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A Review Paper on Project STAAR (Student Attendance Automated Recording) System Using Artificial Intelligence and Machine Learning.

Jambhu Kumar Venkatakrishnan 1 (Client and Delivery Partner Kyndryl (An IBM Spin-Off)), Chennai, India,
Dr. Anusha M 2 (Assistance Professor PG & Research Department of Computer Science National College (Autonomous) Trichy 620001 Bharathidasan University India,
Raman Swaminathan 3 (COE Data Analyst Kyndryl (An IBM Spin-Off), Chennai, India

Abstract - In this modern era, face recognition system plays a pivotal role in almost every sector. Face recognition is one of the mostly used biometrics. Identification of students in the classroom of any college for the purpose of attendance marking using the AI and ML technique. The use of Student Attendance Automated Recording System (STAAR) is to perform the analysis of the regular activities of attendance marking and reduced human intervention. In this research or analysis we require human faces to be captured using digital method to ensure that the system recognise and process the data for modern student management. This system can be used via SAAS and PAAS service for any organisation that require the data to be storage and retrieved via various reports against the duration of set off time. Using the AI and ML techniques, Student Attendance Automated System records the student availability and ensure that the data is maintained for future reference.

Keywords- Face Recognition, Student Attendance Management System, Attendance Management System

I. INTRODUCTION

At present the student attendance management is managed via manual / traditional method of attendance tracking. Manual tracking need to be then converted into digital format for further processing which requires more manual effort. Traditional method is more time consuming and require accuracy in converting the data to digital platform. Maintenance of each and every student attendance using older methods is very unattractive for every college / university / institute and very messy on any of the situation.

In the recent times facial recognition, image and data processing is a very interesting learning topic that has surfaced from other forms like biometrics (Fingerprint, Eye recognition, RFID etc.). Using facial recognition systems use a set of features distinct to one-person using coordinates etc. The idea for this project came to us in class as we saw the amount of time that has to be skipped for attendance and the nonchalance of students who had already marked their attendance which leads to the method being delayed further, we then decided that this would be a good and interesting field to delve into for our Project as the field of Image processing, recognition etc; has a world of scope

A **Student Attendance Management System** is a comprehensive software application designed to streamline and automate various administrative and academic processes in educational institutions. The system helps manage student-related information, from admissions and enrollment to grading, attendance, and communication, making it easier for schools, colleges, and universities to operate efficiently.

Traditional vs. Modern Attendance:

- Traditional methods of manual attendance are time-consuming and prone to errors.
- The shift to automated systems using face recognition simplifies the process and improves accuracy.

Face Recognition Technology:

- Face recognition is a biometric method that identifies individuals by analysing their facial features.
- It's becoming a popular choice due to its ease of use and minimal user effort.

Machine Learning and Attendance:

- Machine learning algorithms play a crucial role in automating attendance systems.
- They process data and provide efficient solutions.

Purpose and Objectives:

The primary purpose of a Student Management System is to provide a centralized platform that simplifies the management of student data and academic activities. It aims to:

Centralize Data Management:

- Store and manage all student-related information in one secure database.
- Ensure easy access to data for authorized personnel like administrators, teachers, and students.

Enhance Efficiency:

- Automate routine administrative tasks such as attendance tracking, grading, and reporting.
- Reduce manual work, minimizing errors and saving time for educators and staff.

Improve Communication:

- Facilitate communication between students, teachers, parents, and administrators.
- Provide platforms like portals, messaging systems, and notifications for seamless interaction.

Support Academic and Administrative Decisions:

- Provide insights and analytics on student performance, attendance, and behaviour.
- Aid in data-driven decision-making for academic interventions and administrative planning.

Ensure Compliance and Security:

- Ensure that student data is managed in compliance with regulations (e.g., FERPA in the U.S., GDPR in Europe).
- Implement robust security measures to protect sensitive information.

Key Features of a Student Management System:

Student Information Management:

Profile Management: Store and manage personal details, contact information, and academic history for each student.

Enrollment and Registration: Handle student admissions, course registration, and class assignments.

Attendance Management:

Tracking and Reporting: Record and monitor student attendance, generate reports, and identify patterns of absenteeism.

Integration: Link with other systems like biometrics or RFID for automated attendance tracking.

Grading and Assessment:

Gradebook: Manage and record grades for assignments, tests, and exams.

Assessment Analytics: Analyse student performance over time and generate progress reports.

Timetable and Scheduling:

Class Scheduling: Create and manage timetables for classes, exams, and extracurricular activities.

Conflict Resolution: Ensure that schedules are optimized and free from conflicts.

Communication Tools:

Messaging: Enable communication between students, teachers, and parents through messages, emails, or SMS.

Notifications: Send automated alerts for important updates, deadlines, and events.

Fee Management:

Billing and Payments: Manage student fees, generate invoices, and track payments.

Financial Reporting: Provide reports on outstanding fees, payment history, and financial transactions.

Parent and Student Portals:

Access to Information: Allow parents and students to view attendance, grades, schedules, and other relevant information.

Online Services: Enable online services like fee payment, course registration, and document requests.

Library Management:

Cataloguing: Manage library resources, track book issuance, and returns.

Student Access: Allow students to search for and reserve books online.

Reports and Analytics:

Data Reporting: Generate various reports on student performance, attendance, financials, and more.

Analytics: Use data analytics to gain insights into academic trends, student behaviour, and institutional performance.

Security and Compliance:

Data Security: Implement encryption, role-based access, and other security measures to protect student data.

Regulatory Compliance: Ensure the system complies with educational data protection regulations.

II. RELATED WORK

Face recognition using Artificial Intelligence (AI) and Machine Learning (ML) represents a significant advancement in the field, enabling systems to recognize and verify faces with high accuracy and adaptability.

Let's explore how facial recognition technology works in attendance systems.

Capturing Images:
- The process begins by capturing digital images of faces using a camera or smartphone.
- These images serve as input for the facial recognition system.

Database Comparison:
- The captured image is then compared against a database of previously collected data.
- This database contains stored profiles of individuals, including their facial features.

Matching Process:
- The system analyses the captured image and looks for similarities with the stored profiles.
- If a match is found, the system confirms the individual's identity.
- Attendance is marked or access is granted based on this verification.

Contactless and Paperless:
- Face recognition is a contactless and paperless technology.
- It eliminates the need for physical cards, tokens, or manual registers.
- Users simply present their face for authentication.

Benefits of a Student Management System:

Streamlined Operations:
Automates routine tasks, reducing administrative burdens and improving overall efficiency.

Improved Decision-Making:
Provides valuable data and insights, helping educators and administrators make informed decisions.

Enhanced Student Engagement:
Facilitates better communication and access to resources, leading to higher student engagement and satisfaction.

Better Parent Involvement:
Keeps parents informed about their child's progress, attendance, and other activities, fostering a collaborative environment.

Scalability and Flexibility:

Can be scaled to meet the needs of different types and sizes of educational institutions, from schools to universities.

Cost-Effective:
Reduces the need for paper-based processes and manual labor, saving costs in the long run.

III. METHODOLOGY

Attendance Management System uses a 3-tier architecture **[Fig.1]** as user interface, database and OS. In this 3-tier architecture, as illustrated below each. User Interface uses Python as language with Raspberry Pie for image processing or capturing. In this method, we use Haar-Cascade classifier to identify the individual student image for the system to understand the perform the processing. The process involves 4 different stages as

1. Collection of datasets
2. Processing the image using Haar-Cascade and LBPH method
3. Storing the captured image using the Machine Learning technique.
4. Student information stored in the database.

1. Collection of Datasets

Students images are captured using a high end camera or web cam. Individual student images are captured in Multiple images from various gestures and angles which require different point of coordinates. All of the individual images undergo pre-processing for image comparison for further analysis during the stage of student tracking and attendance marking. These images would be stored in a folder post which the datasets would be stored as an individual records in the database for easy access and comparison for further processing. Each data would be stored in a compressed which could optimize the storage and database growth. During each classroom session, individual faces will be detected from live streaming video of classroom **[Fig.5]**. The faces detected will be compared with images present in the dataset. If match found, attendance will be marked for the respective student. At the end of each session, list of absentees will be mailed to the respective faculty handling the session.

2. Processing the image using Haar-Cascade and LBPH method

Student Face detection is performed using Haar-Cascade Classifier. Haar Cascade algorithm needs to be trained to detect human faces before it can be used for face detection. This method is called feature extraction.

The system architecture **[Fig.2]** of the proposed system is given below,

We use Haar-Cascade classifier method in face detection and recognition systems, **Haar-Cascade classifier** and **Local Binary Pattern Histogram [Fig.4] (LBPH)** algorithm are commonly used methods:

1. Haar-Cascade Classifier for Face Detection:

- **Haar-Cascade Classifier** is an object detection method that was proposed by Paul Viola and Michael Jones in their paper, "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001.

- This classifier uses **Haar-like features** to identify objects within images, specifically faces in this context.

- The process involves training a cascade function from a large set of positive and negative images (images with and without faces). The classifier can then detect faces in new images by scanning different regions of the image at various scales.

- Haar-Cascade is computationally efficient and effective in real-time applications, making it suitable for face detection.

2. Local Binary Pattern Histogram (LBPH) for Face Recognition:

- **LBPH** is a powerful algorithm used for face recognition, which is the task of identifying or verifying a person from an image or video frame.

- LBPH works by converting the face image into a simple array of integer values that represent the local binary patterns (LBP) of the image. The LBP is calculated by comparing each pixel with its neighbours, and these comparisons are stored as binary numbers.

- The histogram of these patterns is then used to describe the image.
- In the context of face recognition, the LBPH algorithm compares the histogram of the detected face with the histograms of faces in the training set to find the closest match.
- LBPH is known for its robustness to changes in lighting and its simplicity in implementation.

In summary, **Haar-Cascade** is used to detect faces in an image or video, and **LBPH** is then used to recognize or identify those faces. These methods are widely used in various applications like security systems, authentication, and human-computer interaction.

- **Training**: The classifier is trained on thousands of positive images (images containing faces) and negative images (images without faces). This training process involves creating and selecting the best features that can distinguish faces from non-faces.

- **Detection**: Once trained, the classifier can be used to detect faces in new images by scanning the image at multiple scales and locations. The regions that pass all stages of the cascade are classified as faces.

The Haar-Cascade algorithm relies on **Haar-like features** to detect objects such as faces. These features are essentially rectangular regions within an image, and their calculation is based on the difference in pixel intensities between adjacent regions. The computation of these features is made efficient by the use of the **integral image**. Below is an explanation of the core formulas used in the Haar-Cascade algorithm.

Haar-Like Feature Calculation:

A Haar-like feature is defined by the difference between the sum of pixel values within different rectangular regions of the image. Typically, these features can be of different types, such as:

- **Two-rectangle features:** Compares the sum of pixel values in two adjacent rectangles.
- **Three-rectangle features:** Compares the sum of pixel values in three adjacent rectangles.
- **Four-rectangle features:** Compares the sum of pixel values in four adjacent rectangles.

For a two-rectangle feature, the formula can be expressed as:
\text{Haar Feature Value} = \text{Sum of pixels in white rectangle} - \text{Sum of pixels in black rectangle}

Integral Image Calculation:

The integral image $I_{\text{int}}(x, y)$ at a point (x, y) is defined as the sum of all the pixel values above and to the left of (x, y) in the original image $I(x, y)$:

$$I_{\text{int}}(x, y) = \sum_{x{\prime} \leq x, y{\prime} \leq y} I(x{\prime}, y{\prime})$$

Where:

- $I_{\text{int}}(x, y)$ is the integral image value at position (x, y) .
- $I(x{\prime}, y{\prime})$ represents the pixel value at position $(x{\prime}, y{\prime})$ in the original image.

Calculating the Sum of Pixels in a Rectangle using Integral Image:

Given the integral image, the sum of pixel values within any rectangular region R can be calculated using just four references to the integral image:

$$\text{Sum of pixels in } R = I_{\text{int}}(x_4, y_4) - I_{\text{int}}(x_3, y_3) - I_{\text{int}}(x_2, y_2) + I_{\text{int}}(x_1, y_1)$$

Where:

- (x_1, y_1) is the top-left corner of the rectangle.
- (x_2, y_2) is the top-right corner of the rectangle.
- (x_3, y_3) is the bottom-left corner of the rectangle.
- (x_4, y_4) is the bottom-right corner of the rectangle.

Feature Classification using AdaBoost:

During training, each Haar feature h is associated with a weak classifier h(x) that produces a binary decision (e.g., face or non-face). The output of a weak classifier is:

h(x) =
\begin{cases}
1 & \text{if } p \cdot f(x) < p \cdot \theta \\
0 & \text{otherwise}
\end{cases}

Where:

- f(x) is the feature value.
- \theta is a threshold value.
- p is a polarity that determines the direction of the inequality.

AdaBoost combines these weak classifiers into a strong classifier:

H(x) = \text{sign} \left(\sum_{t=1}^T \alpha_t h_t(x) \right)

Where:

- \alpha_t is the weight assigned to the t -th weak classifier.
- h_t(x) is the t -th weak classifier.
- T is the total number of weak classifiers.

The final decision is based on the sign of the weighted sum of all weak classifiers.

Cascade of Classifiers:

The Haar-Cascade classifier is composed of multiple stages, where each stage is a strong classifier. If a region of the image passes all stages, it is classified as containing the object. Otherwise, it is discarded as a non-object.

The decision rule at each stage can be represented as:

H_s(x) =
\begin{cases}
1 & \text{if } \sum_{t=1}^{T_s} \alpha_t h_t(x) \geq \text{threshold}_s \\
0 & \text{otherwise}
\end{cases}

Where:

- H_s(x) is the decision of the s -th stage.
- \text{threshold}_s is the threshold for stage s .
- T_s is the number of weak classifiers in stage s .

If $H_s(x) = 0$ for any stage s, the region is immediately classified as a non-object and is not processed further by subsequent stages.

3. Storing the captured image using the Machine Learning technique.

Face recognition process **[Fig.3]** can be divided into different steps- prepare training data, train face recognizer, prediction. During training student data will be the images present in the dataset. Individual identity would be assigned for individual student as integer label. Captured images would then be used for face recognition. In this method we use Face recognizer as Local Binary Pattern Histogram. As a Pre-requisite the list of local binary patterns(LBP) of entire face is obtained. Post capturing of the images LBPs are converted into decimal number and then histograms of all those decimal values are made. Processing of images would form a histogram of each image in the trained data. Post training and recognition histogram of the individual faces is calculated with the coordinates and compared with the earlier or stored information for comparison analysis which returns the best suitable availability as positive result dataset.

4. Student information stored in the database.

After face recognition process, the recognized faces will be marked as present in the database as per class session and the remaining students would be marked as absent and the list of absentees will be mailed via the registered email to the respective faculties along with a SMS trigged to the respective registered mobile numbers. Faculties and parents or guardian would be updated with monthly attendance sheet at the end of every month.

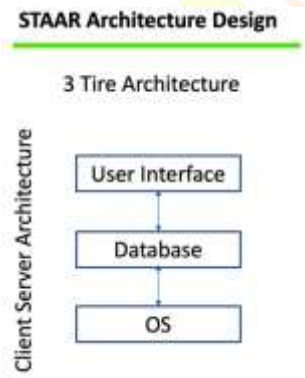

Fig.1

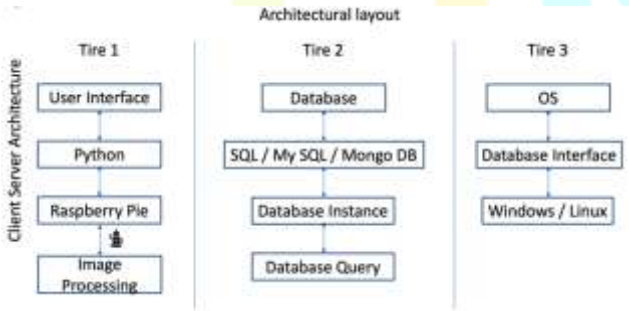

Fig.2

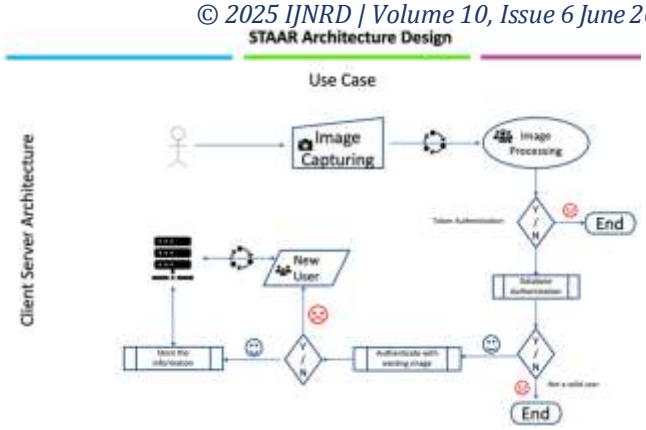

Fig.3

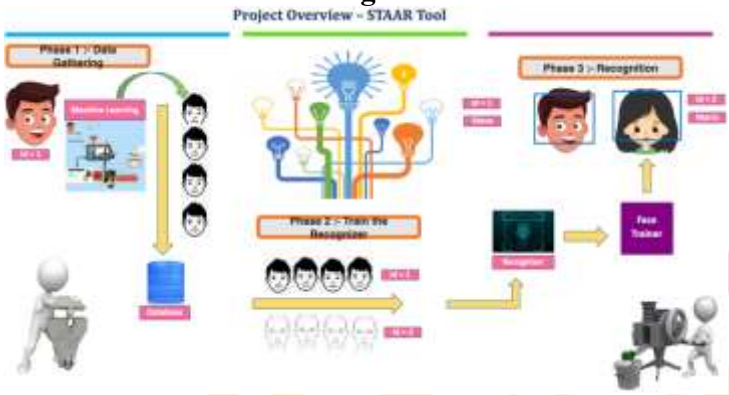

Fig.4

Fig.5

IV. CONCLUSION

In this proposed Attendance Management System Using Face Recognition is the better model for attendance management for students in the classroom and also at the other places. Now in this todays era a large number of systems are available like biometrics or other methods but the facial recognition is the best option for the accuracy .There is no special hardware requirement for the implementation of the system. A camera Laptop and database are sufficient for developing attendance management system using face recognition

This system aims to build an effective class attendance system using face recognition techniques. The proposed system will be able to mark the attendance via face Id. It will detect faces via webcam and then recognize the faces. After recognition, it will mark the attendance of the recognized
student and update the attendance record.

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