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Implementation of a Chatbot-Based AI Agent for Employee and Student Attendance Systems with Face Recognition and N8N Integration

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Abstract

Students frequently rely on direct messaging to verify the presence of lecturers and staff on campus, a practice that often results in delayed responses due to the recipients' busy schedules. This study aims to design, implement, and evaluate an automated attendance system based on an AI agent utilizing face recognition technology and n8n as a centralized workflow automation platform. The research employs a Research and Development (R&D) approach with the Agile development method. Real-time face detection and recognition are performed from CCTV camera feeds using a Python module that integrates the InsightFace and MediaPipe algorithms. Identified attendance data is automatically stored in Google Sheets, subsequently processed by n8n to deliver information to users via a WhatsApp chatbot powered by the Gemini 2.5 Flash model. Testing conducted on 419 samples yielded an accuracy of 86.16%, with 275 True Negative values demonstrating the system's capability in filtering unregistered faces. The overall average system latency was 15.9 seconds, with a chatbot automation response time of only 9.3 seconds. This research demonstrates that the integration of workflow automation and AI agents is effective in improving the efficiency of academic attendance information access.

Keywords: *AI agent; chatbot; face recognition; N8N; workflow automation*.

1. Introduction

Lecturer and staff attendance constitutes critical information for sustaining the smooth operation of academic activities in higher education institutions [1]. Students frequently require real-time confirmation of personnel availability, particularly for thesis supervision and academic consultations, yet they continue to rely on direct messaging as the primary inquiry method, a practice that is inherently inefficient since responses are entirely dependent on the recipient's availability, resulting in significant information delays that disrupt student time management [2], [3]. Existing automated attendance solutions predominantly employ IoT-based hardware or standalone face recognition pipelines without an integrated information distribution mechanism [15], [16], meaning that even when attendance data is captured automatically, delivering that information to end-users still requires manual intervention and negates a substantial portion of the automation benefit. No prior work has examined the use of n8n — a fair-code workflow automation platform — as the central orchestrator connecting real-time face recognition, cloud databases, and instant messaging in a unified academic attendance system [17], [18], [19]. This study addresses that gap by designing, implementing, and evaluating an AI agent-based attendance system that integrates InsightFace-powered face recognition via CCTV, Google Sheets as the data backend, and a WhatsApp chatbot driven by the Gemini 2.5 Flash language model, with n8n serving as the end-to-end workflow automation hub to deliver attendance information autonomously and in near-real-time. This paper is organized as follows: Section 2 reviews the relevant literature; Section 3 describes the research methodology; Section 4 presents results and discussion; and Section 5 concludes with directions for future work.

2. Literature Review

2.1. Artificial Intelligence and AI Agents

Artificial Intelligence (AI) is a field of science and engineering focused on developing intelligent machines, particularly computer programs or applications capable of mimicking human intelligence [7]. AI has become a key concept in the era of Industry 4.0 and Society 5.0, encompassing the development of computer programs, machine learning algorithms, and the integration of hardware and software to create intelligent and adaptive systems [8]. One of the rapidly developing forms of AI application is the AI agent, a system designed to operate autonomously or semi-autonomously in executing specific tasks [9].

2.2. Chatbot

A chatbot, or automated conversational agent, is a computer system designed to simulate natural interaction with human users through visual displays, written text, or spoken conversation [10]. In chatbot systems, language models serve as the primary intelligence component, enabling the chatbot to understand human language and generate relevant, comprehensible responses within a conversational context [11]. This positions chatbots not merely as communication technologies but also as adaptive mediators bridging human interaction needs with digital systems.

2.3. Face Detection and Face Recognition

Face detection is a significant application within computer vision that enables systems to automatically recognize the presence of faces in images or videos, offering substantial potential in expediting and efficiently processing visual data [12]. This study employs MediaPipe as the face detection algorithm due to its key advantages in processing speed, efficiency, and accuracy. MediaPipe is a machine-learning-based framework capable of processing visual data in real-time with high performance [13].

Face recognition represents a method deployed across various technological devices to identify users. The face recognition algorithm employed in this study is InsightFace, a framework built on a Convolutional Neural Network (CNN) architecture. InsightFace operates by extracting edge features and gradient patterns from detected face images, thereby effectively representing the structural characteristics of a face [14]. Each detected face is converted into a numerical feature vector (face embedding) of 512 dimensions. This feature vector is subsequently compared against stored facial data using Euclidean distance measurement to determine the degree of similarity between faces.

2.4. N8N Workflow Automation

N8N is a fair-code-based automation platform that provides flexibility in building workflows tailored to user requirements. When combined with AI-powered Natural Language Processing (NLP) technology, this integration creates significant opportunities to develop smarter and more responsive chatbots. Through automated workflows, chatbots can be optimized to perform various functions, ranging from recording conversation histories and categorizing data by context to presenting analytical reports in both visual and textual formats [6]. N8N functions as the primary connector between face recognition modules, databases, and WhatsApp chatbot services.

2.5. Related Work

Several studies are relevant to this research. An IoT-based student attendance system utilizing ESP32 Cam and NodeMCU combined with barcode and face recognition technology achieved approximately 80% success rate, with a 20% error rate primarily influenced by facial pose during detection [15]. A CNN-based face recognition attendance system integrated with OpenCV demonstrated high accuracy and the ability to label unregistered individuals as unknown [16]. N8N has been applied for automated technical documentation validation workflows integrated with GitHub and WhatsApp for real-time notifications, sharing similarities with the present study in employing n8n as a workflow automation platform [17]. Deep learning architectures have been explored for intelligent workflow dynamics in n8n, emphasizing autonomous orchestration and adaptive task scheduling [18]. The performance of n8n in self-hosted workflow automation has been evaluated, demonstrating that n8n can accelerate workflow execution, reduce latency, and provide superior control over automation systems in managed environments [19].

3. Research Method

3.1. Research Type and Location

This research is classified as applied research with an evaluative dimension, conducted at the 4th floor of the Faculty of Science and Technology Building, UIN Alauddin Makassar. The study not only constructs a face recognition system based on InsightFace and n8n workflow automation but also evaluates its success through metrics of accuracy, precision, recall, F1-Score, and system latency.

3.2. Research Approach and Data Sources

A quantitative descriptive approach is applied to analyze numerical data obtained from testing the face recognition-based attendance system, encompassing True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN) values to measure the performance and accuracy of the facial recognition algorithm, alongside latency measurements in seconds to evaluate the speed of workflow automation on the n8n platform.

Primary data consists of facial images of lecturers/staff obtained from the official website of the Information Systems Study Program (https://sin.fst.uin-alauddin.ac.id/), and facial images of student teaching assistants collected through online communication or direct capture using a smartphone camera. Secondary data was obtained from relevant literature, including scientific journals, articles, and technical documentation related to face recognition, chatbot, workflow automation, and n8n.

3.3. System Development Method

This study employs the Agile development method, an iterative approach used in software development to produce adaptive and responsive systems in response to changing requirements [20]. The Agile model encompasses six stages: Requirement, Design, Development, Testing, Deployment, and Maintenance. Each stage was iteratively applied throughout the system development cycle.

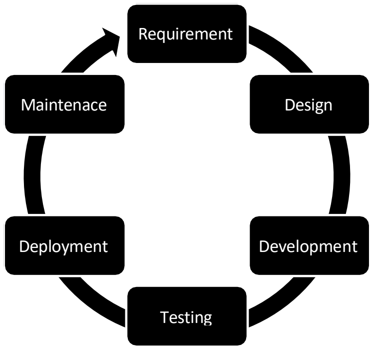


Fig. 1: Agile development method employed in this study

3.4. System Architecture

Fig. 2 illustrates the end-to-end flow of the proposed system. The process begins when the CCTV camera captures facial images in real-time, which are then processed by the Python-based face recognition module. The system checks whether the detected face matches a registered identity in the dataset. If matched, attendance data comprising the individual's name, status, timestamp, and a snapshot link is automatically stored in Google Sheets. If unmatched, the face is recorded as Unknown. N8N continuously monitors the Google Sheets database and, upon detecting new entries, coordinates the AI agent to process user requests and deliver attendance information through the WhatsApp chatbot interface.

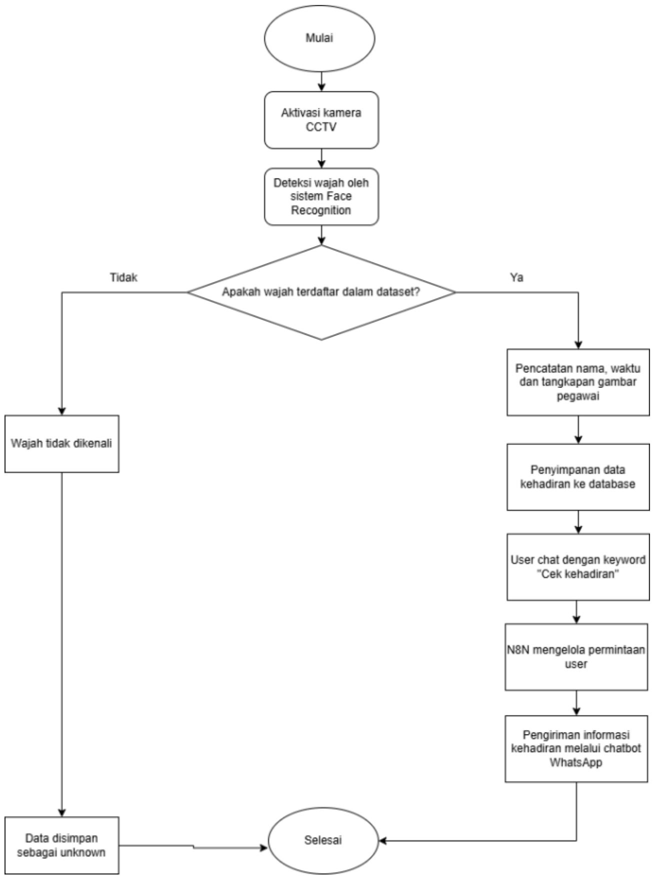


Fig. 2: Proposed system architecture diagram

3.5. Data Processing Pipeline

The data processing pipeline encompasses five sequential stages. In the first stage, **Data Preparation**, facial images of 12 staff/lecturers and 23 student teaching assistants are collected and validated as the initial dataset. The second stage, **Data Preprocessing**, involves upscaling and augmentation of facial images to diversify data variations, after which the InsightFace Buffalo_L model converts all images into 512-dimensional numerical vectors known as face embeddings. The third stage, **Embedding Matching**, compares facial vectors captured from the CCTV against the dataset using the Euclidean distance formula $d(p,q) = \sqrt{\Sigma(p_i - q_i)^2}$; if $d(p,q) < 1.09$

(ACCEPT_THRESHOLD) the identity is verified as a registered individual, whereas if *d(p,q)* > 1.20 (REJECT_THRESHOLD) the face is classified as Unknown. In the fourth stage, **Data Synchronization and Storage**, the system uploads a facial snapshot to Google Drive and writes the packaged metadata comprising name, status, timestamp, and image link to Google Sheets. Finally, in the fifth stage, **Data Distribution**, n8n monitors Google Sheets via event-driven triggers and coordinates the AI agent powered by Gemini 2.5 Flash to synthesize contextual messages and deliver attendance information to users via the WhatsApp API in real-time.

3.6. Evaluation Metrics

System performance is evaluated using four standard classification metrics derived from the confusion matrix. Accuracy measures the overall correctness of the system, as defined in equation (1). Precision quantifies the proportion of correctly identified registered individuals among all positive predictions, as defined in equation (2). Recall measures the proportion of registered individuals correctly detected by the system, as defined in equation (3). The F1-Score represents the harmonic mean of precision and recall, providing a balanced performance indicator, as defined in equation (4).

$$\text{Accuracy} = (TP + TN) / (TP + FP + FN + TN) \times 100\% \quad (1)$$

$$\text{Precision} = TP / (TP + FP) \quad (2)$$

$$\text{Recall} = TP / (TP + FN) \quad (3)$$

$$\text{F1-Score} = 2 \times (\text{Precision} \times \text{Recall}) / (\text{Precision} + \text{Recall}) \quad (4)$$

System effectiveness is additionally assessed through end-to-end latency, measured from the moment the CCTV camera first captures an identity to the point at which the attendance notification is fully received by the user via WhatsApp.

4. Results and Discussion

4.1. System Implementation

The system was successfully implemented and deployed at the 4th floor of the Faculty of Science and Technology, UIN Alauddin Makassar. The n8n platform, self-hosted via Docker, orchestrates two distinct workflows. Workflow 1 manages real-time user interactions from WhatsApp trigger reception through the Waha API, AI agent processing, Google Sheets data retrieval, to response delivery. Workflow 2 handles proactive notification dispatch monitoring new attendance entries via Google Sheets Trigger, matching detected names against the queued notification list (save_antrian sheet), and automatically sending WhatsApp messages upon successful name matching.

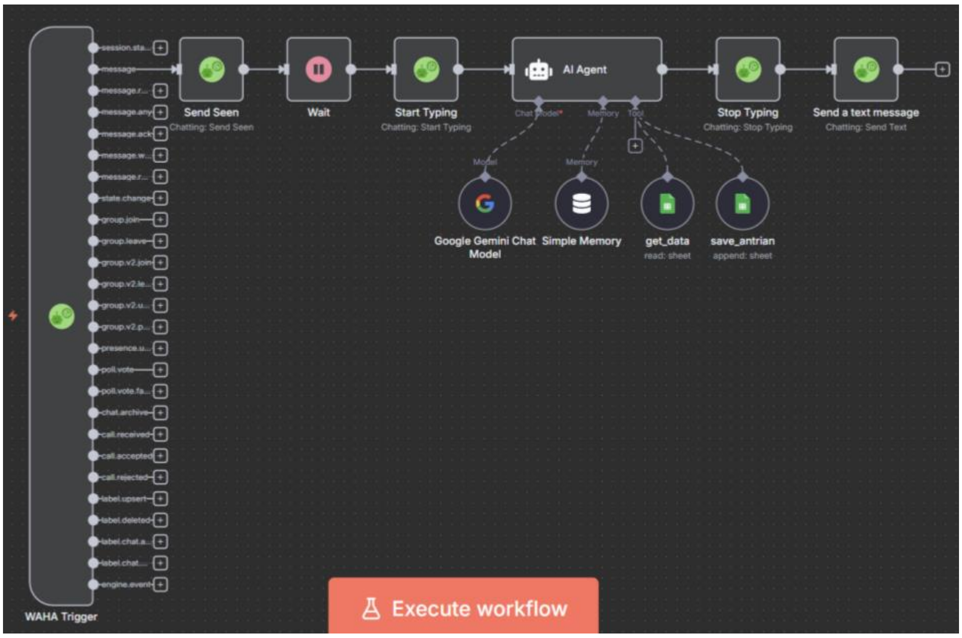


Fig. 3: Implementation of Workflow 1 in n8n platform

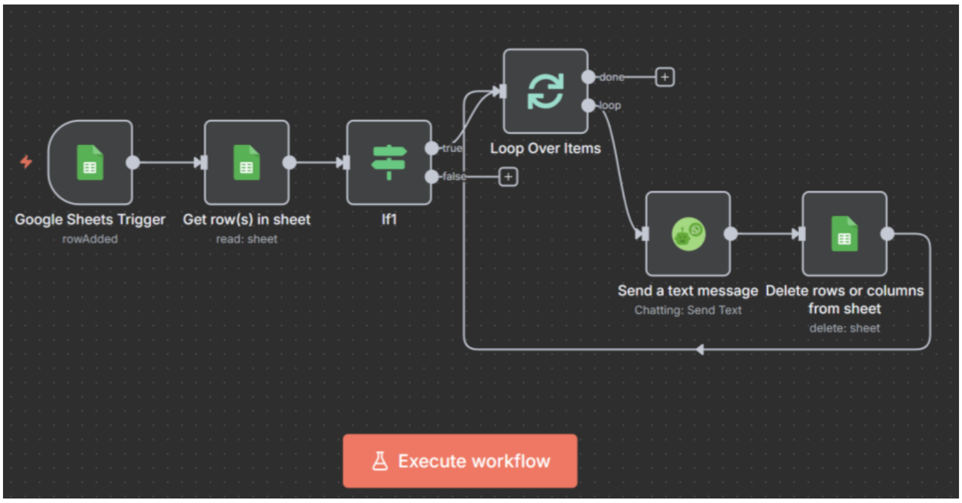
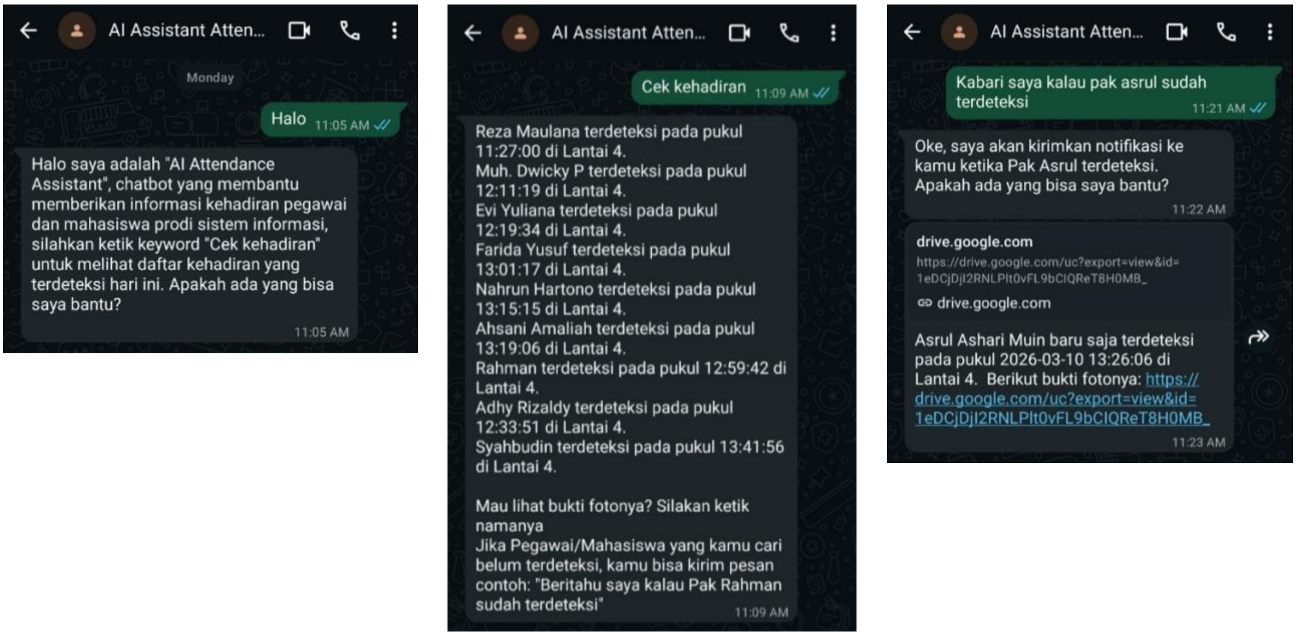


Fig. 4: Implementation of Workflow 2 in n8n platform

The chatbot interface, accessible via WhatsApp, supports multiple interaction scenarios including attendance checking, attendance proof verification (with Google Drive image links), proactive notification requests, and graceful handling of typos, informal messages, and ambiguous inputs, all powered by the contextual understanding capability of the Gemini 2.5 Flash model.



(a) (b) (c)

Fig. 5: WhatsApp chatbot interface: (a) initial conversation, (b) attendance check, (c) notification request.

4.2. Dataset and Preprocessing Results

The dataset registered in the system comprised two groups from the academic community of the Information Systems Study Program, UIN Alauddin Makassar, as presented in Table 1.

Table 1: Facial dataset composition

No.	Category	Number of Individuals
1	Lecturers/Staff	12
2	Student Teaching Assistants	23
	Total	35

Following upscaling and augmentation, all facial images in the dataset were converted by the InsightFace Buffalo_L model into 512-dimensional numerical vectors. Representative sample embeddings are presented in Table 2.

Table 2: Sample face embedding results from data preprocessing

No.	Identity Label	Face Embedding (512d)
1	Subject A	[-5.321, 1.180, -3.808, …, -3.126]
2	Subject B	[-5.467, -6.311, -3.087, …, -2.168]
3	Subject C	[-6.181, -6.180, -4.148, …, 4.582]
4	Subject D	[-1.205, 3.303, 2.659, …, -2.593]
5	Subject E	[2.508, 6.156, 5.048, …, -4.583]

4.3. Face Recognition Accuracy Evaluation

The face recognition system was evaluated against 419 samples collected across multiple observation sessions at the research location. Table 3 presents the resulting confusion matrix.

Table 3: Confusion matrix of face recognition results

	Predicted Positive	Predicted Negative	Total Actual
Actual Positive	86 (TP)	38 (FN)	124
Actual Negative	20 (FP)	275 (TN)	295
Total Predicted	106	313	419

The calculated performance metrics derived from the confusion matrix are summarized in Table 4.

Table 4: System performance metrics

Metric	Value (%)
Accuracy	86.16
Precision	81.13
Recall	69.35
F1-Score	74.78

The system achieved an overall accuracy of 86.16%, derived by substituting TP = 86, TN = 275, FP = 20, and FN = 38 into equation (1). The high True Negative count (TN = 275) demonstrates that the InsightFace algorithm with the configured acceptance threshold is highly robust in filtering unregistered faces as "Unknown", ensuring the integrity of the attendance database. However, the Recall value of 69.35% indicates that a number of registered subjects were not detected by the system (38 False Negatives). The 38 False Negative cases and 20 False Positive cases are further examined in the context of functional testing results presented in Section 4.5.

4.4. System Effectiveness and Latency Evaluation

System effectiveness was evaluated through end-to-end latency measurement, defined as the interval from the moment the CCTV camera first detects an identity to the point the attendance notification is fully received by the user via WhatsApp. Table 5 presents the latency results for ten representative detection events.

Table 5: End-to-end system latency results

Subject Detected	CCTV Timestamp	Sync Duration (CCTV→Sheets)	Chatbot Response (Bot→User)	Total Latency
Subject A	2026-02-26 12:52:54	5 sec	9 sec	14 sec
Subject B	2026-02-27 09:59:14	5 sec	10 sec	15 sec
Subject C	2026-02-27 13:14:56	19 sec	9 sec	28 sec
Subject D	2026-03-10 12:08:58	6 sec	10 sec	16 sec
Subject E	2026-03-10 13:50:14	8 sec	10 sec	18 sec
Subject F	2026-03-11 14:42:01	5 sec	10 sec	15 sec
Subject G	2026-03-04 13:03:03	4 sec	7 sec	11 sec
Subject H	2026-03-04 08:08:49	5 sec	9 sec	14 sec
Subject I	2026-03-03 13:09:29	5 sec	10 sec	15 sec
Subject J	2026-03-06 10:36:22	5 sec	8 sec	13 sec

The average total end-to-end latency across all evaluated events was 15.9 seconds, with an average chatbot automation response time of 9.3 seconds. These results confirm that the system operates within a near-real-time performance envelope suitable for academic service provision.

4.5. Functional Testing Results

Black-box testing was conducted to validate system functionality across all defined use cases. Table 6 and Table 7 present the results for face detection/recognition tests and chatbot response tests, respectively.

Table 6: Black-box testing results face detection and recognition

Test Case	Input	Expected Result	Status
Registered face detection	Enrolled subject's face	Identity recognized; attendance recorded	Pass
Unregistered face detection	Face not in dataset	Detected with Unknown status	Pass
Multi-face detection	Multiple faces in frame simultaneously	All faces detected and identified	Fail
Fast-moving subject	Subject running past CCTV	Face detected and saved to database	Fail
Masked face detection	Face covered by mask	Face detected	Fail
Backward-facing subject	Subject facing away from camera	No data saved	Pass
Excessive subject distance	Face too far from camera	Face not detected (too small)	Pass
Network disruption	Network issues during upload	4 retries; >4 attempts = Upload Failed	Pass
Poor lighting conditions	Too dark / overexposed environment	Face detected and saved	Fail

Table 7: Black-box testing results chatbot WhatsApp response

Test Case	Input	Expected Result	Status
Initiate chatbot	"Hello"	Chatbot description displayed	Pass
Attendance check	"Check attendance"	Attendance data returned from database	Pass
Attendance proof check	Subject name (after offer)	Google Drive image link sent	Pass
Notification request (not yet detected)	"Kabari saya kalau Pak Rahman sudah terdeteksi"	Notification sent upon detection	Pass
Confirm notif after absent check	"Has Mr. Asrul arrived?"	Notification subscription offer sent	Pass
No attendance data	"Check attendance"	No data detected today message	Pass
Typo in notification request	"Notify me when Ms. Frida has arrived"	Name corrected; notif sent upon detection	Pass
Informal input / typo	"cek Mr. Ady"	Name recognized; attendance status shown	Pass
Ambiguous message	Meaningless string (e.g., zxcvbnm)	System: message not understood	Pass

All chatbot interaction scenarios passed functional testing, confirming the effectiveness of the Gemini 2.5 Flash model in understanding natural language, handling typographical errors, and managing context-aware multi-turn conversations. Face recognition testing revealed that the system performs robustly under normal single-face, static conditions but encounters challenges with multi-face frames, occluded faces, motion blur (fast-moving subjects), and extreme lighting. These limitations are consistent with documented shortcomings of real-time CCTV-based face recognition systems and provide clear directions for future optimization.

The proposed system distinguishes itself from prior work in several respects. Unlike IoT-based approaches that require dedicated embedded hardware [15], the present system achieves comparable functionality using standard CCTV infrastructure and a consumer-grade laptop (Intel Core i5 12th Gen). The use of InsightFace offers lighter computational requirements suitable for CPU-only environments compared to CNN-based implementations reported in previous studies [16]. The integration of n8n as a no-code/low-code workflow automation hub represents a novel architectural contribution compared to prior fully-coded pipelines [17][18][19], enabling rapid reconfiguration without redevelopment. Furthermore, the dual-workflow design separating reactive chatbot interactions (Workflow 1) from proactive notifications (Workflow 2) provides an architectural pattern not explored in the related literature, significantly reducing redundant user queries and information wait times.

5. Conclusion

This study has demonstrated that the integration of n8n as a centralized workflow automation hub with InsightFace-based face recognition and a Gemini-powered WhatsApp chatbot constitutes an effective and scalable solution for real-time academic attendance information delivery. The system successfully eliminated dependence on manual communication by autonomously capturing, storing, and distributing attendance data with an average end-to-end latency that is substantially lower than any manual alternative. The high True Negative count further confirms the system's reliability in preserving database integrity by accurately filtering unregistered individuals. Future work should prioritize the adoption of more robust recognition algorithms such as ArcFace to improve recall performance, provision of a dedicated and stable network infrastructure to minimize synchronization failures, and deployment of GPU-accelerated hardware to further reduce detection-side latency. The architectural pattern established in this study, positioning n8n as the orchestration layer connecting AI-powered recognition, cloud storage, and instant messaging, provides a replicable template for the broader digital transformation of administrative processes in academic institutions.

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