

Implementation of Geofencing Method and Face Recognition Integration in the Development of a Location-Based Attendance System to Improve Attendance Accuracy

Nika Wirana¹, Yuliana², Helena Anggraeni Tjondro Sugianto³, Maria Magdala Albrisia Putri⁴

^{1,2,4}Information Technology Program, Shanti Bhuana Institute, Bengkayang, Indonesia

³Management Study Program, Shanti Bhuana Institute, Bengkayang, Indonesia

*Corresponding author: nikawirana@gmail.com

ABSTRACT

Location-based attendance systems still face challenges in validating location and verifying user identity, making them vulnerable to fake GPS manipulation and unauthorized attendance practices. This research aims to develop a web-based employee attendance system that integrates Geofencing, Haversine Formula, Face Recognition, and Cosine Similarity methods to improve the accuracy, security, and reliability of employee attendance recording at PT. Pangan Merah Putih Bengkayang. Geofencing is used to establish a virtual attendance area boundary with a 50-meter radius from the company's coordinates, while the Haversine Formula calculates the distance between the user's GPS coordinates and the central point of attendance. Face Recognition, based on the Face-api.js model, generates a 128-dimensional face embedding that is matched using Cosine Similarity with a threshold of 0.92. The system was developed using PHP, JavaScript, and MySQL, utilizing a software engineering approach and quantitative methods. Test results show that location validation using Geofencing and the Haversine Formula achieved a 100% success rate: out of five test coordinates, the system accepted four data points within the radius as valid and rejected one data point at a distance of 55.05 meters as invalid. Face recognition testing under seven conditions (lighting variations, facial angles, and unregistered faces) yielded cosine similarity values ranging from 0.92 to 0.98 for registered faces. Overall system evaluation using a Confusion Matrix on 30 scenarios of location and face combinations yielded 14 True Positives, 13 True Negatives, 2 False Positives, and 1 False Negative, with an Accuracy of 90%, Precision of 87.5%, Recall of 93.33%, and an F1-Score of 90.32%. Black box testing of eight key features (login, face registration, location validation, face verification, attendance history, and logout) demonstrated that all features performed as expected. The integration of these four methods ensures that attendance can only be performed in designated areas and by users whose identities are verified, resulting in more accurate and accountable attendance data than conventional attendance systems. However, location validation still depends on the accuracy of the user's device's GPS signal and is not yet equipped with a mock location/GPS spoofing detection mechanism, while Face Recognition accuracy is still influenced by variations in lighting and the angle at which the facial image is taken.

Keywords: Web-based attendance, Geofencing, Haversine, GPS, Face Recognition, Identity verification.

1. INTRODUCTION

Advances in information technology have encouraged various organizations and companies to undertake digital transformation, including in employee attendance

management(Gregorius Aryo Prasajo & Christian Cahyaningtyas, 2025). Previously manual attendance systems still suffer from weaknesses, such as being prone to fraud, recording errors, and slow data recapitulation. Therefore, a technology-based attendance system is needed that can increase attendance validity while minimizing data manipulation. Several previous studies have shown that integrating location-based technology and facial biometrics can be an effective solution in developing attendance systems. Research by Miharja demonstrated that an Android-based attendance system combining Face Net, Cosine Similarity, and GPS-based location restrictions significantly improved attendance validation accuracy(Miharja, 2024). Meanwhile, other research on geolocation- and facial recognition-based employee attendance systems demonstrated that the combination of location and identity verification can help speed up the attendance process and simplify attendance recording. In this study, the problem identified was that the previously developed web-based attendance system still had limitations in validating user location and identity. The system was still vulnerable to location manipulation, including the use of fake GPS, which could allow attendance to be taken from outside the designated work area. Furthermore, the available selfie feature cannot fully guarantee that the attendance process is carried out by the legitimate account holder. This situation indicates the need to develop a system that not only validates user presence spatially but also verifies user identity through facial biometrics.

To address this issue, this research implements the Geofencing method combined with the Haversine Formula to more accurately calculate the distance between the user's position and the center point of the attendance location. Geofencing is used to limit the attendance area based on a specific radius, while Haversine helps ensure the distance calculation is carried out mathematically by considering latitude and longitude coordinates(Gede et al., n.d.). Thus, the system only accepts attendance when the user is within the permitted area. In addition to location validation, this research also integrates Face Recognition to verify user identity through facial matching. In thesis, this process uses the Cosine Similarity approach and facial embedding data to represent the user's facial features. This integration is crucial to minimize the practice of taking attendance for granted, the use of accounts by others, and the misuse of photos, thereby making the attendance system more secure and accountable(Sirait et al., 2025).

Based on the above description, the research entitled "Implementation of Geofencing Method and Face Recognition Integration in the Development of a Location-Based Attendance System to Improve Attendance Accuracy" was conducted to produce a web-based attendance system capable of validating location and identity simultaneously. This system is expected to improve attendance accuracy, strengthen attendance data security, and support a more effective employee attendance management process at PT. Pangan Merah Putih Bengkayang.

2. METHODS

This research uses software engineering methods with a quantitative approach to develop and web-based attendance systems that integrate Geofencing methods, Haversine algorithms, and Face Recognition.

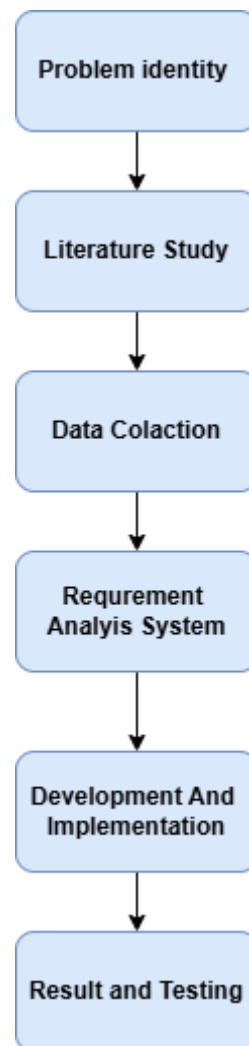


Figure 2.1 Research stages

Based on Figure 1, the research begins with problem identification as the basis for system development. The next stages include a literature study and data collection to obtain relevant information. Subsequently, a system requirements analysis is conducted to support the development and implementation process. Finally, the developed system is tested to evaluate its performance and produce research results in accordance with the defined objectives.

2.1 Geofencing

According to (Najah & Frendiana, 2025), geofencing is a technology that establishes virtual geographic boundaries on a map to monitor the movement of objects or individuals within a specific area. By establishing virtual parameters around the desired area, this system can provide alerts when a device crosses a specific boundary. One way to implement geofencing is by installing a GPS to track the object and its location, comparing it to the geofence location

2.2 Haversine

The Haversine Formula equation is used to calculate the distance between two points on the Earth's surface using longitude and latitude as input variables. According to (Albanu et al., 2026), the Haversine Formula is an important equation in navigation, used to find the distance between two points on a sphere using longitude and latitude. This is a special form of spherical trigonometry equation, the law of haversines, which finds the relationship between the sides and angles of a triangle in a spherical plane.

2.3 Face Recognition

According to (Fadlil & Prayogi, 2022), face recognition is a biometric system widely applied across various fields, particularly for identification and verification purposes in security contexts as it identifies and verifies individuals based on facial characteristics. Each face recognition method has its own distinct process, along with respective advantages and limitations. However, scientifically, face recognition is a biometric identification technique that uses the face as the primary parameter to verify or identify an individual's identity through analyzing contour patterns, distances between features, and facial texture in digital images or videos (Giovanni et al., 2023).

2.4 Data Collection

Data collection technique explains the important steps in research to obtain accurate and relevant information according to the research needs.

Observation

Directly observing the attendance process at PT. Pangan Merah Putih. This activity aims to understand the system flow, identify any problems, and understand the need for a more effective and secure attendance system.

Interviews

Interviews were conducted with relevant parties, such as the company's HRD and operational managers. The goal was to obtain direct information regarding the system requirements, current obstacles encountered in the attendance process and attendance data management, and user expectations regarding the system to be developed.

Documentation

The documentation technique was carried out by collecting data in the form of documents, reports, and other supporting data related to the attendance system. The documents collected in this study were employee attendance data. This data is used to supplement the information obtained from observations and interviews, thereby supporting a more comprehensive analysis and system development process

2.4.1 Manual Calculation

Manual calculations were performed to ensure that the implementation of the Haversine algorithm in the system resulted in accurate distance calculations. The following is the data used in calculating distance using haversine. the following data is used.

Table 2. 1 Location Data

No	Lalitude	Longitude
1	0.83947000	109.47942400
2	0.83986250	109.47959285
3	0.83984859	109.47961815
4	0.83968870	109.47964800
5	0.83969670	109.47964000

Table 3.1 presents the GPS coordinate data used as the basis for calculating Geofencing and the Haversine algorithm in the location validation process in the attendance system. The first stage in this manual calculation begins by calculating the user's absence distance, whether it is within the radius or not. The five location data points in Table 3.1 above will be averaged to determine the office location coordinates.

Average latitude = $((0.83947000 + 0.83986250 + 0.83984859 + 0.83968870 + 0.83969670))/5$
 $= 0.83971330$

Average longitude = $((109.47942400 + 109.47959285 + 109.47961815 + 109.47964800 + 109.47964000))/5$
 $= 109.47966460$

Therefore, the coordinates used are

Average latitude = 0.83971330

Longitude = 109.47966460

The office coordinates were obtained by averaging five GPS coordinate samples. The averaging process aims to reduce GPS signal fluctuations and provide a more stable reference

point. Based on the calculation, the office coordinates are latitude 0.83971330 and longitude 109.47966460, which are then used as the geofence center in the distance calculation.

- Parameter Value

Office latitude 0.83971330

Office longitude 109.47966460

User longitude 0.83929750

User longitude 109.47970650

The calculation parameters consist of the office coordinates as the geofence reference point and the user's coordinates obtained from the device's GPS during attendance. These coordinates serve as the input data for the Haversine distance calculation.

- Manual Haversine Calculation

Degree to Radian Conversion Formula: $(^\circ) \times \pi/180$

Note: $\pi = 3.14159$

$\text{lat1} = 0.83971330 \times 3.14159/180 = 0.01465576 \text{ rad}$

$\text{lat2} = 0.83929750 \times 3.14159/180 = 0.01464850 \text{ rad}$

$\text{lon1} = 109.47966460 \times 3.14159/180 = 1.91078061 \text{ rad}$

$\text{lon2} = 109.47970650 \times 3.14159/180 = 1.91078134 \text{ rad}$

Since the Haversine formula uses trigonometric functions, all coordinate values expressed in degrees must first be converted into radians using the equation $\text{degree} \times \pi/180$, where π equals **3.14159**. These converted values are then used in the following calculations.

- Calculating the Coordinate Difference

$\Delta\text{lat} = \text{lat2} - \text{lat1}$

$\Delta\text{lat} = 0.0146850 - 0.01465576$

$\Delta\text{lat} = -0.00000726$

$\Delta\text{lon} = \text{lon2} - \text{lon1}$

$\Delta\text{lon} = 1.91078134 - 1.91078061$

$\Delta\text{lon} = -0.00000073$

Next, the differences in latitude and longitude between the user's position and the office location are calculated. These coordinate differences represent the positional gap between the two locations and are required for the Haversine equation.

- Substitute into the Haversine Formula

Formula: $a = \sin^2(\Delta\text{lat}/2) + \cos(\text{lat}1) \times \cos(\text{lat}2) \times \sin^2(\Delta\text{lon}/2)$

$$a = \sin^2(-0.00000726/2) + \cos(0.01465576) \times \cos(0.01464850) \times \sin^2(-0.00000073/2)$$

$$a \approx (1.31769 \times 10^{-11})^2 + (0.99989260)(0.99989270) \times (1.33225 \times 10^{-13})^2$$

$$a \approx 1.31769 \times 10^{-11} + 1.33196 \times 10^{-13}$$

$$a \approx 1.33101 \times 10^{-11}$$

The value of a is obtained by substituting the coordinate differences into the Haversine formula. This value represents the square of half the chord length between two points on the Earth's surface. The calculation results in $a = 1.33101 \times 10^{-11}$.

- Calculating Values c

Formula: $c = 2 \times \arcsin(\sqrt{a})$

$$\sqrt{a} = \sqrt{(1.33101 \times 10^{-11})}$$

$$\sqrt{a} = 3.64830 \times 10^{-6}$$

$$c = 2 \times \arcsin(3.64830 \times 10^{-6})$$

$$c \approx 2 \times 3.64830 \times 10^{-6}$$

$$c \approx 7.29660 \times 10^{-6}$$

- Calculating Distance

Formula: $d = R \times c$

Where:

$$R = 6,371,000 \text{ meters}$$

$$d = 6,371,000 \times 7.29660 \times 10^{-6}$$

$$d = 46.48 \text{ meters}$$

Determining Geofence Status

Geofence radius = 50 meters

Calculated distance = 46.48 meters

Because: $46.48 \text{ meters} \leq 50 \text{ meters}$

Then the user's location is within the geofence area and the attendance is accepted.

2.2 Requirements Analysis System

A system requirements analysis was conducted to identify functions, devices, and limitations to ensure attendance is recorded only in designated areas with identity verified through facial recognition. These requirements covered functional, non-functional, user, and security aspects, as well as issues with the previous system. The following is a flowchart of the attendance system.

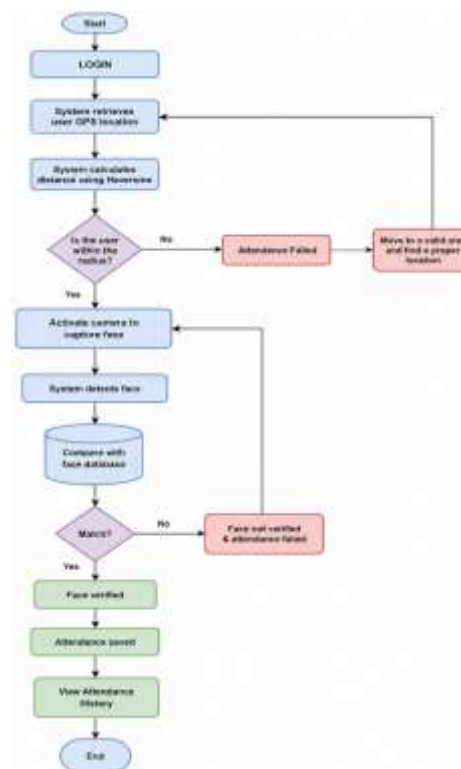


Figure 2. 1 Flowchart

Figure 2.1 illustrates the workflow of the proposed attendance system. The system validates location using Geofencing and the Haversine algorithm, then verifies user identity through Face Recognition. Attendance data is only stored if the user is within the designated area and facial identity is successfully verified.

3. RESULTS AND DISCUSSIONS

3.1 Implementation Results

This research successfully developed a web-based attendance system that integrates GPS-based geofencing, Haversine Formula calculations, and facial recognition technology as a user identity validation mechanism. The system implementation consists of several main modules: the attendance page and the attendance history page.

Attendance Page

This attendance page is the main interface used by users to record attendance based on geofencing and facial recognition. On this page, the system displays a real-time camera to detect and verify the user's face

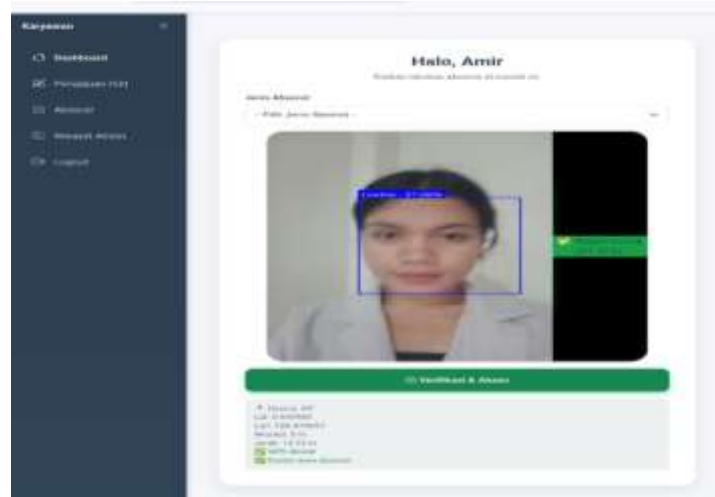


Figure 3.3 Absence Page

Based on the image above, the system successfully detected the user's face, which is marked with a blue box in the camera area. Users can press the face verification button to begin the face matching process with previously stored facial data in the system. At the bottom of the face page, the user's location information is displayed. The "Within Attendance Area" status indicates that the user is within the specified geofencing radius and therefore meets the requirements for attendance.

Absence History page

The attendance history page is a feature used to display all employee attendance data. This feature is designed to provide transparency and convenience for employees to independently monitor and evaluate their attendance history



The screenshot shows the 'Riwayat Absensi - Amir' page. It features a table with columns: No, Tanggal, Jam Masuk, Jam Pulang, Status, and Detail. The table contains four rows of attendance data for the employee Amir.

No	Tanggal	Jam Masuk	Jam Pulang	Status	Detail
1	23-01-2026	13:23:55	11:30:54	Hadir	Detail
2	23-01-2026	14:01:41	14:20:16	Hadir	Detail
3	27-01-2026	16:29:05	16:10:48	Hadir	Detail
4	27-01-2026	13:30:40	15:47:19	Hadir	Detail

Figure 3.4 Absence History Page

Based on the image above, the absence history page displays a list of employee attendance data in a structured table. This page allows employees to check their saved attendance data, facilitating accurate and well-documented monitoring and verification of absence history.

3.2 Test Result

3.2.1 Face Recognition Testing

The face matching process is performed using the Cosine Similarity method by comparing the 128-dimensional face embedding of the face image during attendance with the facial data stored in the database. The obtained similarity value is then compared with a threshold to determine whether the user's face matches or not. The results of the Face Recognition test using the Cosine Similarity approach are presented in Table 3.1.

Table 3. 1 Face Recognition Test Result

No	Test Conditions	Cosine Similarity	Threshold	Result
1	Normal light facing the camera	0.97889	0.92	Accepted
2	Bright light facing the camera	0.96099	0.92	Accepted
3	Dim light facing the camera	0.94066	0.92	Accepted
4	Normal light left	0.95888	0.92	Accepted
5	Normal light right	0.95909	0.92	Accepted
6	Normal light looking down/up	0.920808	0.92	Accepted
7	Face not registered	0.864663	0.92	Rejected

These results show that the use of Face Recognition based on face embedding and Cosine Similarity has a high level of reliability for application in digital attendance systems.

3.2.2 Geofencing dan Haversine Test Result

This test was conducted to determine the system's ability to validate attendance locations using the Geofencing method. Input parameters were the latitude and longitude coordinates of seven test points obtained directly from a GPS device. The distance of each test point to the center of the attendance location was calculated using the Haversine algorithm, then compared to the 50-meter geofencing radius to determine whether it was "within the radius" or "outside the radius." The test results are presented in Table 3.2.

Table 3. 2 Geofencing Test Result

No	Latitude	Longitude	Haversine distance	Geofencing Status	Test Results
1	0,830414	109,479695	11,93	Within Radius	succeed
2	0,830322	109,479556	19,55	Within Radius	succeed
3	0,830426	109,479694	20,09	Within Radius	succeed
4	0,830426	109,479694	26,19	Within Radius	succeed
5	0,830650	109,479996	36,20	Within Radius	succeed
6	0,830106	109,479827	44,37	Within Radius	succeed
7	0,830106	109,479703	55,05	Outside Radius	rejected

Based on the test results in the table above, six of the seven test points (Nos. 1–6) produced distances between 11.93–44.37 meters, all within a 50-meter radius, thus declared "Within radius" and the attendance status is Valid. The 7th test point produced a distance of 55.05 meters, exceeding the specified radius limit, thus declared "Outside radius" and the attendance status is Invalid. These results indicate that the system is able to accurately distinguish the user's position based on the Haversine distance calculation, with a location validation success rate of 100%.

3.2.3 Attendance validation testing

The overall system testing was conducted using the Confusion Matrix method to evaluate the system's performance in classifying attendance processes as Valid or Invalid based on a combination of Geofencing and Face Recognition. The assessment used four main components, namely True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN), against 30 test scenarios with various combinations of location conditions (inside/outside radius) and facial conformity (match/not match registered data).

Table 3. 3 Attendance validation testing

No	Test scenario	Current	System results	Category
1	Within radius + face accordingly	Valid	Valid	TP
2	Within radius + face accordingly	Valid	Valid	TP
3	Within radius + face accordingly	Valid	Valid	TP

No	Test scenario	Current	System results	Category
4	Within radius + face accordingly	Valid	Valid	TP
5	Within radius + face accordingly	Valid	Valid	TP
6	Within radius + face accordingly	Valid	Valid	TP
7	Within radius + face accordingly	Valid	Valid	TP
8	Within radius + face accordingly	Valid	Valid	TP
9	Within radius + face accordingly	Valid	Valid	TP
10	Within radius + face accordingly	Valid	Valid	TP
11	Within radius + face accordingly	Valid	Valid	TP
12	Within radius + face accordingly	Valid	Valid	TP
13	Within radius + face accordingly	Valid	Valid	TP
14	Within radius + face accordingly	Valid	Not valid	FN
15	Within radius + face accordingly	Valid	Valid	TP
16	Within radius + face accordingly	Not valid	Not valid	TN

No	Test scenario	Current	System results	Category
17	Within radius + face does not match	Not valid	valid	FP
18	Within radius + face does not match	Not valid	Not valid	TN
19	Within radius + face does not match	Not valid	Not valid	TN
20	Within radius + face does not match	Not valid	Not valid	TN
21	Within radius + face does not match	Not valid	Not valid	TN
22	Within radius + face does not match	Not valid	Not valid	TN
23	Outer radius + face fit	Not valid	Not valid	TN
24	Outer radius + face fit	Not valid	Not valid	TN
25	Outer radius + face fit	Not valid	Not valid	TN
26	Outer radius + face fit	Not valid	Not valid	TN
27	Outer radius + face fit	Not valid	Not valid	TN
28	Outer radius + face fit	Not valid	Valid	FP
29	Outer radius + face fit	Not valid	Not valid	TN
30	Outer radius + face fit	Not valid	Not valid	TN

Based on the test results in Table 5.3, the system obtained 14 True Positive (TP) data, which is the condition when the user is within the geofencing radius and the face is successfully recognized so that the attendance is declared valid, as well as 13 True Negative (TN) data, which is the condition when the system successfully rejects attendance that does not meet the requirements. In addition, 2 False Positive (FP) data were found, which is the condition when the system accepts attendance that should be rejected, and 1 False Negative (FN) data, which is the condition when the system rejects attendance that should be accepted. Overall, from 30 test scenarios, the system successfully classified 27 scenarios correctly (Accuracy 90%) and experienced misclassification in 3 scenarios, indicating that the system has a good level of accuracy in validating the attendance process based on a combination of Geofencing location verification and Face Recognition identity verification

Table 3. 4 Recapitulation of the results of the attendance validation test

Category	Amount
True Positif (TP)	14
False Positif (FP)	2
False Negatif (FN)	1
True Negatif (TN)	13
Total Data	30

Calculation results

Accuracy

$$\begin{aligned}
 \text{Accuracy} &= \frac{TP+TN}{TP+FP+FN+TN} \times 100\% \\
 &= \frac{14+13}{14+14+2+1} \times 100\% \\
 &= \frac{27}{30} \times 100\% = 90\%
 \end{aligned}$$

Precision

$$\begin{aligned}
 \text{Precision} &= \frac{TP}{TP+FP} \\
 &= \frac{14}{14+2} \times 100\% = \frac{14}{16} \times 100\% = 87,5\%
 \end{aligned}$$

Recall

$$\begin{aligned}
 \text{Recall} &= \frac{TP}{TP+FN} \\
 &= \frac{14}{14+1} \times 100\% = 93,33\%
 \end{aligned}$$

F1-Score

$$F1 = \frac{2 \times \text{precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$= \frac{2 \times 87,5 \times 93,33}{87,5 + 93,33}$$

$$= \frac{16332,75}{180,83} 90,32\%$$

Based on the results of the Confusion Matrix calculation, the system achieved 90% Accuracy (27 out of 30 data were correctly classified), 87.5% Precision, 93.33% Recall, and 90.32% F1-Score. These results indicate that the system has good performance and a balance between precision and the ability to recognize valid data (recall) in validating the attendance process using Geofencing and Face Recognition.

4. CONCLUSIONS

This research successfully developed a web-based attendance system integrating Geofencing, Haversine Formula, Face Recognition, and Cosine Similarity to validate user location and identity. Geofencing and the Haversine Formula achieved a 100% success rate in location validation, while the overall system, evaluated using a Confusion Matrix on 30 test scenarios, achieved 90% accuracy, 87.5% precision, 93.33% recall, and an F1-score of 90.32%. These results confirm that the integration of the two methods improves the accuracy and security of the attendance process and helps minimize the potential for fraud. The limitations of this research lie in the influence of lighting conditions, facial angle, and GPS signal stability, which can affect Face Recognition accuracy and location validation consistency. These limitations stem from technical and operational factors during implementation rather than flaws in the research design. Future research is recommended to adopt more adaptive face recognition methods and conduct testing across more diverse environments and a larger number of users to strengthen the validity of the results.

5. REFERENCES

- Fadlil, A., & Prayogi, D. (2022). *Sistem Pengenalan Wajah pada Keamanan Ruangan Berbasis Convolutional Neural Network*. 6(September), 636–647.
- Gede, I. D., Pucanganom, A., Arna, G., Saskara, J., & Seputra, K. A. (n.d.). *GEOFENCING DAN FACE RECOGNITION PADA SISTEM PRESENSI STUDI KASUS: SD SARASWATI 4 DENPASAR*. 14(2).
- Gregorius Aryo Prasajo, & Christian Cahyaningtyas. (2025). Implementasi Algoritma Haversine Formula Dengan Global Positioning System Pada Sistem Absensi Pegawai. *Jurnal Komputer Teknologi Informasi Sistem Informasi (JUKTISI)*, 4(2), 598–607. <https://doi.org/10.62712/juktisi.v4i2.469>
- Miharja, R. B. (2024). *Aplikasi presensi dengan face recognition & geolocation pada koperasi mitra husada mandiri leuwiliang bogor*.
- Sirait, A., Siddik, M., Informatika, T., Asahan, U., Utara, S., & Informatika, T. (2025). *Implementasi Algoritma Cosine Similarity Dalam Pengenalan*. 9(1), 1–17.