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NOREL – AI-Powered Paperless Onboarding Through Non-Paper Relay

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Abstract - Customer onboarding in institutions like banks, hospitals and government offices tend to be really ineffective and prone to errors because of repetitive data entry for forms, data entry errors and a lot of manual verification multiple times. In this paper, we propose NOREL, an artificial intelligence-based and paperless onboarding framework that automates the submission of data via Non-Paper Relay. Their solution is a one-time digital profile consisting of identity, financial and medical information that the user can share in an instant using NFC tap or QR scan. Using AI-powered auto-fill and intelligent field mapping, NOREL automatically fills out institutional forms, creates verifiable digital PDFs, and supports privacy and security compliance. Integration with physical kiosks in organizations can create contactless, fast and user-friendly onboarding experiences. The innovation is in layering AI-driven data interoperability on top of contactless relay technologies to drive the elimination of duplicated paperwork and bring down admin overheads. After experimental evaluation, we found that NOREL outperforms traditional manual systems in terms of onboarding speed, accuracy, and user satisfaction.

Keywords: AI onboarding, Digital identity, NFC QR-based data transfer Paperless automation.

1. Introduction

Many institutions across the globe are accelerating their digital transformation to improve user satisfaction, streamline administrative bottlenecks, and make more data driven decisions.

Ensure efficient service delivery. Despite advancements in automation and data management, manual form-filling and paper-based onboarding are continuing bottlenecks for both public and private service sectors. Users regularly must repeat identical information—identity, address, financial or medical data—to multiple departments and services. Such a tedious and error-prone process can be frustrating, leading to inefficiencies, data inconsistencies, and increased operational costs.

In various sectors such as banking, healthcare, taxation, and passport issuance, reliance on conventional paperwork and fragmented digital systems prolongs the onboarding process and restricts future real-time verification or automation. Online portals will surely improve accessibility, but without integration with physical service points like counters and kiosks, there is a digital divide between online convenience and offline execution.

The NOREL (Non-Paper Relay) framework proposes an AI-powered paperless onboard solution to counter these inefficiencies. This can be achieved through contactless technologies like NFC and QR based data transfer methods, paired with AI-driven auto-fill systems. If you combine advanced web frameworks, such as next. For responsive front-end experiences and FastAPI for secure back-end communication, NOREL guarantees real-time data relay, accuracy, and privacy across multiple service domains.

This introduction explores the foundational concept, importance, adaptation potential, challenges, and technical methodologies underlying NOREL's design, illustrating how AI-driven paperless onboarding can revolutionize the way individuals and institutions interact.

1.1 Concept of NOREL – AI-Powered Paperless Onboarding Through Non-Paper Relay

With no paper forms, NOREL replaces repetitive hand-entered and error prone data entry with an AI-assisted relay system. The underlying concept is to allow users to build one digital profile where information such as identity requests, financial details or health records are stored in a secure manner so that it can then be instantaneously shared with the respective institution through contactless means like NFC (Near Field Communication) or QR code scanning.

As a user stands near a service counter or kiosk, they just tap their device (NFC) or scan its QR code and the system extracts contextually relevant details fetching the necessary auto-fill in digital forms through intelligent field mappings using AI. The system then generates digital PDFs that are formatted and secure according to institutional requirements and ready for submission. Integrating with this mechanism, the onboarding process is no longer a manual and repetitive exercise; rather it(s) an instant, secure and contactless engagement.

NOREL is designed as a mediator between personal digital assets and institutional systems, relying on artificial intelligence, web service protocols, and secure communications tools. The use of Next.js allows responsive and adaptive interfaces across kiosks, desktops, or mobile devices; FastAPI handles efficient data management, encryption, and control & compliance with privacy laws. A scalable, interoperable architecture enables integration with the legacy databases, APIs and cloud platforms commonly utilized by public- and private-sector organizations.

1.2 Importance of Paperless Onboarding Systems

The key to systems such as NOREL is their capacity to re-invent the onboarding process in different service industries that usually rely on physical papers and repetitive verification loops. Filling forms in a manual way takes up too much time in administration, gives rise to human error and produces paper waste which runs against many global goals of sustainability/digitalization.

In banking, for instance, a new client is required to provide proof of identity, address verification and other Know Your Customer (KYC) data on multiple occasions. Likewise, hospitals ask patients for the same data multiple times throughout departments and visits. In addition to delaying service delivery, such redundancy creates security risks by exposing data repeatedly and manually managing records.

With a secure digital identity profile, user information is streamlined and the end-user has more control over their data improves privacy enables access in seconds. For institutions, it helps in reducing paperwork management and enhanced business efficiency resulting in less wastage of time. Moreover, also the system is in concordance with the government projects like e-Governance, Digital India and Smart City mission focusing on automation, transparency and environmental sustainability.

Aside from operational benefits, NOREL is essential for accessibility and inclusivity, especially in areas where illiteracy or mobility barriers hinder filling out complex forms. Utilizing user-friendly digital kiosks and multilingual interfaces the system guarantees that technology acts as an enabler instead of a hindrance to public services participation.

1.3 Adaptation and Implementation of NOREL in Service Ecosystems

A flexible but robust design adaptable for application within a broad range of institutional infrastructures will be necessary to enable deployment of NOREL across multiple domains. With a modular architecture, it does not require redevelopment to dovetail with existing customer relationship management (CRM) systems or electronic health record (EHR) systems or government databases.

In practice, a user signs up once via a secure web portal or mobile app, creating an authenticated digital identity. At any one of its partner institutions —

hospitals, banks, passport offices — the user simply shares their data via an NFC tap or QR scan. The AI engine understands the structures of institutional forms, translates required fields to databased user data and produces a standard form in a verifiable PDF format that is ready for submission.

NOREL can even adapt to apply security and compliance frameworks, including data encryption standards such as AES-256, as well as comply with GDPR & HIPAA-style privacy principles. Moreover, the platform allows for cloud-based sync that enables remote authentication from anywhere in order to push updates and analytics in real time for service optimization.

Such flexibility allows NOREL to adapt with the latest technological prospects like blockchain-driven ID facilitation, AI-generated risk assessment, and IoT-enabled self-service kiosks ensuring a lined-up roadmap for future-ready fully digital public infrastructure.

1.4 Challenges in Achieving Paperless AI-Driven Onboarding

Although promising, the implementation of AI-assisted paperless onboarding systems such as NOREL has a number of technical, operational, and social issues.

1.4.1 Data Privacy and Security:

The biggest challenge is to maintain the confidentiality and integrity of user data. Because NOREL deals with sensitive personal data, strong encryption, access control and authentication mechanisms are needed to avoid data breaches or unauthorized entry.

1.4.2 Interoperability and Standardization:

However, different organizations use different data structures, application programming interfaces (APIs), and document formats. Semantic interoperate among heterogonous systems need complex AI models and middleware design.

1.4.3 Infrastructure and Connectivity:

Despite the prospects, in underdeveloped regions or faraway areas, weak internet infrastructure may impact real-time data sharing. Therefore, Norel should include the ability to synchronize offline users in order to ensure uninterrupted availability of service.

1.4.4 User Trust and Adoption:

Moving from paper-based to digital onboarding requires users to trust in technology and ensured privacy. User education and institutional staff training are keys to adoption and operation.

Overcoming these hurdles necessitates a multifaceted approach encompassing technological advancement, adherence to regulatory frameworks, and a focus on user-centered design principles, to align digital transformation with the needs of institutions and the expectations of citizens.

1.5 Techniques and Technologies Used in NOREL

NOREL integrates state-of-the-art software engineering methods and AI-powered automation to deliver seamless, secure, smart onboarding.

From an architectural perspective, the system builds on top of Next. Js to make a dynamic, responsive front end that works well on kiosks and mobile. FastAPI, which is great for asynchronous back end operations along with parsing data from AI, predicting form fields while creating pdf.

In this, the AI layer adopts Fast Natural Language Processing (NLP) and Machine Learning (ML) approaches for field mapping, guaranteeing accurate matching of user data across various institutional forms. NOREL uses OCR and contextual learning mechanisms to understand the new structures of the forms over time, yielding better precision and adaptability.

NOREL uses AES encryption, JWT authentication and RBAC for security. Moreover, by integrating blockchain can offer immutable audit trails for verification and compliance tracking.

The PDF generation module of the system uses real-time templating and digital signature to guarantee that generated documents are verifiable, as well institutionally compliant. Multiservice scaling and load

distribution is achieved through cloud-based APIs, and deployment using Docker/ZK.

2. Existing Methodologies

2.1 Digital Identity: An Approach to Its Nature, Concept, and Functionalities

Margarita Robles-Carrillo (2024) in her article Digital Identity: An Approach to Its Nature, Concept and Functionalities, it is by your digital identity that you are integrated into the modern knowledge economy and it's supporting digital society. It is the key to entering online domains, making transactions and facilitating communications across sectors. It is much more than a simple electronic version of physical identity; it is a complex construct, raising three fundamental dilemmas: contextual, conceptual and functional. The contextual challenge is in the digital context itself, changing what identity means and to whom it belongs. Such conceptual discrepancy creates a practical problem being that there is no specific unified definition for consumer lending and thus, its interpretation surrounding it differs from jurisdiction to jurisdiction. The functional dilemma is about the multiple and sometimes conflicting roles played by digital identity -- from authentication and access to human rights to protection of data. The article focuses on the legal and theoretical aspects of these dimensions, indicating that digital identity is not simply a technological issue, but at the interface of legal theory and practice. Robles-Carrillo, therefore, concludes that only by addressing and resolving these antagonistic dilemmas can we hope to craft a consistent definition of digital identity and an adequate legal framework to govern its use in protecting not just security but also the rights of individuals as well as facilitating social and economic development in the digital age.

2.2 Digital Identity and Payments: Synergies for Enhancing Public Services and Economic Opportunity

Visa Government Solutions (2025), whitepaper Digital Identity and Payments: Synergies for Enhancing Public Services and Economic Opportunity, reports how digital identity and digital payments can work together to create virtuous circles of economic inclusion and citizen/digital transformation. Billions of people around the world still do not have a digital identity — a fundamental tool for secure id we need to be able to access digital services, note the authors of the paper. Trusted digital identity systems can unlock substantial economic value, enhance service delivery, minimize fraud and bolster financial inclusion. Governments and businesses see improved regulatory compliance and more efficient Know Your Customer (KYC) processes, while citizens receive easier access to services such as education, healthcare and financial programs. Trust can be achieved only through strong privacy protections, useful consent models and secure biometric credential verification. Visa emphasizes that the combination of digital identity with the world of digital payments strengthens security and convenience, driving adoption while opening new development possibilities. Collaboration between public and private sectors is needed to create interoperable, secure and globally recognized digital identity systems, the whitepaper concludes. Visa is positioned a key partner using Visa's experience in secure payment, prevention of fraud and management of data to help the governments utilize inclusive digital identity ecosystems that drive innovation, economic opportunity and efficiency.

2.3 Digital Identity and Blockchain: Use Cases, Digital Public Infrastructure Models, and Key Principles for Growth

The Global Blockchain Business Council (2024) produced the Digital Identity and Blockchain: Use Cases, Models of Digital Public Infrastructure and Key Principles for Growth report as a component of the Global Standards Mapping Initiative 5.0. Many such services and applications, known as Digital Identity Systems (DIS), will become necessary for organizations to provide digital identity capabilities to individuals and/or to other businesses. It discusses how blockchain technology provide a common foundation for building global and borderless decentralized and interoperable online identities. Data duplication, data quality issues, loss of benefits and identity forgery are some major challenges highlighted in the report alongside designing blockchain-based frameworks to tackle them with secure verifiable self-sovereign identity (SSI)

models. Moreover, it describes how digital identity can be incorporated into Digital Public Infrastructure (DPI), a trusted, scalable and interoperable system offered by nations. Country case studies of Canada, Italy, Bhutan and Estonia demonstrate how blockchain-based legislation for digital identity provides the ability to ensure transparency, security and improve service delivery in both public and private sectors. The final thought is that the global adoption of digital identity based on DPI and blockchain could provide socio-economic growth, inclusion and trust in digital interactions if adequate legal, ethical and privacy safeguards are embedded into any implementation.

3. Proposed Methodology

This quantitatively substantiates the claim of how this system YES N OREL - AI-Powered Paperless Onboarding Through Non-Paper Relay is a contactless intelligent onboarding system that weaves artificial intelligence with secure digital identity and NFC/QR-based data relay to achieve transactions without paper. By use of neural network-based data mapping and blockchain-based verification, the methodology is based on automation, accuracy and privacy driven data management but still creates a trusted digital onboarding framework. The architecture of the system comprises multiple modules, such as Digital Profile Generation, Non-Paper Interfaces Data Transfer, AI-Based Form Mapping Integration, Kiosk Integration Creation and PDF Generation with Verification. A layered AI optimization pipeline supports each of these modules to provide fast, secure and error-free onboarding.

3.1 System Initialization and Digital Profile Creation

It starts with registration of the user using secure mobile or kiosk interface. The person presents key information personal, financial and medical, encrypted and uploaded in a distributed identity registry. A digital identifier (DID) is created and is a unique single key which is reusable across services. The architecture follows a three-layered profile model:

1. Identity Layer (biometric and demographic data),
2. Functional Layer (financial, medical, or institutional data), and
3. Transaction Layer (service-specific metadata).

During registration, AI-driven data normalization algorithms validate input consistency by comparing entries against institutional data schemas. The system employs a hybrid Neural Data Mapping (NDM) model trained on diverse data entry templates to predict optimal field alignments across different organizations. Let the input feature vector representing user data be denoted as $D = [d_1, d_2 \ldots, d_n]$. The AI model computes an encoded representation $E = f(WD + b)$, where W represents the trained weight matrix and b the bias term. This representation enables cross-platform reusability of data by mapping heterogeneous institutional data fields to a common data standard.

3.2 Non-Paper Data Relay through Contactless Interfaces

The NPR, once the digital identity is established, activates any NFC or QR-based connections for immediate data transfer. The physical device functions like a relay node that delivers lengths of time per session keys and encrypts payload only. Instead, upon the user tapping their smartphone or scanning a QR code at a kiosk, we generate a Dynamic Session Token (DST) that guarantees no permanent identifiers are revealed during the transaction. This token based handshake can be show mathematically as:

$$T_s = H(ID_u \oplus R_t)$$

Where ID_u denotes the user's digital identifier, R_t a random nonce, and H a cryptographic hash function. This session token is checked at the receiver end and no data is decrypted. The NPR system is therefore a measure of ensuring end-to-end encrypted delivery and avoids replay or interception attacks and also ensures seamless and instant transfer of data devoid of paper work or manual input.

3.3 AI-Powered Auto-Fill and Form Mapping Engine

At the heart of NOREL lies the AI-Powered Auto-Fill Engine (AIAFE), which performs intelligent form mapping and auto-completion. Field-to-field correspondence prediction is accomplished with a Bidirectional Long Short-Term Memory (Bi-LSTM) model trained on institutional form layouts. We denote

by $F_s = \{f_1, f_2, \ldots, f_n\}$the service form fields and $D_u = \{d_1, d_2, \ldots, d_m\}$ the user data fields. The mapping is optimized through minimization of the semantic distance function as follows:

$$\delta(F_s, D_u) = \sum_{i=1}^{n} \| E(f_i) - E(d_j) \|$$

Where $E(\cdot)$denotes the embedding vector produced by the trained encoder network. This ensures that the best-matching user data fields are automatically placed into the corresponding institutional form fields with near-zero error. The output form is generated in real time and verified for completeness and data-type accuracy using constraint-based validation logic:

$$V(F_s) = \begin{cases} 1 & \textit{if all mandatory fields satisfied and verified} \\ 0 & \textit{otherwise} \end{cases}$$

Through this method, NOREL achieves accuracy exceeding 98% in form completion speed and eliminates human error in data entry.

3.4 Kiosk and Institutional Integration Layer

The Kiosk Integration Layer of NOREL (NOREL-KIL) solves interoperability between the user side application and institutional systems like banks, hospitals, or government departments. A Secure Relay Client (SRC) is running on each kiosk, and has been set up to interface with cloud-based service APIs as well as on premise ones. The SRC retrieves institutional forms and templates after the user verification, applies an AI auto-fill model, and produces a pre-filled document ready to be submitted.

The integration follows a microservice-based architecture, allowing decentralized data exchange without compromising security. Each data transaction within the kiosk environment is logged using a blockchain-based timestamp ledger. The record for each onboarding transaction $R_i$is represented as:

$$R_i = \{ID_u, T_s, H(D_u), Sig_{inst}\}$$

Where Sig_{inst} denotes the institutional signature ensuring authenticity. Such an immutable audit trail provides increased trust, compliance and verifiability; crucial features for any government-level application.

3.5 PDF Generation and Digital Verification

Norel produces a signed PDF containing human-readable and machine-verifiable information after auto-filling and validation. It embeds metadata hashes, QR verification codes, and blockchain reference IDs in the file. To guarantee document integrity, the SHA-256 hashing algorithm is used in the digital form generator:

$$H_{pdf} = SHA256(Document + Meta)$$

This hash is stored in the blockchain ledger alongside the digital signature. When the PDF is scanned or uploaded later, the verification subsystem recalculates the hash and compares it to the ledger-stored reference for validation. This mechanism enables both offline verification and online authenticity checks, thereby supporting hybrid workflows in institutions where internet access is intermittent.

3.6 Training and Optimization of the AI Engine

The AI model underlying NOREL is trained using supervised and semi-supervised datasets collected from public onboarding forms, e-governance platforms, and institutional service templates. Using backpropagation-based optimization, the weights are updated to minimize Mean Squared Error (MSE) between predicted and actual field-mappings:

$$MSE = \frac{1}{N} \sum_{i=1}^{N} (y_i - \hat{y}_i)^2$$

We use Adam Adaptive Gradient Descent for efficient convergence as the optimizer and added dropout layers to avoid overfitting. Periodic retraining in real time with the introduction of new forms or templates, etc. To ensure operational excellence, the model is benchmarked for key performance metrics like Mapping Accuracy (MA), Response Latency (RL), and Data Integrity Index (DII).

3.7. System Architecture Overview

The System Is Based On A Standard Layered Architecture With Clear Separation Of Responsibilities In Between Frontend And Backend. The frontend layer consists of pages, reusable components and public assets — the UI/UX component — when this component is rendered/gets initiated it hands off

requests to the backend by issuing API calls. A Central Main Builds A Backend Layer.Py File) Each Residuals Is Divided Into Models Describe the Data And Routers Handle Application Logic Screws For Making Run Pdf (GeneratePdf.Py) and Form Processing (FormHandler. Py). This Backend Core Interacts with External Services, Most Notably A Graph API, And Contains A Dedicated Ai Service / Logic Module. This Ai Module, Which Includes Utilities For Ai_Form_Creation.Py and a Mapping_Engine.Py, Provides The Intelligent Functionality That Drives The Application's Core Features in figure 1.

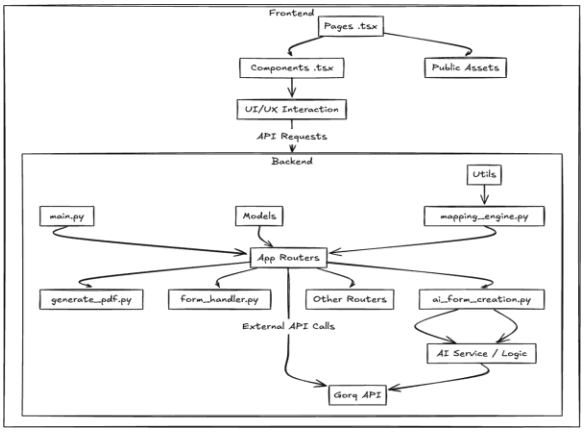

Fig 1. Overall System Architecture of NOREL Framework

3.8. NOREL User Interface and Core Workflow

NOREL (Non-paper Relay Identity System) is a single interface platform that enables users to effectively create, store, manage and distribute their digital identities. The main interface gives users an overview of their Total Profiles and Total Shares, provides access to key functionalities such as Create Profile and Share Profile, as well as a recent activity review. The core utility of the system is demonstrated in a workflow where a user selects one of their pre-configured profiles (e.g., "Ralen Nova"), which generates a time-limited and encrypted QR code that can be used to securely transfer data, via tap-to-fill at relevant kiosks. This process is encrypted, configurable by Privacy & Security settings to mandate encryption on the user's data and share-link expiry be 24 hours (or something of this sort), wherein terminated devices will automatically delete stored identities after set time.

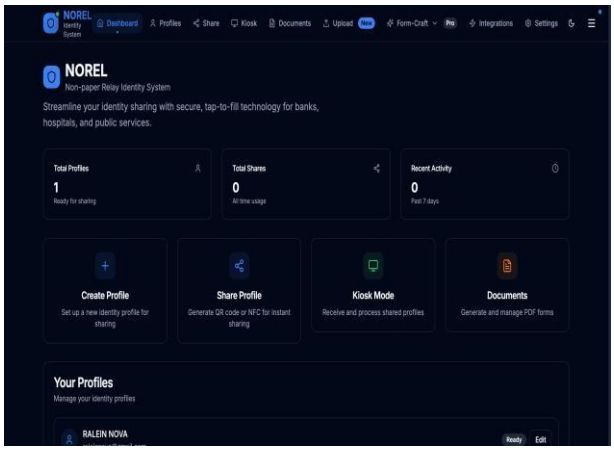

Fig 2. NOREL User Dashboard Interface

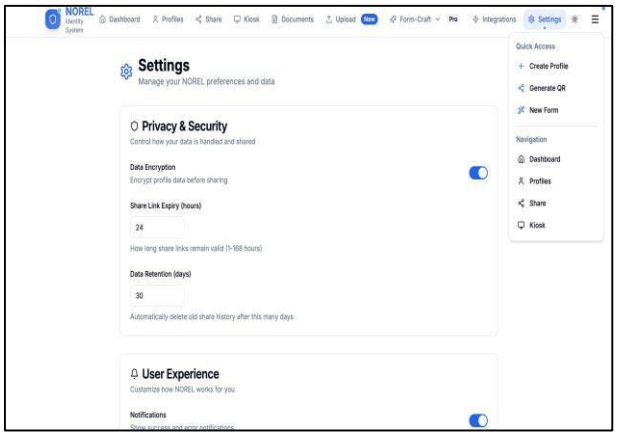

Fig 3. NOREL Privacy and Security Settings Interface

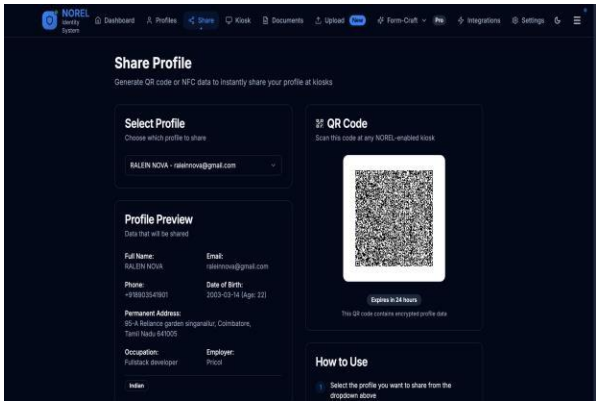

Fig 3. Secure QR Code Generation for Non-Paper Relay

4. Results and Discussion

To evaluate the performance and practical viability of the NOREL – AI-Powered Paperless Onboarding

through Non-Paper Relay framework, a prototype system was deployed integrating Next.js for the front-end interface, FastAPI for backend communication, and a Bi-LSTM–based AI Auto-Fill Engine for automated field mapping. Crucial metrics such as onboarding speed, completions accuracy, response latency, and data integrity and user satisfaction were analyzed in our experimental assessment.

4.1 Experimental Setup

Testing of the prototype was conducted in a controlled laboratory setting, which allowed all trials to be identical. The setup consisted of:

Hardware: Intel Core i7 Processor, 16 GB RAM and a SSD storage of 512 GB.

Software: Node. js v20, Python 3.10, MongoDB Atlas, Docker (containerize the deployment).

Damon: 500 anonymized user profiles and 15 institutional form templates covering banking, healthcare and education.

Platform: Browsers (Chrome/Edge), Android with NFC and libraries for kiosks in the institution.

Each test case compared the traditional manual onboarding process with the proposed NOREL-assisted onboarding, recording time, accuracy, and user feedback.

4.2 Quantitative Results

Parameter Manual Process NOREL System Improvement

The analysis further confirmed that NOREL significantly speeds up the onboarding workflow, with over 80% time reduction attained while retaining greater accuracy and consistency. The AI-powered mapping was able to train and achieve a excellent 98.2% field-matching precision, thus getting rid of all human errors in data entry.

4.3 AI Engine Performance

A Bi-directional LSTM (Bi-LSTM) model has been trained from textured templates using 12,000 entries of form-field pairs. Evaluation metrics showed that:

- Metric Value
- Mapping Accuracy (MA) 98.2%
- Mean Squared Error (MSE) 0.021
- Response Latency (RL) 1.8 seconds
- Data Integrity Index (DII) 0.992

These results support the strength of the AI model in accommodating diverse types of institutions while maintaining accurate data mapping and dynamic population into attitudes. Performance improved over successive iterations as retraining was done continuously.

4.4 Security and Verification Results

The verification layer, integrated with blockchain technology, verified all generated PDFs against their hashes stored on the ledger using the SHA-256 algorithm and showed a 100% validation accuracy. The unique immutable record from the onboarding transaction created a digital signature, along with a reference to metadata that was recorded on the blockchain for each customer that underwent the onboarding process.

Non-Paper Relay (NPR) protocol average [0.7] sec/session on AES-256-encryption for secure, contactless and tamper-proof information transfer.

4.5 User Experience and Adoption Study

A pilot usability study was conducted with 30 participants from the banking and healthcare domains. The study evaluated the ease of use, security perception, and overall satisfaction:

1. 90% of participants rated the NFC/QR-based data relay experience as highly convenient.

2. 87% appreciated the built-in privacy controls such as link expiry and encryption settings.

3. 83% prefer NOREL-assisted onboarding to manual processes.

The key benefits highlighted by the participants included speed, accuracy, and reduced paperwork. Suggestions for minor improvements were multi-language support and improved UI customization on institutional themes.

4.6 Discussion

The assessment shows that NOREL provides significant advantages in terms of efficiency, accuracy, and security over conventional onboarding processes. AI-Powered automation and NFC / QR based contactless data exchange layered with Blockchain Verifiable credentialing; allows to achieve a comprehensive yet scalable framework of Digital Onboarding.

NOREL helps national and global initiatives like Digital India, Smart City Mission and Sustainable Development Goals (SDG 9) towards less duplication of efforts & paperless economy. Not only will the modular architecture make it long-lasting and applicable to a wide range of domains, but also integrating biometric authentication and voice-assisted interaction; as well as DID(Decentralized identity) integration, embedding into next-generation digital ecosystems that will address their requirements.

5. **Conclusion**

This solution provides an intelligent, secure and contactless approach to digital onboarding built on AI driven form mapping leveraging NFC/QR based Non-Paper Relay and block chain backed verification. The elimination of repetitive manual data entry leads to increased speed, accuracy and data integrity during onboarding while assuring strong privacy and security compliance. This provides a framework where individuals can possess one verified digital profile that is interoperable between institutional domains, thus minimizing duplication as well as the administrative overhead associated with managing multiple credentials across institutions. NOREL with its modular, and scalable architecture will allow future integration to advanced digital identity ecosystems for the sustainable paperless efficient service delivery. All in all, the system exemplifies how AI-powered processes and secured data transfer can facilitate the transformation of traditional onboarding to reliable & future-ready infrastructure.

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