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Design and Implementation of Classroom Attendance System Based on Image Recognition Technology

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Abstract: *With the rapid development of educational informatization, traditional classroom sign-in methods (such as paper sign-in, card sign-in, etc.) have gradually shown problems such as low efficiency and easy cheating. In order to improve the efficiency and accuracy of classroom sign-in and reduce the management burden of teachers, this paper proposes a classroom sign-in system based on image recognition technology. The system uses face recognition technology to realize students' automatic sign-in, which not only improves the efficiency of sign-in, but also effectively prevents cheating behaviors such as signing on behalf of others. This paper introduces the software design and implementation of the system in detail, including the system logical architecture, functional module structure, administrator platform function ER diagram and the detailed process of system implementation. The reliability and practicality of the system are verified through functional testing, performance testing and user experience testing. The experimental results show that the system can complete the classroom sign-in task efficiently and accurately, providing a new solution for educational informatization.*

Keywords: *Image Recognition; Classroom Sign-In; Face Recognition; Educational Informatization; Sign-In System*

1. Introduction

With the rapid development of educational informatization, traditional classroom sign-in methods (such as paper sign-in, card sign-in, etc.) have gradually shown problems such as low efficiency and easy cheating. In the modern educational environment, classroom sign-in is not only an important part of teaching management, but also a key means to ensure student attendance and classroom order. However, the traditional sign-in method has many drawbacks in practical application and urgently needs to be improved through technical means[1].

First, although paper sign-in is simple and easy, it is inefficient, especially in large classes, where teachers need to check students' names one by one, which takes a lot of time. In addition, paper sign-in is easily signed by students, and there is a lack of effective cheating prevention mechanism, which makes it difficult to ensure the authenticity of sign-in data. Secondly, although card sign-in has improved efficiency to a certain extent, there are still some problems. For example, students may forget to bring their cards, or their cards may be borrowed by others, resulting in inaccurate sign-in data. In addition, card sign-in requires hardware equipment, which increases the deployment and maintenance costs of the system[2-3].

In order to overcome the shortcomings of traditional sign-in methods, a classroom sign-in system based on image recognition technology came into being. The system uses face recognition technology to collect students' facial images through cameras to realize the automated sign-in process. Compared with traditional methods, the sign-in system based on image recognition has the following significant advantages:

Efficiency: Students only need to face the camera and the system can quickly complete the sign-in, greatly shortening the sign-in time, which is especially suitable for large-class teaching scenarios[4-6].

Accuracy: Facial recognition technology can accurately identify students' identities, effectively prevent cheating such as signing in on behalf of others, and ensure the authenticity of sign-in data.

Real-time: The system can record the sign-in status in real time and generate sign-in reports,

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making it convenient for teachers and administrators to check students' attendance at any time.

Convenience: No need to carry any cards or equipment, students can sign in through the camera, which simplifies the sign-in process[7].

Based on the above advantages, the classroom sign-in system based on image recognition can not only improve the efficiency and accuracy of classroom sign-in, but also reduce the management burden of teachers and provide a more scientific and convenient solution for teaching management. With the continuous advancement of artificial intelligence technology, image recognition technology has broad application prospects in the field of education and is expected to become an important tool for classroom management in the future[8].

This paper will introduce the design and implementation of a classroom sign-in system based on image recognition. First, the overall architecture and functional modules of the system are introduced; then, the implementation process of the system is described in detail, including login, registration, sign-in, query and management functions; then, the reliability and practicality of the system are verified through functional testing, performance testing and user experience testing; finally, the characteristics of the system and future improvement directions are summarized. Through the research in this paper, it is hoped that it can provide useful reference and reference for the development of educational informatization.

2. Software Design

2.1 System Logical Architecture

The logical architecture of the classroom sign-in system based on image recognition is meticulously designed to ensure robust functionality and ease of maintenance. It is primarily divided into three distinct but interconnected levels: the front-end user interface, the back-end server, and the database[9-10].

1) Front-End User Interface: This is the layer that students and teachers interact with directly. It is designed to be intuitive and user-friendly, providing a seamless experience for users. The interface includes features such as real-time display of attendance status, notifications for successful or unsuccessful sign-ins, and easy access to attendance reports. It also supports multiple devices, ensuring that users can sign in and view attendance data from smartphones, tablets, or computers.

2) Back-End Server: The back-end server acts as the backbone of the system. It processes the facial recognition algorithms, manages user authentication, and handles the logic for attendance recording and reporting. The server ensures that the system can handle multiple sign-in requests simultaneously without any lag, making it suitable for large-scale deployments. It also includes security features to protect user data and prevent unauthorized access.

3) Database: The database is where all the critical data is stored. This includes student profiles, facial recognition templates, attendance records, and other relevant information. The database is designed to be highly scalable, allowing it to accommodate a growing number of users and data entries. It also ensures data integrity and provides efficient data retrieval mechanisms to support the system's operations.

This layered architecture design aims to improve the modularity and maintainability of the system while ensuring efficient collaboration between various parts. Each layer can be developed, tested, and updated independently, which simplifies the development process and reduces the risk of errors. At the same time, the clear separation of concerns ensures that the system remains efficient and responsive.

ISSN 2706-655X Vol. 7, Issue 3: 35-42, DOI: 10.25236/IJFET.2025.070306

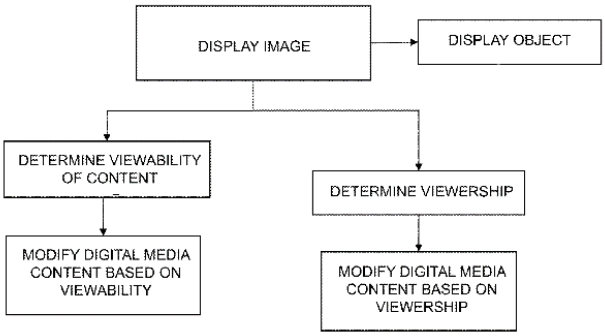

Fig.1 Flow Diagram representing display attendance

To illustrate the functionality of the system, FIG. 1 is a flow diagram representing display attendance. This diagram shows the step-by-step process of how attendance data is displayed to users. It begins with the system retrieving attendance records from the database, processing them through the back-end server, and finally presenting the information in a clear and organized manner on the front-end user interface. This flow ensures that users can quickly and easily see their attendance status, making the system both practical and user-friendly.

Front-end user interface: responsible for interaction with users, including student side and administrator side. The student side provides sign-in function and sign-in record query; the administrator side provides user management, course management and sign-in data management functions.

Backend server: responsible for processing image recognition, sign-in logic and data storage. The server receives the image data sent by the front end, performs identity authentication through the face recognition algorithm, and stores the sign-in results in the database.

Database: used to store student information, sign-in records and other data. The database uses a relational database (such as MySQL) to store structured data to ensure data integrity and consistency.

2.2 Module functional structure

The functional module structure of the system mainly includes the following modules:

1) Image acquisition module: collects students' facial images through the camera. This module supports multiple devices (such as built-in cameras, external cameras), and provides image preprocessing functions (such as grayscale, denoising, etc.) to improve image quality.

2) Image recognition module: Use face recognition algorithm to identify the collected images. The system uses face recognition algorithm based on deep learning (such as OpenCV, Dlib, etc.), which can efficiently and accurately identify the identity of students.

3) Check-in management module: handles the student check-in logic, including check-in status update and record. This module is responsible for storing the check-in results in the database and providing real-time feedback on the check-in status.

4) User management module: manages the account information of students and administrators. This module supports functions such as user registration, login, information modification, and ensures the security of user data.

5) Data statistics module: Statistics on student attendance and generating reports. This module provides multiple statistical functions (such as by date, by course, etc.) and supports report export (such as Excel, PDF, etc.).

2.3 ER diagram of administrator platform usage function

The functions of the administrator platform mainly describe how administrators can manage users, courses and attendance data through the system. The following entities and relationships:

Administrator: Responsible for managing the system's users and data. Administrators can manage users, courses, and attendance data through the system.

ISSN 2706-655X Vol. 7, Issue 3: 35-42, DOI: 10.25236/IJFET.2025.070306

User management: including adding, deleting and modifying user information. Administrators can view the detailed information of all users and perform corresponding operations.

Course management: Administrators can create and manage course information, including course name, course time, instructors, etc.

Attendance record management: record students' attendance status and time. Administrators can view students' attendance records and export reports for further analysis.

2.4 System Design Summary

The logical architecture and module function design of this system are designed to achieve efficient and accurate classroom sign-in functions while ensuring the scalability and maintainability of the system. Through layered architecture and modular design, the system can flexibly respond to different teaching scenarios and user needs. In the future, the system can be further optimized, such as introducing more efficient face recognition algorithms, supporting multi-device sign-in, etc., to improve user experience and system performance.

The classroom sign-in system based on image recognition realizes efficient and accurate classroom sign-in function through face recognition technology, effectively solving the drawbacks of traditional sign-in methods. The modular design and logical architecture of the system make it scalable and maintainable, providing a new solution for educational informatization. In the future, the system can be further optimized, such as introducing more efficient face recognition algorithms, supporting multi-device sign-in, etc., to improve user experience and system performance.

3. System Implementation

3.1 Facial Recognition Classroom Attendance System Login

The login module is the core entrance of the system. Users authenticate by entering their username and password. To improve security, FIG. 2 is a flow diagram for detecting facial expressions. the system supports two login methods:

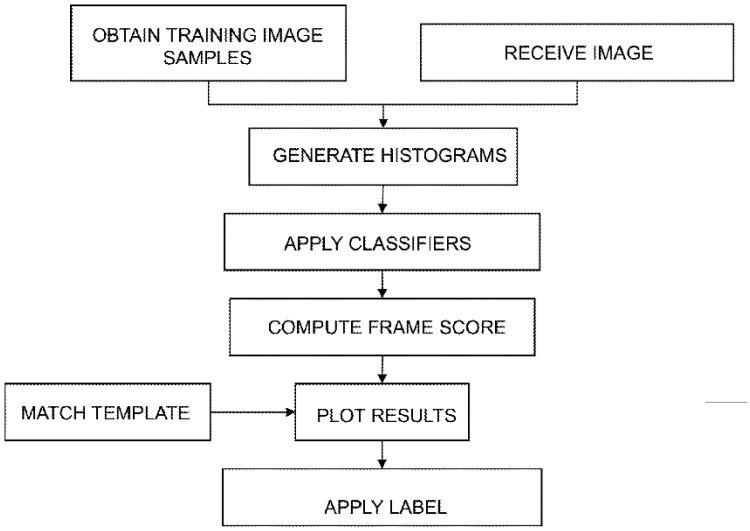

Fig.2 Flow diagram for detecting facial expressions

1) Username and password login: The user enters the username and password used during registration to log in. The system will verify whether the username and password entered match the records in the database. If the match is successful, the user will enter the system main interface; otherwise, the system will prompt "Incorrect username or password".

2) Face recognition login: The user collects facial images through the camera, and the system verifies the user's identity through the face recognition algorithm. The system will compare the collected face image with the facial features stored in the database. If the match is successful, the user will enter the system main interface; otherwise, the system will prompt "Face recognition failed".

ISSN 2706-655X Vol. 7, Issue 3: 35-42, DOI: 10.25236/IJFET.2025.070306

Implementation details:

Username and password login: Use encryption algorithms (such as SHA-256) to encrypt and store passwords to ensure password security.

Face recognition login: Use a deep learning-based face recognition algorithm (such as OpenCV, Dlib, etc.) to collect face images in real time through the camera and compare them with the face features stored in the database.

3.2 Facial Recognition Classroom Attendance System Registration

The registration module allows new users (students or teachers) to register with the system. Users need to fill in basic information and upload face images for subsequent face recognition.

Implementation details:

Information Verification: The system will verify the information entered by the user to ensure its integrity and accuracy. For example, the password and confirmation password must be consistent, and the student/work number must conform to a specific format.

Face image upload: Users upload face images through the camera, and the system will pre-process the image (such as grayscale, denoising, etc.) and extract facial features and store them in the database.

3.3 Student sign-in recognition

The sign-in module is one of the core functions of the system. Students sign in by collecting facial images through the camera. The system automatically recognizes the face in the image and compares it with the registered face in the database. If the match is successful, the sign-in status is recorded as "successful", otherwise it prompts "sign-in failed".

Implementation details:

Image acquisition: The facial image of the student is collected in real time through the camera and a preview is displayed on the interface.

Image recognition: Use face recognition algorithms to identify the collected images, extract facial features and compare them with the features in the database.

Check-in record: If the match is successful, the system will update the check-in status to "success" and record the check-in time; if the match fails, the system will prompt "check-in failed" and record the error log.

3.4 Student Attendance Query

The query module allows students and teachers to query historical sign-in records. Students can check their own sign-in status, and teachers can check the attendance of students in the class, such as.

Implementation details:

Query function: Users can query by entering their student ID/work ID, name and date range, and the system will return the check-in records that meet the criteria.

Data statistics: The system will count students' attendance, including total sign-ins, lateness, early departures, etc.

Report export: Users can export query results as reports in Excel or PDF format for further analysis.

3.5 Facial Recognition Classroom Attendance System Management Function

The management module provides administrators with system maintenance and data management functions, including student and teacher information management, sign-in record management, etc.,. The interface for managing student and teacher information.

Implementation details:

User management: Administrators can add, delete and modify user information, including username, password, name, student/work ID and role.

ISSN 2706-655X Vol. 7, Issue 3: 35-42, DOI: 10.25236/IJFET.2025.070306

Course management: Administrators can create and manage course information, including course name, course time, instructors, etc.

Attendance record management: Administrators can view students' attendance records and export reports for further analysis.

3.6 System Implementation Summary

This system uses facial recognition technology to achieve efficient and accurate classroom sign-in functions. The main modules include login, registration, sign-in, query and management functions. The system interface design is simple and intuitive, and the operation process is clear, which can meet the different needs of students, teachers and administrators. In the future, the system can be further optimized, such as supporting multi-device sign-in and introducing more efficient facial recognition algorithms to improve user experience and system performance.

4. Face recognition classroom sign-in system test

In order to verify the functions and performance of the system, we conducted a comprehensive test on the system, including functional testing, performance testing and user experience testing. The following are the specific contents and results of the test.

4.1 Functional Testing

Functional testing mainly verifies whether each module of the system can work properly. Test cases include normal conditions, boundary conditions and abnormal conditions, as shown in Tables 1.

Table 1 Functional test cases and results

Test case number	Test functionality	Test Data	Expected Results	Actual Results
TC001	User login	Correct username and password	Login successful	Login successful
TC002	User login	Wrong username or password	It says "Incorrect username or password"	It says "Incorrect username or password"
TC003	Face recognition login	Correct face image	Login successful	Login successful
TC004	Face recognition login	Wrong face image	Prompt "Face recognition failed"	Prompt "Face recognition failed"
TC005	User Registration	Complete registration information and face image	Successful registration	Successful registration
TC006	User Registration	Incomplete registration information	Prompt "Please fill in complete information"	Prompt "Please fill in complete information"
TC007	Student Sign-in	Correct face image	Sign in successfully	Sign in successfully
TC008	Student Sign-in	Wrong face image	Prompt "Sign-in failed"	Prompt "Sign-in failed"
TC009	Check-in	Student ID and date range	Show attendance record	Show attendance record
TC010	Administrator manages user information	Add, delete, and modify user information	Operation successful	

4.2 Performance Testing

Performance testing mainly evaluates the system's response time and resource usage. We simulated different numbers of users using the system at the same time, and the test results are as follows, as shown in Tables 2:

Table 2 Performance test results

Test scenario	Number of users	Averageresponse time	CPU usage (%)	Memoryusage (%)
Single user login	1	1.2	15	20
Single user sign-in	1	2.5	20	25
100 users logged in simultaneously	100	3.8	45	60
100 users sign in at the same time	100	5.2	60	75
Administrator query sign-in records	1	1.8	18	22
Administrator exports attendance report	1	3.0	25	30

ISSN 2706-655X Vol. 7, Issue 3: 35-42, DOI: 10.25236/IJFET.2025.070306

4.3 User Experience Testing

The user experience test mainly evaluates the usability and interface friendliness of the system. We invited 10 students and 5 teachers to conduct the test and collected their feedback, as shown in Tables 3.

Table 3 User experience test results

Test indicators	Satisfaction(%)	Suggestions and Feedback
User-friendly interface	90	The interface is concise and the operation process is clear, but some buttons can be more obvious.
Convenience of operation	85	The system is easy to operate, but some functions (such as check-in query) require more guidance.
System stability	95	The system runs stably without any crash or freeze.
Functional completeness	80	The functions basically meet the requirements, but more statistical functions are expected to be added (such as attendance analysis)

5. Conclusion

This paper presents the design and implementation of a classroom sign-in system based on image recognition. The system leverages advanced face recognition technology to achieve efficient and accurate classroom sign-in functions, effectively addressing the limitations of traditional sign-in methods such as manual sign-in sheets or card swipes, which are often time-consuming and prone to errors.

The system's reliability and practicality have been thoroughly verified through a series of comprehensive tests, including functional testing to ensure all features work as intended, performance testing to evaluate the system's efficiency and stability under various conditions, and user experience testing to gather feedback and make necessary adjustments. These tests have demonstrated that the system is robust and user-friendly, capable of significantly enhancing the classroom sign-in process.

In future development, we plan to further optimize the system in several key areas:

1) Algorithm Optimization: We aim to introduce more efficient face recognition algorithms to improve recognition speed and accuracy. This will involve researching and integrating the latest advancements in artificial intelligence and machine learning to enhance the system's ability to accurately identify individuals under different lighting conditions, angles, and other variables.

2) Multi-Device Support: The system will be expanded to support multi-device sign-in, including both mobile and web platforms. This will provide users with greater flexibility and convenience, allowing them to sign in using their preferred device, whether it be a smartphone, tablet, or computer. This will also ensure that the system is accessible to a wider range of users and can be easily integrated into existing educational environments.

3) Enhanced Statistical and Analytical Functions: We plan to add more comprehensive statistical and analytical functions to the system. These will include detailed attendance analysis, lateness and early departure statistics, and other relevant metrics. By providing educators with detailed insights into student attendance patterns, the system will enable more effective classroom management and allow for timely interventions when necessary.

4) Scalability Improvements: To ensure the system can support larger-scale users and data, we will focus on improving its scalability. This will involve optimizing the system's architecture, enhancing database management, and ensuring that the system can handle increased loads without compromising performance. This will be crucial as the system is adopted by more educational institutions and the volume of users and data grows.

In conclusion, we believe that through continuous optimization and improvement, this classroom sign-in system based on image recognition will become an important tool for educational informatization. It will provide greater convenience for teaching management, enhance the overall educational experience, and contribute to the modernization of educational processes. We are committed to ongoing development and innovation to ensure that the system remains at the forefront of educational technology solutions.

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