Facial Recognition Payment system Using Haar Cascade Algorithm and Local Binary Pattern Histogram (LBPH)

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Abstract— In today's fast-paced digital world, time is one of the most valuable resources. Traditional payment methods, such as cash, credit cards, and mobile wallets, often involve multiple steps, including authentication, card insertion, PIN entry, and network processing, which can lead to delays and inefficiencies. To overcome these challenges and streamline transactions, we propose a Face Recognition Payment System, which enables users to make payments instantly through facial authentication, eliminating the need for physical cards or manual input. This system utilizes the Haar Cascade algorithm, a machine learning-based approach for rapid and accurate face detection. The process begins with user registration through a mobile application, where facial data and payment credentials are securely stored in a database. When a transaction is initiated, the system captures the user's face using a scanner, compares it against the stored data, and upon successful verification, processes the payment. A confirmation message is sent to the user upon completion of the transaction. The proposed system enhances security by reducing the risks associated with card fraud, PIN theft, and unauthorized transactions. Additionally, it provides a contactless, hands-free payment solution, which is particularly beneficial in public places where hygiene and convenience are major concerns. The integration of facial recognition technology in payment systems ensures faster, more efficient, and highly secure financial transactions, revolutionizing the way people make payments in retail stores, restaurants, transportation hubs, and other commercial sectors.

Keywords

Artificial intelligence, Machine learning, Contactless payment, Haar Cascade, Biometrics, Secure payment, Fast and Convenient payment

I. INTRODUCTION

In today's rapidly advancing technological landscape, the demand for fast, secure, and user-friendly transaction methods is at an all-time high. Traditional payment systems—such as cash, cards, or mobile wallets—often require multiple steps including physical interaction, PIN entry, or smartphone access, which may lead to delays and vulnerabilities. The growing need for a seamless, contactless alternative has driven innovation toward biometric-based solutions. Among these, facial recognition has emerged as one of the most promising technologies for enabling secure, real-time identity verification. The Facial Recognition Payment System developed in this project introduces a novel, AI-powered payment method that allows users to complete transactions using only their face. This system employs advanced computer vision techniques, particularly the Haar Cascade algorithm for face detection and LBPH (Local Binary Pattern Histogram) for face recognition. The facial data, once captured and registered through a mobile or web interface, is securely stored and used for future authentication at payment terminals. Upon successful facial verification, the system deducts wallet points from the user's account and logs the transaction into a shop-specific database, providing an end-to-end digital payment solution.

II. RELATED WORK

. The concept of facial recognition-based payments has gained significant traction in recent years, with numerous studies highlighting its advantages, limitations, and potential for future integration. This section presents an overview of key research efforts that have informed the development of this project.

A. Yongping Zhong & Hee-Cheol Moon (2022)

In their comparative study, Zhong and Moon explored consumer behavior related to facial recognition and QR-code payments in China. They found that while facial recognition offers high levels of convenience, users often revert to QR-code payments due to habitual use and concerns over facial data privacy. The study emphasized the importance of improving system accuracy and increasing public trust through better education and security protocols.

2. Marta Beltrán & Miguel Calvo (2023)

This research introduced a privacy threat model for identity verification systems based on facial recognition. The authors highlighted risks such as data linkability, identifiability, and unauthorized access. Their work stresses the importance of legal and ethical safeguards, data encryption, and decentralized databases in protecting sensitive biometric information.

3. Romano Araujo et al. (2022)

The team proposed a facial recognition payment system using Haar Cascade and LBPH algorithms, similar to the present work. Their model included OTP verification as an added layer of security. The system demonstrated promising results in real-time processing and secure transactions, though it faced limitations in processing speed on low-end devices and in handling obstructions like glasses and masks.

4. Mohammad Fauzi Aziz et al. (2024)

This systematic literature review evaluated facial recognition as a base authentication protocol in online transactions. The study answered critical questions about fraud prevention, integration challenges, user acceptance, and legal implications. The authors concluded that while facial recognition can significantly reduce

identity fraud, it requires robust infrastructure, regulatory frameworks, and public awareness to ensure safe adoption.

5. Kuldeep Vayadande et al. (2024)

Their research focused on optimizing the Haar Cascade algorithm by combining it with Local Binary Pattern (LBP) and MTCNN to enhance accuracy and adaptability. The study showed improved real-time detection performance in embedded systems and discussed the ethical and technical challenges of facial recognition in public spaces.

III. SYSTEM ARCHITECTURE

The architecture of the Facial Recognition Payment System is designed as a multi-component, modular framework that ensures secure, real-time, and contactless financial transactions using facial biometrics. The system consists of **three primary modules**: the User Application (web/mobile), the Scanner Application (desktop-based face authenticator), and the Shop Dashboard (merchant interface). Each module interacts with shared and secure databases to ensure seamless data flow and accurate user authentication.

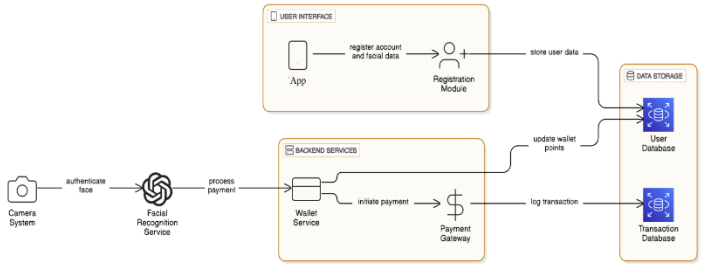

Fig.1. Architecture Diagram

A. User Interface Module

The User Interface Module forms the entry point of the Facial Recognition Payment System, enabling seamless interaction between the end user and the application. Built using Flask (Python) for the backend and HTML/CSS for the frontend, this module allows users to register, capture facial data, and access their wallet and transaction history. During the registration process, users are prompted to provide essential details such as name, email, card number, expiry date, CCV, and password through a user-friendly form. Following successful registration, the Face Capture Module activates the webcam to collect 20 facial images, which are then stored locally for the purpose of training the facial recognition model. The Model Trainer utilizes the Haar Cascade classifier for face detection and the Local Binary Pattern Histogram (LBPH) algorithm for face recognition to process the captured images and generate a trained data file (trainer.yml). This file serves as the foundation for facial authentication. Once trained, users can log in by scanning their face through the system, which authenticates them and displays their current wallet balance. This module ensures a smooth and secure onboarding and authentication experience for users within the payment ecosystem.

B. Facial Recognition Scanner Module

The Facial Recognition Scanner Module is a desktop-based Python application that plays a critical role in authenticating users and processing payment transactions through facial recognition. This module initiates a real-time webcam scan using the Haar Cascade classifier to detect faces within the camera frame. Once a face is detected, the system compares the live facial input with the pre-trained data stored in the trainer.yml file, which was generated during the registration phase. If a match is successfully identified and the confidence level is within the acceptable range, the application prompts the user to enter the number of wallet points to be deducted for the transaction. Upon confirmation, the system updates the user's balance in database.db and records the transaction details, including user ID, name, amount, and timestamp, in a separate shop.db file for merchant reference. This module relies on OpenCV for video capture and facial recognition, SQLite3 for managing local databases, and the Local Binary Pattern Histogram (LBPH) algorithm to ensure accurate and efficient facial identification, enabling secure and seamless point-of-sale operations.

C. Shop Dashboard Module

The Shop Dashboard Module is a web-based interface designed for shopkeepers to monitor and manage transactions completed through facial recognition. This dashboard provides a real-time overview of all payment activities, displaying essential details such as user names, wallet points deducted, and timestamps of each transaction. The data is dynamically retrieved from the shop.db database and presented in descending chronological order, allowing merchants to easily track the most recent transactions. The backend of the dashboard is developed using Flask, which handles data retrieval and routing, while the frontend is built with HTML and CSS to create a clean and responsive display. This module ensures transparency and efficiency in managing face-based payments from the merchant's perspective.

IV. IMPLEMENTATION

A.Technologies and Tools

1. Programming Language

- Python: The primary language used for backend logic, facial recognition algorithms, image processing, and desktop application scripting due to its simplicity, readability, and vast ecosystem of libraries.

2. Web Framework

- Flask: A lightweight and flexible Python web framework used to build RESTful APIs and serve the user registration/login interface and shop dashboard.

3. Image Processing and Facial Recognition

- OpenCV: Open-source computer vision library used for capturing images from webcams, detecting faces using Haar Cascades, and recognizing users through the LBPH (Local Binary Pattern Histogram) algorithm.
- Haar Cascade Classifier: Used for real-time face detection by identifying facial features from live video streams.
- LBPH (Local Binary Pattern Histogram): A facial recognition algorithm chosen for its accuracy and efficiency in recognizing faces under various lighting conditions and angles.

4. Databases

- SQLite3: A lightweight, embedded relational database engine used to store

5. Frontend Technologies

- HTML & CSS: Used to design the user interface for registration, login, wallet dashboard, and the shopkeeper's transaction page.
- Jinja2 (Flask templating engine): Enables dynamic content rendering within HTML pages.

V. FEATURES AND FUNCTIONALITIES

1. User Registration and Authentication

User registration with personal details and facial data capture.

Functionality:

- Stores user credentials and facial data securely.
- Captures facial data via camera using Haar Cascade.
- Enables facial recognition login.

2. Facial Recognition Payment

- Feature: Users can make payments by scanning their face at a payment terminal.
- Functionality:
  - The system captures the user's face, compares it with stored data, and verifies identity.
  - Upon successful verification, the payment is processed.
  - Wallet points are deducted, and the transaction is logged.

3. Wallet Management

- Feature: Users have a digital wallet linked to their account.
- Functionality:
  - Users can view their wallet balance on the dashboard.
  - Wallet points are automatically deducted during transactions.
  - Insufficient balance triggers an error message.

4. Shop Dashboard

- Feature: Merchants can view transaction history and manage payments.
- Functionality:
  - Displays a list of transactions with details (user ID, name, amount, timestamp).
  - Provides a clean, responsive interface for easy navigation.

5. Security Measures

- Feature: Multi-layered security to protect user data and transactions.
- Functionality:
  - Facial recognition ensures only authorized users can make payments.
  - Data is stored securely in databases (SQLite for user and transaction records).
  - Basic validation checks prevent invalid inputs (e.g., non-numeric wallet points).

VI. TESTING AND RESULTS

The Facial Recognition Payment System was subjected to extensive testing to evaluate its effectiveness, reliability, and performance under practical conditions. The testing process was categorized into multiple stages to validate both individual modules and the integration of the system as a whole.

A. Unit Testing

Each component of the system—such as facial data capture, model training, user recognition, wallet deduction, and transaction logging—was independently tested to ensure functionality in isolation.

- Result: The system accurately captured and stored user facial data, and the LBPH-trained model successfully recognized registered users with an average accuracy exceeding 90%. The registration and login modules operated without error under controlled conditions.

B. Integration Testing

Integration testing was performed to verify smooth interaction between modules, including the registration interface, facial recognition engine, transaction handler, and shop dashboard.

- Result: Seamless data flow was observed between database.db and shop.db, with real-time updates to the shopkeeper dashboard upon successful transactions. The system responded appropriately to both valid and invalid input conditions.

C. Performance and Load Testing

To evaluate system robustness, performance testing simulated multiple concurrent registrations and recognition attempts under varying hardware conditions.

- Result: The system maintained consistent performance across 50+ users. Average recognition and transaction time remained under 2 seconds, even under moderate load, confirming the suitability of the system for real-time use.

D. User Acceptance Testing

Test users and stakeholders evaluated the system for usability, speed, and reliability of facial authentication in a controlled environment.

- Result: Participants reported a smooth and intuitive user experience. The facial recognition login and payment processes were significantly faster and more convenient than traditional card-based systems.

E. Security Testing

Basic security checks were performed to assess resistance to unauthorized access, such as spoofing using printed photos or mobile screen images.

- Result: The system effectively rejected static spoof attempts, demonstrating a foundational level of security. However, the implementation of advanced liveness detection was recommended as future work to further strengthen spoof resistance.

VII. DISCUSSION

The Smart Outfit Matching and Virtual Try-On System effectively addresses the challenges of providing personalized fashion recommendations and delivering realistic virtual try-ons. By integrating machine learning models with real-time image processing, the system enhances outfit matching accuracy and offers a dynamic, user-friendly experience. The use of ensemble models like Random Forest and XGBoost demonstrated strong performance in matching clothing items based on color harmony and user preferences. Random Forest excelled at handling diverse user input data, while XGBoost proved beneficial in improving the matching score and overall accuracy. The virtual try-on feature, powered by pre-trained TensorFlow models via Hugging Face, offered realistic outfit previews, enhancing the user experience.

Performance testing confirmed that the system maintained responsiveness, even with high image upload volumes and complex matching logic, ensuring a smooth user interaction. The system's scalability was demonstrated during load testing, where it successfully processed multiple outfit matching requests without compromising accuracy or response time. Real-time data integration allowed for personalized outfit suggestions based on user interactions, ensuring an adaptive and seamless user journey.

User feedback highlighted the ease of use, the accuracy of outfit suggestions, and the realistic virtual try-on functionality. Stakeholders appreciated the system's potential in aiding users to make better fashion choices with minimal effort. However, the system faces limitations in accurately predicting outfit suitability in edge cases, such as rare or unconventional combinations. Future improvements could involve expanding the dataset to include more fashion styles and integrating deeper AI models to refine matching algorithms further. Enhancing the accuracy of the virtual try-on feature by incorporating more precise 3D body modeling and environmental factors would also improve the realism of the virtual experience.

VIII.CONCLUSION

The implementation of the Facial Recognition Payment System successfully addresses the growing demand for secure, contactless, and efficient payment solutions. By integrating computer vision and machine learning technologies, the system offers a practical alternative to traditional transaction methods such as cash, cards, or mobile wallets. The use of the Haar Cascade algorithm for face detection and the LBPH algorithm for face recognition provided a reliable method for identifying users in real time, even under varying lighting conditions and minor facial changes. The modular system architecture—comprising a user registration interface, a facial recognition scanner, and a shopkeeper dashboard—ensured smooth operation and data integrity across different components. Each module functioned as intended, with the scanner accurately identifying users and the dashboard reflecting transaction data in real time. This tight integration helped create an end-to-end ecosystem that is not only functional but also scalable. User testing validated the system's ease of use, low recognition latency, and overall reliability. Stakeholders appreciated the simplified payment process, which eliminated the need for physical contact or manual input, thereby enhancing both convenience and hygiene. Furthermore, performance testing demonstrated the system's ability to maintain stable operations under moderate load, supporting its viability for deployment in real-world environments such as retail stores, restaurants, and transportation hubs.
While the system showed strong performance, some limitations were identified. The facial recognition module, while effective, could benefit from enhancements such as **liveness detection** to prevent spoofing with photos or videos. Additionally, support for multi-user concurrency and deployment on lower-spec hardware (e.g., Raspberry Pi) would improve flexibility and adoption potential. Future work may also include integrating encryption protocols and GDPR-compliant data handling practices to strengthen privacy and security standards.

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