### Attendance Vision: Attendance Tracking Using Facial Recognition Technology

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***Abstract***

In a rapidly evolving technological world, the "Attendance Vision" app offers an innovative solution to the problem of proxy attendance in various environments, including schools, colleges, and corporate organizations. This application automates the attendance tracking process, eliminating the need for users to sign a ledger or swipe a card, which can lead to proxy attendance issues.

"Attendance Vision" leverages facial recognition technology from Computer Vision to streamline this process.

In addition to application details, this report provides insights into the potential development of the product as a viable business model.

# Problem Statement

Since childhood, we have faced the task of attendance, and we all understand the importance of this process. Whether in a school, college, or corporate office, it is crucial to track the attendance of students or employees. This information is useful for various purposes, such as monitoring an individual’s presence in the organization and addressing any related issues or concerns. It is also important for maintaining accurate records and generating reports. For companies, this information is vital for payroll purposes.

Typically, attendance tracking is done manually, requiring individuals to sign a ledger or swipe a card, or relying on a dedicated person, such as a teacher, to take attendance each day.

Organizations, particularly colleges, often face the issue of proxy attendance. Teachers call out students' names and mark them as present without verifying their actual presence.

The "Attendance Vision" app aims to recognize a person standing in front of the system's camera based on previously saved images of that person.

The objective is to maximize the recognition accuracy of the product while making it user-friendly and providing a robust solution to replace the manual attendance process.

# Customer Needs Assessment

The application has a broad scope across various premises that need to track attendance, such as schools, universities, and companies. Here are a few examples of where similar applications are currently in use:

* 1. **Schools**  
     Schools worldwide are eager to adopt this application for surveillance and automatic attendance tracking. In India, several states including Andhra Pradesh, Delhi, Gujarat, Tamil Nadu, Uttar Pradesh, and Assam are using this technology in government schools. The primary objectives include:
     1. **Addressing Proxy Teachers and Ghost Students**: Government schools face significant challenges with proxy teachers and inflated student attendance figures. This app will mitigate proxy attendance issues and provide accurate headcounts to government officials, which is crucial for reporting in schemes like PM POSHAN.
     2. **Streamlining Attendance Taking**: Taking attendance can be cumbersome and time-consuming for both teachers and students. Manual processes are also prone to errors.
     3. **Integration with Existing Systems**: By integrating with existing attendance management software, the application can offer insights into students’ attendance patterns, enabling teachers to analyze situations and resolve issues promptly.
  2. **Universities**  
     Some universities in India, such as Kanpur University in Uttar Pradesh and Kolhan University in Jharkhand, are already utilizing such applications to track attendance.
  3. **Companies**  
     In India, service providers, like Mobico Comodo (truMe app) and DigiSME, offer automatic attendance tracking solutions for companies. This indicates a rapidly growing demand for automated attendance systems at corporate offices.

# 3.0 Revised Needs Statement and Target Specifications

* 1. **Core Functionality**  
     The application will consist of several modules to ensure smooth operation:
     1. **User Management**  
        Users can be added and updated easily. For each user, multiple photos must be uploaded. The system will preprocess these images (cropping and resizing) before saving them. There should also be an option to update photos as needed.
     2. **Model Training Interface**  
        Whenever new users are added or existing users are updated, the app should be retrained with the updated data. It will evaluate its performance, and once ready, it can be used on a daily basis.
     3. **Attendance Marking**  
        The application will capture an image of the individual standing in front of the camera and recognize them using the trained model. Upon successful recognition, the system will display the person's name and ID on the screen and mark their attendance. In the event of a failure, the system will report an error, and the user will be able to mark their attendance by entering their User ID and Name in the system.
  2. **Fallback System**
     1. **Attendance via Name/ID**: If the system fails to identify a person, it should save the individual’s photo at the time of attendance tracking. The person should then be allowed to enter their name, ID to mark their attendance.
     2. **Verification of Failed Cases**: An offline service should be available for administrators to verify failed cases by reviewing the photos taken at the time of attendance along with the provided name/ID.
  3. **Performance Requirements**
     1. **Speed and Efficiency**: As a real-time application, the facial recognition algorithm must operate efficiently to quickly mark attendance. It should achieve a minimum accuracy of 90% in identifying individuals.
     2. **Usability**: The application should have a user-friendly interface.
     3. **Scalability**: The system must maintain its efficiency even as the number of users increases significantly.
  4. **Support System:**

**3.4.1 User Manuals**: User manuals need to be precise, easy to read, and comprehensive enough to cover all the features of the product.

* + 1. **Training and System Setup**: Training users is a key part of the deployment process. Cameras and light arrangements must be done properly to ensure they capture high-quality images, which are essential for the model to accurately recognize individuals.
    2. **Customer Support**: Effective customer support is critical for this product, as it involves advanced technology, specialized hardware such as cameras, and intermittent system updates when new users are added or existing datasets are updated. A robust and responsive support service is essential for the smooth functioning of the product.

# External Search

Different states in India are using various facial recognition-based attendance tracking systems in government schools. There are vendors in India that also provide cost-effective cloud-based apps for tracking staff attendance.

## Benchmarking

* 1. **RailTel Corporation of India Ltd**: They have deployed an AI-based identification system for collecting attendance in 48,000 schools across 33 districts in Assam. The product also includes a Student Database Management Information System.
  2. **Microsoft's Kaizala**: This mobile application was proposed for use in Gujarat by the government. It aims to keep track of 250,000 government school teachers across various schools in the state. However, teacher organizations opposed this application due to security and privacy concerns.
  3. **truMe**: The truMe Attendance Management App is an IoT platform developed by the Indian company Mobico Comodo. The app includes features such as real-time leave management, allowing employees to apply for leave and supervisors to grant it through the app. It is a cloud-based attendance management system that requires no hardware, making it cost-effective. With a single click on the app, the user's device captures a live photo of the employee and records their geolocation. Organizations can also opt to install a tablet for the Face Recognition Attendance System, which captures the employee's face upon entry and exit.
  4. **DigiSME**: This mobile app is integrated with the company’s payroll software.

## Applicable Patents

Many patents have been filed for this innovative technology of facial recognition. China alone has filed more than 900 facial recognition patents, which is ten times the number of patents filed in the U.S.

**6.1 KR101710200B1** : "Automatic Attendance System Using Face Recognition and method thereof" (South Korea)

The present invention is an automatic attendance management system that utilizes facial recognition technology. Each lecture room terminal recognizes an RFID tag or user input, captures a face photo upon button press, and sends this data to a U-Campus information server. The system standardizes photo sizes and analyzes facial features to accurately record attendance, preventing proxy attendance and monitoring student engagement without the need for card keys.

## Applicable Standards

* 1. **Child Rights in India**  
     When implementing facial recognition systems in schools in India, it is important to consider the Protection of Child Rights, which includes:
     1. The right to privacy for minors under Article 21 of the Constitution : As per the law, children have a fundamental right to privacy that must be protected during data collection.
     2. The right to free and compulsory education under Article 21A: Every child aged 6 to 14 is entitled to free and compulsory education, ensuring technology doesn’t block access to learning.
     3. The Right of Children to Free and Compulsory Education Act, 2009: This act ensures that all children have the right to education while protecting their rights and preventing discrimination in schools.
  2. **India’s Data Protection Law**: Clarity is needed on whether government schools can be exempted from provisions related to an individual’s consent before sharing their data. This law contributes to the legal uncertainties surrounding the use of facial recognition technology by public and private institutions.
  3. **United States**: In the United States, similar applications have been criticized by civil society organizations such as the Electronic Frontier Foundation and the New York Civil Liberties Union. This criticism ultimately led the State of New York to introduce a temporary suspension on the use of facial recognition in schools.

## Applicable Constraints

* 1. **Cost:**

Initial setup costs can be high, including cameras and software.

* + 1. In Gujarat, the installation cost per school ranges from ₹5,000 to ₹10,000. Therefore, the total installation cost for 35,000 primary schools amounts to crores.
    2. RailTel’s overall project cost is INR 19.20 crore for deploying the system in 48,000 schools throughout Assam’s 33 districts.
  1. **Trained Users:**  
     Trained and experienced personnel are required to operate the system effectively, including both software and hardware components.
  2. **Security and Privacy:**
     1. Approximately 60% of primary teachers in Gujarat are women, and uploading photos for attendance could lead to potential misuse.
     2. The use of facial recognition for attendance may violate individuals' right to privacy.
  3. **Social Issues:**  
     Considering incidents like the hijab ban in Karnataka, which targeted Muslim women for wearing hijabs in classrooms, this technology could pose social challenges for certain communities.
  4. **Effectiveness of the Technology:**  
     The technology faces challenges such as difficulties in detecting age and low accuracy rates, which can drop to as low as 80%.

## Business Opportunity

Currently, very few states in India are using this application, and primarily only in government schools. This presents significant opportunities to build and deploy the app in various organizations, such as schools, universities, and corporate offices, while adhering to existing laws. Doing so requires careful consideration of the legal frameworks, including:

* + **Compliance with Privacy Laws**: Developers must ensure that data collection practices respect the right to privacy under Article 21 and comply with relevant data protection regulations.
  + **Consent Mechanisms**: Implementing clear consent processes is crucial, especially when collecting data from minors.
  + **nsuring Educational Rights**: The deployment should not interfere with children's right to free and compulsory education, meaning the technology must enhance, not hinder, access to learning.
  + **Monitoring and Accountability**: Organizations should establish policies to protect children’s rights and address any potential misuse of the technology.

1. **Business Model**
   1. **Subscription system**

The business model can offer multiple subscription options:

* + 1. **Basic Version**: The subscription cost will depend on the number of users (staff members/students) of the application.
* Organizations will need to raise support tickets to add new users to the system. Tickets will be charged based on their criticality and complexity.
* Basic email support will be provided.

**10.1.2** **Premium Version**: This model will provide advanced features such as:

* Data Analytics: It will offer detailed reports, allowing organizations to gain insights into attendance patterns and trends.
* Custom Reports: Provide customized reporting solutions for organizations that require specific data metrics, with additional fees for these services.
* Integration Features: This system can be integrated with existing HR and payroll systems.
* Model Upgradation for New Users: This allows addition of new users to the system.
* Premium Support System: This includes both email and call support.
  1. **Customer Support**

The service charge will depend on:

* + 1. The number of tickets raised.
    2. The criticality (urgent or regular) of the tickets.
    3. The complexity (bug fixing or new feature implementation) of the tickets.
    4. Retraining of the Model for New User Additions: If a new user is added to the system, the application needs to be updated.
    5. Hardware Support: Support for camera and system setup issues.
  1. **Hardware Support**

This application requires specific hardware, such as cameras. Support can be provided in the following ways:

* + 1. Purchase of Hardware: The institution can purchase hardware through the service, and support fees will be charged to them.
    2. Recommendation of Hardware: In this case, a commission would be taken from the hardware vendor for recommending their products.

# Concept Generation

The field of computer vision is advancing rapidly. Every day, we see the development of finer, more advanced, and more accurate state-of-the-art models for tasks such as object detection. This progress has expanded the applications of computer vision models, helping to solve everyday issues. One notable application is facial recognition.

Facial recognition has a wide range of uses, including city surveillance and election monitoring. In India, few states are utilizing or considering this technology for these purposes.

**Attendance Vision** is a similar application designed to assist with attendance tracking for students, teachers, and employees in various organizations.

In this document, I propose a basic application focused solely on tracking attendance. This application can be further extended to integrate with other organizational systems, such as payroll, leave management, and report generation. Additionally, it can be adapted for mass attendance tracking, leveraging object detection techniques alongside facial recognition.

# Concept Development

This product is designed for any organization, such as educational institutions or corporate offices, that needs to track attendance for students or staff members. It uses a face recognition model to identify individuals standing in front of a camera. Once a person is identified, their attendance is recorded in the database.

The model is built using a dataset of user photos collected by a staff member from the organization. If the model is unable to correctly identify a person, there is an option to manually mark attendance using the person’s ID or name.

# Final Product Prototype with Schematic Diagram

* 1. **Deployment Phases**

The deployment of the product will occur in four phases:

* + 1. **Data Collection Phase**: Staff members will upload multiple photos of each user into the application.
    2. **Model Building and Deployment**: Developers will build a face recognition model using this data and deploy it on the server.
    3. **Real-Time Attendance Logging**: The application will be used daily for automatic attendance tracking.
    4. **Upgrades**: If new users join the organization or if existing user photos need updating, staff members can update the data through the application UI and run the upgrade module to retrain the model with new data.
  1. **Application Modules**

The application will have four modules:

* + 1. **Data Collection Module**: This module will allow staff members to upload user photos into the application.
    2. **Real-Time Attendance Logging Module**: This module will enable the system to capture a photograph of a person using the camera and mark their attendance in the system.
    3. **Fallback Module**: If the model fails to recognize a person, users can mark attendance using this module. The user ID and name will be entered through the UI, and attendance will be recorded for that user. The user's photo will also be saved on the server for later verification by staff members.
    4. **Model Upgrade Module**: Staff personnel can add or update user photos using this module. It will also retrain and update the model with the new data on the server.
  1. **Application architecture diagram**

Cloud Server (AWS etc.)

Data Collection Module

Staff member

MySQL

Build Model

Developer

Attendance Logging Module

Application Users

Camera

Fallback Module

Photos of all the users

ID, Name of User

Photos

ID, Name of User

Photos

Model Deployment

Photo

User Recognized?

No

Yes

Application Users

User ID

Save Photo

Mark Attendance

File System

1. **Product Details**

### Data Sources

The application will utilize user data, including information such as name, ID, and photos, collected during the data collection phase. This data will be processed as follows:

* + 1. **User Details**: User information, including name and ID, will be stored in a database such as MySQL.
    2. **Photos**: Photos will be stored either locally on the server, with their paths recorded in the database for smaller organizations, or on a cloud storage system (e.g., AWS S3 or Google Cloud) for larger organizations.
    3. **Image Embeddings**: The generated embeddings for each photo will be stored in either the local database or on a cloud server, depending on the volume of data.
    4. **Attendance Records**: The local database will maintain attendance records for all users, which will be updated daily.

### Technical Details

The product consists of both software and hardware components.

* + 1. **Hardware**:
* A server where the application will run.
* A camera connected to the server.
  + 1. **Software**:
* A desktop application that provides a user interface for accessing all features supported by the product.
* A face recognition application that performs the following activities:
  + **Preprocessing**: Images are cropped, resized, and normalized.
  + **Feature Extraction**: Embeddings are generated using a pre-trained model such as VGG16 and stored in the data source.
  + **Model Training**: The embeddings are used to train a model, such as SVM.
  + **Evaluation**: The accuracy of the model is verified to ensure it meets the requirements.
* A **CI/CD pipeline** will be implemented for model upgrades whenever the user database changes due to the addition or updating of user photos.

### Team Requirements

* + 1. **Development Team**: The team will be responsible for building the user interface of the application and implementing its functionality. Expertise in computer vision is essential for developing the model and a CI/CD pipeline will be established to automate model updates and deployment whenever there are changes to the user database or model requirements.
    2. **Customer Support Team**: A team is required to handle customer issues and provide assistance.
    3. **Sales and Marketing Team**: This team will focus on promoting the product and driving sales.
    4. Legal team - A team dedicated to patent investigation and compliance is crucial for the success and protection of the product. Legal professionals or patent attorneys have the specialized knowledge required to navigate intellectual property laws, patent searches, and application processes. This team would assist in following tasks:
  + Risk Management: A dedicated team can assess potential infringement risks and ensure that the product does not violate existing patents.
  + Compliance: Legal experts can ensure compliance with relevant regulations and standards, especially regarding data privacy and protection.

### What Does It Cost?

The cost of the Attendance Vision Product includes development expenses (salaries, software), hardware costs (servers, cameras), operational costs (cloud services, support), and marketing expenses. The total cost varies based on implementation scale and organizational needs.

1. **Code Implementation/Validation on Small Scale**

Github link to the code implementation:

<https://github.com/preeti-vi/FeynnLabs/blob/main/Face%20Recognition%20Model.ipynb>

The code has the following parts:

* Find bindings for the faces in the photos using the **Haar Cascade** classifier.
* Create embeddings for each identified face using the **VGG16** model.
* Build an **SVM** model for image classification
* Evaluate the model on test data

# Conclusions

The Attendance Vision product is one of the leading applications in the field of computer vision. It addresses the common challenge of tracking attendance faced by organizations of all sizes. With advancements in computer vision technology, we achieve a high level of accuracy in recognizing individuals, making the process seamless and efficient.

To further enhance reliability, our fallback module is designed to address any shortcomings of the primary model, ensuring consistent performance even in less-than-ideal conditions.

While there are a few products currently available in the market, the demand for efficient attendance solutions is on the rise. As organizations increasingly seek to streamline operations, the need for such innovative products will continue to grow.

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