Using PRISMA

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2.4. Research Questions

To guide the systematic review and address the identified domain gaps, this study addresses three core Research Questions (RQs):

Table 2. Research Questions and Objectives

RQ ID	Research Question	Main Objective
RQ1	How has the literature on web-based attendance systems evolved in publication volume and distribution between 2022 and 2026?	Map publication trends, yearly progress, and primary demographic indexing sources.
RQ2	What software engineering frameworks, database architectures, and validation technologies are predominantly utilized in web-based attendance platforms?	Identify current technological stacks and compare single-factor vs. multi-factor validation implementations.
RQ3	What are the primary technical limitations of existing systems, and what research gaps exist regarding hybrid validation architectures?	Synthesize security vulnerabilities, operational trade-offs, and establish the gap for hybrid systems.

3. Results and Discussion

The empirical findings of this systematic review are synthesized from 71 selected manuscripts retrieved from the Scopus repository focusing on web-based employee attendance systems. These insights were captured by systematically tracking publication volumes, temporal progression trends, geographic provenance, and key institutional sources. Furthermore, the assessment highlights the structural, architectural, and technological parameters defining contemporary web-based attendance models, including software frameworks, database structures, validation technologies, and prevailing technical limitations.

3.1. RQ1: How has the literature on web-based attendance systems evolved in publication volume and distribution between 2022 and 2026?

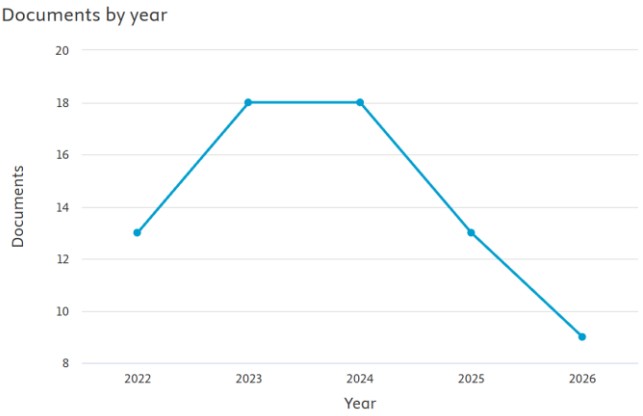


Figure 2. Annual Publication Trends of Web-Based Attendance Systems (2022-2026)

Based on the systematic extraction of 71 peer-reviewed manuscripts indexed in the Scopus database between 2022 and 2026, the scholarly interest in web-based employee attendance platforms demonstrates a consistent and active research trajectory. As depicted in Figure 2, the annual output commenced with 13 publications in 2022 and reached its peak in 2023 and 2024, with both years recording 18 publications. This surge reflects an intensified effort among researchers to modernize workforce tracking and automate organizational operations following the digital transformation wave. The publication output recorded 13 documents in 2025 and 9 documents up to September 2026, confirming that web-based attendance research remains a relevant topic in computer science and information systems literature.

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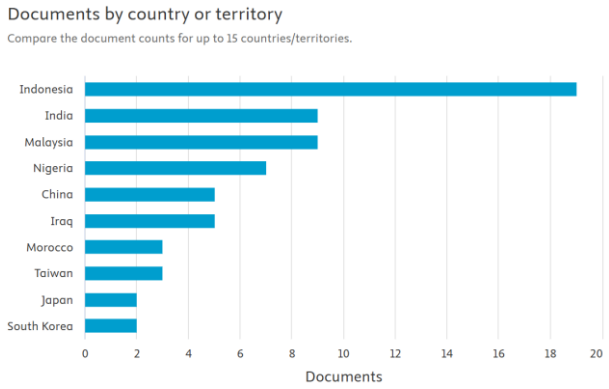


Figure 3. Geographical Distribution of Publications by Country

In terms of geographical distribution shown in Figure 3, Indonesia leads global research productivity in this domain with 19 documents, followed by India and Malaysia with 9 documents each, Nigeria with 7 documents, and both China and Iraq with 5 documents. Additional scientific contributions were identified from Morocco (3 documents), Taiwan (3 documents), Japan (2 documents), and South Korea (2 documents). Institutionally, research efforts are evenly distributed across prominent universities, including Universitas Indonesia, Bina Nusantara University, Universitas Ahmad Dahlan, Universiti Teknologi MARA, Universiti Teknologi Malaysia, Tokyo City University, Cadi Ayyad University, and the University of Mosul, each contributing 2 documents. The strong presence of contributions from emerging economies highlights a high practical demand for cost-effective, accessible, and automated web-based platforms tailored for workforce management.

3.2. RQ2: What software engineering frameworks, database architectures, and validation technologies are predominantly utilized in web-based attendance platforms?

The analysis of the 71 included articles provides a comprehensive overview of the software engineering frameworks, database architectures, and validation technologies predominantly utilized in web-based attendance platforms. These technical findings are elaborated in the following sections.

a) Software Engineering Frameworks and Technology Stack

Based on the data extraction from the 71 selected studies, the application of software engineering frameworks in attendance system development is distributed across several software architecture domains. In the machine learning and computer vision domains, frameworks such as TensorFlow/Keras [18], [19] and PyTorch [20], [21], [22] emerge as the primary choices implemented for deep learning modeling, facial feature extraction, and liveness detection. Meanwhile, for backend management and web interfaces, researchers predominantly utilize Flask due to its ability to facilitate native Python-based microservice integration with biometric algorithms, alongside Laravel and ASP.NET MVC5 for robust relational data management, attendance reporting, and role-based access control. On the mobile client side, cross-platform frameworks such as Flutter and React Native are leveraged to facilitate real-time facial image capture while simultaneously validating GPS location coordinates (geofencing). Overall, the literature reveals a strong trend toward hybrid stack architectures, where Python-based AI frameworks process biometric data on the backend, which is then connected via API services like Express.js/Node.js to web and mobile user interfaces.

b) Database Architectures and Data Management Technologies

The reviewed studies reported various data storage technologies used in attendance systems. As shown in Table 3, MySQL was the most frequently reported Relational Database Management System (DBMS), appearing in 9 studies. Microsoft SQL Server and Redis were each reported in 2 studies, while MongoDB, Firebase/Firestore, and SQLite were each identified in 1 study. In addition to conventional DBMSs, Google

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Sheets or spreadsheets were utilized in 2 studies, whereas lightweight file-based storage—including Excel, CSV, JSON, and serialized files—was reported in 8 studies.

Table 3. Distribution of Database Technologies and System Architectures in Attendance System

Database technology	Frequency (n)
MySQL	9
Microsoft SQL Server	2
Redis	2
MongoDB	1
Firebase/Firestore	1
SQLite	1
Google Sheets/Spreadsheet	2
File-based storage (Excel, CSV, JSON, or serialized files)	8
Cloud storage/deployment reported	6
Client-server/web-server architecture reported	8

Regarding system architecture, client–server or web-server architectures were explicitly reported in 8 studies, while cloud storage or cloud-based deployment was reported in 6 studies. These findings indicate that modern attendance systems rely not only on dedicated DBMSs for data management but also on file-based storage and cloud services to accommodate varied operational scales. Consequently, storage approaches vary according to the specific technical requirements, hardware constraints, and design objectives of each platform.

Overall, MySQL was identified as the most prevalent DBMS among the reviewed literature, alongside a notable usage of file-based storage for lightweight or prototype implementations. However, these reported frequencies represent the prevalence of each technology across the literature rather than a direct evaluation of performance or effectiveness. Because a single system implementation may incorporate multiple components (e.g., combining an RDBMS with cloud storage), the total frequency across categories does not necessarily match the total number of reviewed studies.

c) Validation Technologies in Attendance Systems

Based on the mapping results of the Systematic Literature Review (SLR) on the analyzed research articles, attendance validation technologies are categorized into two main groups: Single Validation Technology (unimodal) and Hybrid Validation Technology (multi-factor combination). Overall, the distribution of these technologies encompasses various biometric modalities, token-based devices, as well as location and environmental sensors, as summarized in Table 4.

Table 4. Category and Type Distribution of Attendance Validation Technologies

Validation Technologies	Category	Count
Face recognition	Single	37
Fingerprint	Single	5
Face recognition & Fingerprint	Hybrid	4
RFID	Single	4
QR code	Single	3
Face recognition & Liveness/Anti-spoofing	Hybrid	2
QR code & Geolocation	Hybrid	2
GPS	Single	2
Iris	Single	1
Gait	Single	1
Acoustic signal	Single	1
Face recognition & IP-based geolocation	Hybrid	1
Face recognition & Liveness	Hybrid	1
Face recognition & Liveness & Ultrasonic sensor	Hybrid	1
RFID & Ultrasonic sensor & Photo evidence	Hybrid	1

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The Single Validation Technology approach continues to dominate the literature, with Face Recognition being the most popular and extensively researched technology due to its touchless nature and high user convenience. Aside from face recognition, other single physical biometric modalities include fingerprint scanning, iris recognition, and gait recognition. Meanwhile, for non-biometric categories based on tokens or location, the literature records the utilization of RFID, QR codes, GPS-based location tracking, and experimental technologies such as high-frequency acoustic signals.

Although unimodal systems prevail, recent research trends show a shift toward Hybrid Validation Technology to address the limitations of single-technology implementations, such as proxy attendance and location spoofing. The combination of Face Recognition and Fingerprint represents the most widely applied dual-biometric hybrid scheme. Furthermore, researchers have developed integrations combining face recognition with liveness detection, ultrasonic proximity sensors, and dynamic QR codes or RFID paired with geolocation and photo evidence. These developments highlight a growing research focus on multi-layered validation architectures, although seamlessly combining direct identity verification with precise location data remains a key challenge.

3.3. RQ3: What are the primary technical limitations of existing systems, and what research gaps exist regarding hybrid validation architectures?

Synthesizing the limitations reported across the included studies reveals seven recurring technical and security challenges, summarized in Table 5. Taken together, they show that most weaknesses sit in the validation layer rather than in the web infrastructure itself.

Table 5. Key Technical and Security Limitations in the Reviewed Studies

Challenge	Reported evidence
Environmental sensitivity of face recognition	Accuracy fell to 91.2% under extreme pose (>45°) and 87.3% under heavy occlusion [20]. A KNN-based mobile prototype failed to recognize either test subject wearing a mask [23]. Poor lighting and low-quality cameras reduced recognition accuracy [24], [25].
Small or controlled evaluation data	Training data for each individual were limited and imbalanced, resulting in the best classifier achieving an accuracy of only 0.61 after anomaly removal [26]. Test datasets also frequently failed to represent actual workplace conditions: one study used a small set of celebrity photographs downloaded from the internet [24], while another used approximately 3,000 images from 150 participants at a single institution [25]. Accuracy was also lower when evaluated on a demographically diverse benchmark (RFW), indicating performance disparities across user groups [19].
Absent or weak spoofing defense	No liveness detection was implemented in [27]. Liveness detection (for example, blink detection) was recommended as future work in [25]. Printed, replayed, and mask-based attack levels were described as unresolved threats in [19].
Weak or unverified location validation	Location was derived from IP addresses in [28] or embedded in a QR payload in [29]. GPS verification was reported as vulnerable to spoofing and limited in vertical accuracy [22]. GPS integration with face recognition was only proposed as future work in [23].
Possession-based and device-bound validation	RFID verifies card possession rather than identity, and its authors list biometric authentication as a needed extension [30]. Fingerprint systems depend on dedicated devices [21]. Acoustic validation is exposed to relay attacks [22].
Performance, scalability, and cost	Verification took 6.00 s, rising to 7.98 s under dim light, which may cause queues [27]. A single-threaded Streamlit deployment lacked multi-user access control and required GPUs and HD cameras [25]. No formal load benchmark was reported in [29].
Privacy and fairness	Encryption and privacy protection of facial data were flagged as necessary [13]. AES-256 encryption and informed consent were applied in [25]. GDPR compliance and bias mitigation were discussed in [19]. Privacy concerns also affect gait-based systems [21].

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Single-factor validation remains the main source of risk. Face recognition, the most widely used modality (Table 4), is sensitive to capture conditions and data scarcity, and several evaluated systems omit a liveness check, leaving them open to printed or replayed images [25], [27]. Token-based alternatives such as RFID and QR codes verify possession rather than identity [30]. Dedicated biometric hardware avoids some of these risks but reintroduces device cost and maintenance overhead [31], which is the same burden that motivates web-based designs [32].

Hybrid validation is still immature. Only 12 of the 66 studies with an identifiable validation technology (18.2%) in Table 4 combine more than one mechanism. These combinations serve different purposes: four combine face recognition with fingerprint, four combine face recognition with liveness or anti-spoofing (one also adds an ultrasonic sensor), three introduce location (QR with geolocation in two studies, face recognition with IP-based geolocation in one), and one combines RFID, an ultrasonic sensor, and photo evidence. Critically, no hybrid in Table 4 pairs face recognition with device-level GPS, and none combines identity verification, liveness detection, and location validation in a single flow. Where location is used, its trustworthiness is limited by IP-based inference [28], payload-embedded coordinates [29], or susceptibility to spoofing [22]. None of the examined studies evaluates a hybrid scheme against combined attacks, such as a presented photo accompanied by falsified coordinates. The resulting research gaps are summarized in Table 6.

Table 6. Research Gaps in Hybrid Validation Architectures

ID	Gap	Supporting evidence
G1	No integrated flow of identity, liveness, and location	Hybrids pair face recognition with liveness (4 studies) or location (3 studies), never both; no face recognition + device GPS (Table 4).
G2	Weak trust in location data	IP-based inference [28], payload-embedded location [29], GPS spoofing [22], GPS integration only proposed [23].
G3	No explicit decision logic across factors	Factor fusion is mentioned as a plan, without thresholds, ordering, or fallback when one factor fails [21], [28].
G4	Evaluation is not attack-oriented	Attacks are tested on a single factor at most [22]; combined face and location attacks are not evaluated.
G5	Field employees and multi-site validation	Employees working at changing installation sites [23], while most reviewed systems target classrooms or fixed checkpoints.
G6	Privacy-by-design for combined face and location data	Encryption, consent, and bias handling are addressed separately [19], [23], [25].

3.4. Future Research

Based on the gaps in Table 7, we propose a staged research agenda. It is deliberately scoped to be implementable with common open-source tooling, so that the novelty comes from the architecture and its evaluation rather than from complex new algorithms.

Table 7. Proposed Future Research Directions

ID	Direction	Gap	Practical realization
F1	Web-based face recognition with GPS geofencing under one server-side decision rule	G1, G2, G3	Browser camera capture and Geolocation API; the server accepts attendance only if the face match score and the distance to an authorized site both pass. Open-source Python face recognition pipelines have proven feasible in comparable systems [26], [28].
F2	Multi-site geofencing for field employees	G5	A table of authorized sites (coordinates, radius, schedule) assigned per employee, motivated by the field-installation scenario in [23].
F3	Lightweight liveness check before matching	G1, G4	Random challenge-response (for example, blink or head turn), as recommended in [25].
F4	Location plausibility checks	G2	Reported GPS accuracy threshold, IP-to-GPS consistency (extending), and impossible-movement detection between

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			consecutive check-ins; these reduce but cannot eliminate spoofing in a browser.
F5	Attack-scenario evaluation	G4	Scripted tests with printed photos, replayed video, and falsified coordinates, reporting false acceptance and false rejection rates.
F6	Privacy-by-design storage	G6	Store face embeddings instead of raw images, encrypt at rest, and record consent, following [19], [25].

Taken together, F1 to F6 define a web-based employee attendance architecture that couples face recognition, liveness, and GPS geofencing under a single decision rule and is evaluated against combined spoofing scenarios. Within the scope of this review, such a configuration has not been reported, which indicates a defensible novelty position for follow-up system development. This conclusion is bounded by the review scope (open-access, English, Scopus-indexed journal articles), and future reviews should extend it to conference papers and other databases.

3.5. Contributions

This study makes four contributions. First, it provides a systematic mapping of 71 articles published between 2022 and 2026, covering publication trends, geographical distribution, and the software, database, and validation technology stacks of web-based attendance systems. Second, it introduces a validation taxonomy that separates single from hybrid schemes and quantifies their distribution. Third, it consolidates the reported technical and security limitations (Table 5) and derives six research gaps (Table 6), most notably the absence of a hybrid architecture that integrates face recognition, liveness, and device-level GPS in a web environment. Fourth, it translates these gaps into a practical research agenda (Table 7) that prioritizes low and medium implementation effort, so that future systems can be developed and evaluated with accessible tooling.

4. Conclusion

This systematic literature review analyzed 71 web-based employee attendance studies published between 2022 and 2026. Regarding RQ1, publication output peaked at 18 articles in both 2023 and 2024 and was led by Indonesia (19 documents). Regarding RQ2, the technology stacks combine Python-based AI frameworks with Flask, Laravel, or ASP.NET back ends, MySQL is the most frequent DBMS, and single-technology validation dominates, with face recognition as the most common modality. Regarding RQ3, hybrid schemes account for only 12 of 66 studies with an identifiable validation technology, and none integrates face recognition, liveness detection, and device-level GPS validation. Existing systems are further limited by environmental sensitivity, small evaluation datasets, spoofable or indirect location data, absent decision logic across factors, and fragmented privacy handling.

These findings establish a clear research gap and a feasible agenda: a web-based attendance architecture that fuses face recognition, liveness, and GPS geofencing under an explicit decision rule, supports multi-site field employees, and is evaluated against combined spoofing attacks. They also provide the empirical positioning for the authors' follow-up development of a web-based employee attendance system based on face recognition and GPS.

Declaration

AI Statement

The authors declare that generative AI tools were used solely to assist with language editing and grammatical improvement. All research ideas, analyses, interpretations, and conclusions are the authors' own. The authors take full responsibility for the content of this manuscript.

Author contribution

Mutia Raysha: Original Draft, Writing, Editing
Yusuf Durachman: Supervision and Reviewing

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Conflict of interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Additional information
No additional information is available.

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