Final Project Report

Intelligent Face Recognition Attendance System (FRAS V2.0)

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Subject: Advanced Computer Vision & Web Application Development

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📑 Table of Contents

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1. Executive Summary

The **Intelligent Face Recognition Attendance System (FRAS V2.0)** is a cutting-edge web application designed to automate the attendance tracking process using biometric verification. Traditional methods of attendance (paper registers, ID cards) are prone to proxy attendance, time theft, and human error. This project leverages the power of **Artificial Intelligence (AI)** and **Computer Vision** to detect and recognize faces in real-time, marking attendance instantly and securely.

Beyond core functionality, FRAS V2.0 emphasizes a premium user experience with a "Glassmorphism" design aesthetic, specialized accessibility features (Dark/Light robust theme system), and interactive animations (custom magnetic cursor), making it not just a utility tool but a modern software experience.

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2. Introduction

2.1 Problem Statement
In educational institutions and corporate environments, maintaining accurate attendance records is critical. Manual processes are time-consuming and inefficient. Biometric systems like

fingerprint scanners require physical contact, which raises hygiene concerns (especially relevant in post-pandemic scenarios). There is a need for a contactless, fast, and accurate solution.

2.2 Project Objective

The primary objective is to develop a robust, secure, and user-friendly web application that:

1. Captures video input from a camera.
2. Detects faces and identifies users against a registered database.
3. Marks attendance automatically with a timestamp.
4. Provides an administrative dashboard for management and reporting.
5. Delivers a high-quality, responsive visual interface.

2.3 Scope of the Project

The system is designed for small to medium-scale deployment (classrooms, offices). It handles user registration (capturing training images), model training (KNN/Encoding based), real-time recognition, and administrative reporting (CSV/PDF downloads). It also includes basic anti-spoofing measures (liveness detection).

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3. Technology Stack & Tools Used

3.1 Programming Languages

* **Python (v3.x):** The core logic language. Python was chosen for its dominating presence in AI/ML domains and rich ecosystem of libraries.
* **JavaScript (ES6+):** Used for frontend interactivity, creating the SPA (Single Page Application) feel, handling the custom cursor, and dynamic theme toggling.
* **HTML5:** For semantic structural markup of the web pages.
* **CSS3:** For styling, introducing advanced CSS variables, animations, and the Glassmorphism visual style.

3.2 Frameworks & Libraries

*   **Flask (Python):** A lightweight WSGI web application framework. It acts as the bridge between the Python backend (AI models) and the HTML frontend.
*   **OpenCV (cv2):** The industry-standard library for Real-Time Computer Vision. It handles image processing, face detection (Haar Cascades), and video stream management.
*   **scikit-learn:** Used for the K-Nearest Neighbors (KNN) algorithm to classify/identify faces based on embeddings.
*   **Jinja2:** The templating engine used by Flask to render dynamic HTML pages.
*   **NumPy:** For high-performance numerical computations and matrix operations required by image processing.

3.3 Database

*   **MongoDB:** A NoSQL database used to store unstructured or semi-structured data (if applicable for user logs) and flexibility in schema design.
*   **Local File System (CSV):** Used for daily attendance logs to ensure portability and simple backup.

3.4 Development Tools

*   **VS Code:** The Integrated Development Environment (IDE) used for coding.
*   **Git:** For version control.
*   **pip:** Python package manager for dependency management.

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4. Core Concepts & Methodologies

4.1 Computer Vision & Face Recognition

The system relies on a pipeline approach:

1. **Acquisition:** Capturing video frames via webcam.

2. **Detection:** Identifying *where* a face is in the frame using **Haar Cascade Classifiers**.
3. **Extraction:** Converting the face region into a numerical vector (embedding).
4. **Recognition:** Comparing the live embedding with stored known embeddings using the **KNN (K-Nearest Neighbors)** classifier to find the closest match.

4.2 Liveness Detection (Concept)
To prevent "spoofing" (holding up a photo of a person), the system implements liveness checks. This often involves detecting blinking, head movement, or texture analysis to ensure the subject is a real, living human presence.

4.3 Web Architecture (MVC Pattern)
The application follows a Model-View-Controller pattern:
* **Model:** The data handling (face embeddings, CSV logs, MongoDB).
* **View:** The UI (HTML templates, CSS styles).
* **Controller:** The Flask routes (`app.py`) that process user input, interact with models, and serve the appropriate views.

4.4 Responsive User Interface Design
The UI is built using modern CSS principles:
* **Glassmorphism:** Using `backdrop-filter: blur()` and semi-transparent backgrounds to create a depth effect.
* **Flexbox/Grid:** For fluid layouts that adapt to screen sizes.
* **CSS Variables:** For efficient Theme Management (Light/Dark modes).

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5. Key Features & Functionalities

1. **Robust Theme System:**

* A seamless day/night mode toggle that persists user preference via `localStorage`.
* The toggle button is context-aware, displaying text like "Go Dark" or "Robust Theme System".

2. **Interactive "Magnetic" Cursor:**
* A custom Javascript-driven cursor replacing the system mouse.
* Features a "dot" (pointer) and an "outline" (follower) that expands and pulses when hovering over interactive elements.

3. **Smart Navigation (SPA-like):**
* Implemented a mechanism to intercept link clicks and load content dynamically (AJAX/Fetch) without a full page refresh.
* **Benefit:** Allows background processes (like ambient music if enabled) to continue uninterrupted while the user navigates.

4. **Real-Time Attendance Board:**
* Live view of the camera feed with overlay branding (FRAS V2.0).
* Instant feedback on recognition (Name + Probability Score).

5. **Admin Dashboard & Reports:**
* Secured area for adding new users (Registration).
* Detailed lists of registered users.
* Downloadable attendance reports (CSV format).

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6. System Algorithm & Pseudo Code

6.1 Face Detection & Recognition Logic (Python)

```text
ALGORITHM Face_Recognition_Process:
    INITIALIZE: Load 'haarcascade_frontalface_default.xml'
    INITIALIZE: Load trained KNN model (n_neighbors=1)

    START VideoCapture

    WHILE True:
        READ frame FROM VideoCapture
        CONVERT frame TO Grayscale

        # 1. Detect Faces
        faces = detector.detectMultiScale(grayscale_frame)

        FOR (x, y, w, h) IN faces:
            # 2. Extract Face Region of Interest (ROI)
            face_img = frame[y:y+h, x:x+w]
            RESIZE face_img TO (50, 50)
            FLATTEN face_img TO 1D Array

            # 3. Identify
            identity = knn_model.predict(face_img)
            probability = knn_model.predict_proba(face_img)

            IF probability > CONFIDENCE_THRESHOLD:
                DRAW Rectangle around face
                DISPLAY Name label
                CALL Mark_Attendance(identity)
            ELSE:
                DISPLAY "Unknown"
```

```
        DISPLAY annotated frame

        IF 'q' key is pressed:
            BREAK Loop

    RELEASE VideoCapture
    DESTROY Windows
END ALGORITHM
```

6.2 Attendance Marking Logic (Python)

```text
FUNCTION Mark_Attendance(user_name):
    timestamp = GET_CURRENT_TIME()
    date = GET_CURRENT_DATE()
    file_name = "Attendance_" + date + ".csv"

    IF file_name DOES NOT EXIST:
        CREATE file_name
        WRITE Headers ["Name", "Time"]

    READ file_name
    IF user_name NOT IN file_name (for today):
        APPEND [user_name, timestamp] TO file_name
        RETURN Success
    ELSE:
        RETURN "Already Marked"
END FUNCTION
```

```

### 6.3 Front-End SPA Navigation (JavaScript)

```text
EVENT_LISTENER "click" ON document:
    GET target_element

    IF target_element IS Link AND Link IS Internal:
        PREVENT Default Browser Navigation (Stop Reload)
        GET URL from Link

        CALL NavigateTo(URL)

FUNCTION NavigateTo(url):
    SHOW Loading_Cursor

    RESPONSE = AWAIT FETCH(url)
    NEW_HTML = RESPONSE.text()

    PARSE NEW_HTML
    EXTRACT #dynamic-content FROM NEW_HTML

    REPLACE current #dynamic-content WITH new #dynamic-content

    UPDATE Browser History (pushState)
    RE-INITIALIZE Scripts (Theme, Cursor logic)

    HIDE Loading_Cursor
END FUNCTION
```
```

```

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## 7. User Interface (UI) & User Experience (UX)

The project places a heavy emphasis on visual appeal to ensure high user adoption:

1. **Color Palette:**
   * Primary: Cyan/Electric Blue (representing technology & trust).
   * Secondary: Violet/Purple (for accents and modern feel).
   * Background: Deep Slate (Dark Mode) / Crisp White (Light Mode).

2. **Experience Elements:**
   * **Toasts:** Non-intrusive popup notifications for actions (e.g., "Attendance Marked").
   * **Hover Effects:** Cards lift up, buttons glow, and the cursor creates a "magnetic" pull effect, making the interface feel "alive".
   * **Transitions:** Smooth fading between route changes prevents visual jarring.

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## 8. Conclusion & Future Scope

### Conclusion
The **FRAS V2.0** successfully demonstrates the feasibility of using web-based technologies to deploy sophisticated AI models. By combining Flask's flexibility with OpenCV's power, we created a system that is both functional and accessible. The addition of a polished UI ensures that it meets modern software standards.

### Future Scope
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1. **Cloud Integration:** Migrating the local CSV storage to a cloud-based SQL database (PostgreSQL) or Firebase for Realtime updates across multiple campuses.
2. **Mobile App:** Wrapping the web app into a Progressive Web App (PWA) or Native React Native app for mobile guard use.
3. **Emotion Analysis:** extending the AI model to detect student engagement/emotion during class.
4. **Integration with Liveness API:** Replacing basic local liveness checks with advanced APIs (like Azure Face API) for banking-grade security.

Verified and Validated by Development Team.
Software Version: 2.0.1 Stable