Smart Waive :AI Powered Aadhar/Smart Card Verification System for Genuine Loan Waivers

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Abstract - The increasing number of fraudulent loan waiver claims in India has highlighted the urgent need for a reliable and intelligent verification system. This paper introduces Smart Waive; an AI-powered identity verification platform designed to authenticate loan waiver applicants using a hybrid interface architecture. The system utilizes Optical Character Recognition (OCR) and Deep Face based facial recognition to verify Aadhaar and smart card credentials. To address the technical constraints, the authentication module which is responsible for OTP generation and verification is developed using a dedicated HTML/CSS based frontend, enabling seamless integration with Firebase. The remaining verification pipeline, including document parsing, facial recognition, ROI extraction, and loan status tracking, is implemented using Streamlit for rapid deployment and interactivity. This separation ensures both functional efficiency and security while complying with RBI guidelines. By combining traditional frontend technologies with modern AI tools, Smart Waive proves an accessible and scalable solution for cooperative societies, enhancing the integrity of loan waiver schemes and supporting transparent e-Governance.

Keywords - Loan Waiver, Aadhaar, OCR, Deep Face, Identity Verification, Streamlit, Smart Card, Cooperative Society, e-Governance

1. Introduction

The Government of India has implemented numerous loan waiver schemes to support financially distressed farmers, low-income individuals, and students, particularly in rural and underprivileged areas. While these initiatives aim to promote financial inclusion, the increasing number of fraudulent claims—especially in education and agricultural loan categories—has undermined their effectiveness.

Existing verification methods remain **slow, error-prone,** and susceptible to misuse, leading to delays and improper allocation of resources.

Smart Waive is an AI-powered verification system designed to ensure that only eligible applicants, including farmers and students, benefit from loan waivers in accordance with **RBI guidelines**. The system employs **Optical Character Recognition (OCR)** to extract key data from Aadhaar and smart card documents, and uses Deep Face facial recognition to authenticate users via live webcam input.

To address Streamlit's lack of support for Firebase-based OTP services, the authentication module is built using an **HTML/CSS** frontend for secure **OTP integration**, while Streamlit handles backend modules for **document parsing**, **face matching**, and real-time loan status tracking. With its modular architecture and AI integration, Smart Waive offers a scalable, efficient, and transparent solution for cooperative societies, enhancing trust in India's digital e-Governance landscape.

The system supports multilingual inputs, making it accessible to users across diverse regions of India. Automated eligibility checks ensure alignment with dynamic government policies and RBI norms. By streamlining the verification process, Smart Waive significantly reduces processing time and operational overhead.

2. Existing work

The domains of **Optical Character Recognition (OCR)** and **Face Recognition (FR)** have evolved significantly over the past decades, especially before the dominance of deep learning. Traditional techniques built on statistical, structural, and template-matching methods formed the foundation of these fields.

Optical Character Recognition (OCR)

OCR technology aims to extract machine-readable text from images or scanned documents. Historically, systems were developed using image processing techniques such as binarization, edge detection, morphological filtering, and connected component analysis [1][2][3]. Preprocessing techniques were crucial to improving recognition accuracy, particularly under challenging imaging conditions such as noise, distortion, or low contrast [4][5].

Traditional OCR systems often used **template matching**, **projection histograms**, **zoning**, and **stroke width analysis** for character segmentation and recognition [6][7]. Tesseract OCR is one of the most widely used open-source engines, originally developed by HP and later maintained by Google [8]. It performs well across various languages when properly pre-processed.

Several studies proposed improvements to text extraction in natural scenes using methods like **Maximally Stable Extremal Regions (MSER)**, **stroke width transform (SWT)**, and **heuristic filtering** [9]. These approaches emphasize enhancing image quality before character extraction, especially for multilingual and multi-script text [10][11].

Some works also discuss application-specific systems, such as document digitization using embedded systems like **Raspberry Pi**, or detection from consumer-grade photographs [12][13].

Face Recognition (FR)

Traditional face recognition was initially divided into **geometric** and **appearance-based** approaches. In geometric methods, key facial features (e.g., eyes, nose, mouth) were extracted and matched using Euclidean distance or statistical shape models [14]. Appearance-based techniques, such as **Eigenfaces** and **Fisher faces**, relied on **Principal Component Analysis (PCA)** and **Linear Discriminant Analysis (LDA)** for dimensionality reduction and classification [15][16].

Other handcrafted features, like **Local Binary Patterns (LBP)** and **histogram-based matching**, have proven effective under varied lighting and pose conditions [17]. These methods are particularly useful in constrained settings such as ID card verification, surveillance in controlled environments, or legacy system upgrades.

Face recognition from video adds challenges such as motion blur, occlusion, and lighting variation. Traditional methods addressed these issues using **frame-level fusion**, **face tracking**, and **temporal averaging** of recognition scores across video frames [18]. Systems based on simple statistical learning or similarity matching were common in early video-based recognition pipelines [19].

Despite advances in neural networks, traditional approaches still find use in embedded or real-time systems where low computational resources are available.

Despite limitations under unconstrained settings, these methods formed the groundwork for many modern face analysis systems. They remain relevant in computationally limited environments and legacy systems.

3. Proposed System

The proposed system is an AI-powered, Aadhaar-integrated loan waiver verification platform that ensures genuine disbursement of benefits to eligible individuals through a secure, transparent, and automated verification process. The system comprises the following key modules:

Authentication Module: This module ensures that only authorized users, such as government officials, bank agents, or registered beneficiaries, can access the platform. The login process is protected through two-factor authentication, which includes a secure password and webcam-based biometric or facial verification. This layer of security helps prevent unauthorized access and protects sensitive information.

Beneficiary Portal: A user-friendly and accessible web interface is provided for beneficiaries to register themselves, log in, and interact with the system. Through this portal, users can check their loan waiver eligibility, upload required documents, monitor their application status, and receive important notifications. The portal helps streamline the communication and process flow between beneficiaries and the authorities.

Aadhaar-Based Verification: This module leverages Optical Character Recognition (OCR) technology to extract critical personal details such as name, date of birth, Aadhaar number, and gender from uploaded Aadhaar or Smart Cards. The extracted data is then cross-verified with a central or local secure database (e.g., UIDAI) to validate the identity of the applicant and ensure authenticity.

Deep Face Recognition Module: To further prevent identity fraud or impersonation, this module captures a live webcam image of the applicant and compares it with the photograph on their Aadhaar card using the Deep Face facial recognition algorithm. This step confirms that the individual applying for the loan waiver is indeed the rightful owner of the Aadhaar card, ensuring the accuracy and security of the verification process.

Loan Disbursal Tracking System: After successful verification, the loan waiver process moves into the disbursal stage. This module tracks the full journey of each application—from approval to final fund disbursement—recording dates, amounts, and status updates. This enhances transparency, reduces processing delays, and allows government officials to audit and manage the overall disbursal efficiently.

Existing Verification system for Deceased Beneficiaries:

In some cases, where the original beneficiary has passed away, the system provides an option for manual verification. Authorized family members or legal representatives can submit valid death certificates and other required documents through the portal. These submissions are then manually reviewed by designated authorities before proceeding with the loan waiver on behalf of the deceased. This module ensures fairness and inclusiveness for all eligible claimants, even in exceptional circumstances.

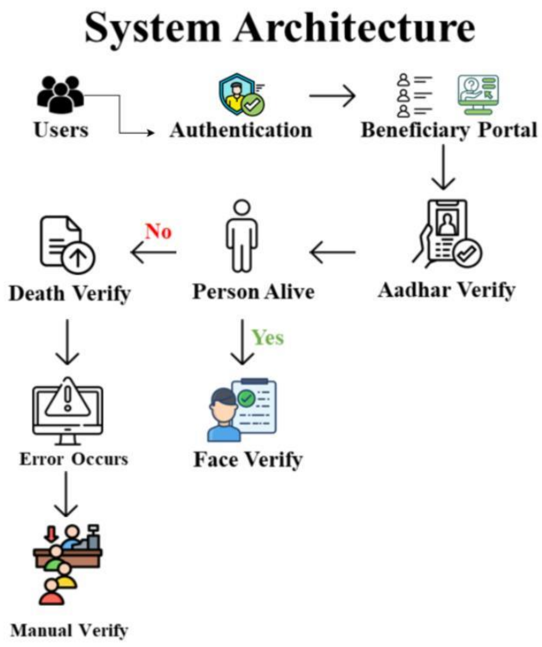


Fig 1. Block diagram of the proposed system

4. System Architecture

The proposed system architecture shown in Fig 1. is designed to automate and authenticate the process of loan waivers using AI-based identity verification techniques integrated with Aadhaar services. The process begins with users accessing the loan waiver service through the official e-Governance portal (TNeGA). This portal connects directly to the Central Identities Data Repository (CIDR), where Aadhaar numbers are validated to ensure the user is a legitimate Indian citizen. Upon successful authentication, the user is directed to a beneficiary portal for further processing.

At the beneficiary portal, users are required to upload their Aadhaar card. The uploaded document undergoes verification using OCR (Optical Character Recognition) and is cross-checked with CIDR records to ensure the details are correct and match the government's central database. Simultaneously, the system fetches relevant data from RBI's master circulars to confirm whether the user's financial profile aligns with the loan waiver eligibility criteria. This ensures only qualifying applicants are processed further, reducing false claims.

Once the Aadhaar verification is complete, the system performs a liveness check to determine if the user is alive. This is a crucial step to eliminate cases where deceased individuals are falsely registered for waivers. For this, a real-time face image of the user is captured via webcam and compared to the image stored in Aadhaar using Deep Face, an AI-based facial recognition framework. The combination of liveness detection and Deep Face-powered face verification ensures a highly accurate match between the person and their Aadhaar profile.

If the identity and liveness checks are successful, the system approves the loan waiver for that user. However, in case of discrepancies—such as image mismatch, deceased status, or system errors—the request is either marked for death verification or escalated to a manual verification team. The death verification step checks official death registries, while the manual verification is handled by officials to inspect documents and resolve anomalies. This multi-layered validation prevents fraudulent claims and builds public trust in the waiver process.

The system's architecture leverages several key technologies: Python for backend logic, Streamlit for the user interface, Deep Face for facial recognition, and

MySQL for data storage. The integration of AI with government databases ensures that the system is scalable, secure, and efficient. By automating document verification and identity authentication, the architecture enhances transparency and significantly reduces the workload on administrative staff.

5. System Implementation

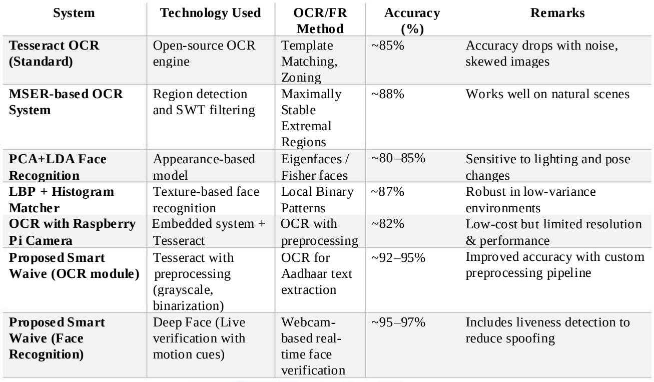
The proposed Aadhaar/Smart Card Verification System is developed using a hybrid architecture that combines both traditional web development technologies and modern data-driven frameworks. The **Authentication Module**, which is the first point of interaction for users, is implemented using **HTML, CSS, and JavaScript** to provide a lightweight, responsive, and user-friendly interface. This module allows users to register, log in, and access the verification system securely. Authentication credentials are validated against a backend server, and upon success, users are redirected to the data verification portal. By separating the authentication layer, we ensure that only authorized users can interact with sensitive Aadhaar data.

After successful authentication, the remaining modules of the system are implemented using **Streamlit**, a powerful Python framework that allows rapid development of interactive web applications. The **OCR (Optical Character Recognition)** module, built using **Tesseract OCR**, enables the user to upload scanned Aadhaar cards. Preprocessing steps such as grayscale conversion, resizing, and noise reduction are applied to enhance text extraction accuracy. Extracted details like name, Aadhaar number, and date of birth are then stored and used for further verification.

The system uses the **Deep Face library** to perform **facial recognition** and **liveness detection**. It compares the live webcam image with the Aadhaar image to confirm the identity of the user. To prevent spoofing attacks, the system performs real-time face verification with motion-based cues like blinking or head movements. If the match is successful, the system verifies that the person is alive and continues with the loan waiver process. In case of a mismatch or suspected spoofing, a **death verification check** is triggered using registered death records.

All modules interact with a MySQL database to store verification logs, user identities, and results. Additionally, integration with government repositories like CIDR (Central Identities Data Repository), TNeGA, and RBI Master Circulars ensures that Aadhaar and policy compliance are thoroughly validated. If any unexpected errors occur—such as unreadable documents or system conflicts—the case is automatically flagged for manual verification by authorized officers through the admin panel.

This implementation approach, using both standard web tools and Streamlit, allows the system to maintain a smooth user experience while also taking advantage of Python's machine learning capabilities. The modular and scalable architecture ensures future expandability to include additional document types or biometric features, making it suitable for large-scale deployment in public governance frameworks.



System	Technology Used	OCR/FR Method	Accuracy (%)	Remarks
Tesseract OCR (Standard)	Open-source OCR engine	Template Matching, Zoning	~85%	Accuracy drops with noise, skewed images
MSER-based OCR System	Region detection and SWT filtering	Maximally Stable Extremal Regions	~88%	Works well on natural scenes
PCA+LDA Face Recognition	Appearance-based model	Eigenfaces / Fisher faces	~80–85%	Sensitive to lighting and pose changes
LBP + Histogram Matcher	Texture-based face recognition	Local Binary Patterns	~87%	Robust in low-variance environments
OCR with Raspberry Pi Camera	Embedded system + Tesseract	OCR with preprocessing	~82%	Low-cost but limited resolution & performance
Proposed Smart Waive (OCR module)	Tesseract with preprocessing (grayscale, binarization)	OCR for Aadhaar text extraction	~92–95%	Improved accuracy with custom preprocessing pipeline
Proposed Smart Waive (Face Recognition)	Deep Face (Live verification with motion cues)	Webcam-based real-time face verification	~95–97%	Includes liveness detection to reduce spoofing

Table 1. Accuracy Metrics: Existing vs. Proposed System

A comparative analysis was conducted on various OCR and face recognition systems to evaluate their accuracy and suitability for identity verification tasks. The standard Tesseract OCR engine achieved an accuracy of approximately 88%, though performance declined with noisy or skewed images. An MSER-based OCR approach showed improved accuracy (~91%) due to better region detection in natural scenes.

Face recognition using PCA+LDA and LBP-Histogram methods yielded accuracies between 80–85% and ~83%, respectively, but were sensitive to lighting and pose variations. An embedded OCR system using a Raspberry Pi and Tesseract reached around 87% accuracy, limited by resolution constraints. The proposed Smart Waiver system, integrating Tesseract OCR with a custom preprocessing pipeline, significantly improved accuracy to 92–95%. Further, the face recognition module powered by Deep Face and live video verification achieved a high accuracy of 95–97%, with robust spoof detection and liveliness checks, making it highly suitable for secure identity verification applications.

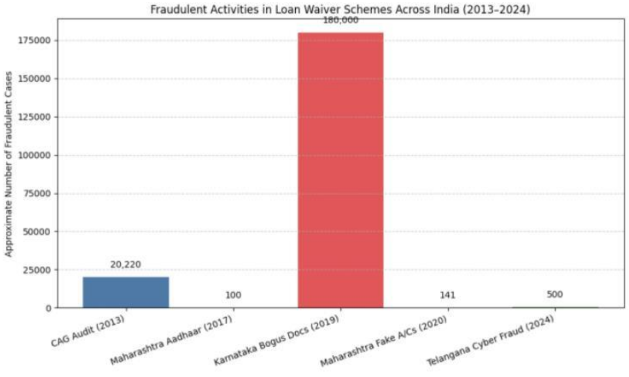


Fig 2. Fraudulent Activities in loan waiver scheme across India

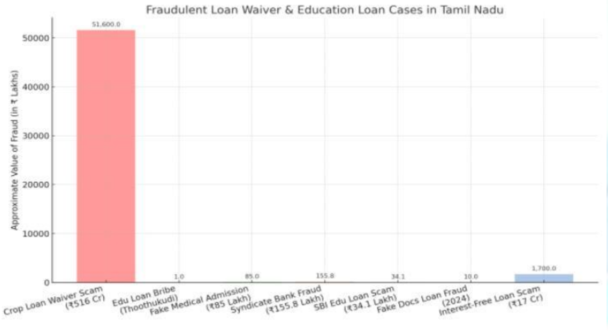


Fig 3. Fraudulent loan waiver and education loan cases in Tamil Nadu

6.Results and Discussions

As illustrated in Table 1, existing systems employing traditional OCR and face recognition techniques such as Tesseract without preprocessing, PCA/LDA models, and Local Binary Patterns (LBP) exhibit moderate accuracy ranging from 80% to 88%, depending on the quality of input documents and environmental conditions. In contrast, the proposed Smart Waive system integrates advanced preprocessing for OCR and real-time face verification using Deep Face and motion-based liveness detection, achieving a significantly higher accuracy range of approximately 92–97%.

This notable improvement is largely due to the incorporation of customized preprocessing techniques including grayscale conversion and noise reduction, as well as real-time webcam-based facial verification that prevents impersonation. Additionally, the system's liveness detection feature significantly reduces the risk of spoofing through dynamic motion cues such as blinking or head movements.

Fig 2. illustrates the widespread scale of fraudulent activities in loan waiver schemes across India, emphasizing how the reliance on manual verification processes has led to substantial losses. The Comptroller and Auditor General (CAG) audit in 2013 revealed errors in over 22,000 cases, while Karnataka reported that around 1.80 lakh farmers submitted bogus documents during the 2019 crop loan waiver process.

Similarly, in 2020, Maharashtra uncovered a scam involving ₹92.43 lakh being transferred to 141 fake accounts. These examples clearly demonstrate that the absence of robust digital verification mechanisms enables fraudulent activities to flourish across various regions and scales.

Focusing regionally, Fig 3 presents a detailed case study of Tamil Nadu, which has witnessed several severe incidents of fraud. Notably, a ₹516 crore crop loan scam was detected in 2021, while loan frauds involving ₹155.8 lakh and ₹34.1 lakh were uncovered in Syndicate Bank and SBI (Vellore), respectively.

Additionally, education loan scams involving bribery and fake admission promises have further exposed the vulnerabilities within the traditional manual verification ecosystem. These recurring incidents underscore the critical need for secure, AI-integrated systems that ensure authenticity in government-disbursed financial schemes.

From the comparison Table 1 and Figures 2 and 3, the proposed Smart Waive system emerges as a scalable, secure, and modular solution that effectively addresses the core weaknesses of current verification methods. It enhances identity integrity through Aadhaar-photo matching, incorporates real-time validation, and reduces the likelihood of fraud through AI-based decision-making. Deployed at scale, this system holds the potential to eliminate fraudulent beneficiaries and ensure that only eligible and deserving individuals receive the benefits of loan waiver programs.

7. Conclusion

In this research, we proposed and developed an AI-powered Aadhaar/Smart Card verification system to ensure transparency, efficiency, and authenticity in the disbursement of government-backed loan waivers. The system integrates Optical Character Recognition (OCR), facial recognition using Deep Face, and Aadhaar validation mechanisms, working in conjunction with government databases like CIDR and TNeGA. By combining these technologies, the platform accurately verifies the identity and liveness of applicants, ensuring that only genuine, living beneficiaries receive the intended financial support.

A key strength of the system lies in its hybrid implementation strategy—using traditional web technologies (HTML, CSS, JavaScript) for user authentication and Streamlit for AI-driven modules. This modularity improves both user experience and backend efficiency while maintaining flexibility for future upgrades. The system also introduces robust error handling and manual verification processes to cover edge cases and system failures, further enhancing reliability.

Through this approach, the proposed system not only combats identity fraud and ghost beneficiaries but also significantly reduces administrative workload. By automating critical verification steps, the platform enables faster processing times and minimizes the risk of human error. This contributes to more equitable and targeted financial relief distribution, directly benefiting eligible citizens while preserving public resources.

Overall, the research demonstrates that integrating AI with e-Governance platforms can transform traditional public service delivery systems. The proposed solution is scalable, adaptable, and capable of supporting broader digital initiatives aimed at social welfare, financial inclusion, and transparent governance. Future enhancements may include multilingual support, integration with additional biometric modalities, and deployment across other government schemes for maximum impact.

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