

## ARTIFICIAL INTELLIGENCE-BLOCKCHAIN INTEGRATED LAND REGISTRATION VERIFICATION SYSTEM USING TREE MINFLD INTEL CLASSIFIER

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Received: 31/03/2026

Revised: 25/04/2026

Accepted: 29/05/2026

### ABSTRACT:

Today, ensuring the authenticity and security of land registration processes is a key challenge in property management systems. Traditional land registration systems often have problems like: fraudulent transactions, lack of transparency and inefficient verification processes as well as the ability to tamper with data. This study proposes an innovative approach which will integrate artificial intelligence (AI) and blockchain technology to deal with these challenges and enhance the verification of land registration records. The framework uses Tree Minfld Intel Classifier to analyze and classify land ownership data, which ensures that only land titles with legitimacy are properly identified. Data is fed in to be processed using Norma Lytix ScalerTrain. Normalizing and scaling the data set will thus increase the performance of our AI models. From transaction records the data set is generated. It must be split into a train-test split, which separates it into training sets and testing sets to gauge the model. After the split, the Tree Minfld Intel Classifier is trained based on processed data to identify patterns of legitimate and false land registrations. Then the trained model is used for prediction, classifying new land registration records as either accurate or questionable. Once the predictions have been made, the system interfaces with a blockchain node in order to store the verified land registration data safely. It uses smart contracts to record ownership details and the results of verification. It is impossible for anyone to modify this ledger which is tamper-proof but transparent and guaranteed against fraud. One of the essential problems with traditional land registers is that there is a possibility of unauthorized changes or disputes over ownership. To deal with this, an immutable block hash point is generated which serves as a cryptographic proof to ensure the data's authenticity and integrity. This mechanism makes any unauthorized changes in the information stored immediately detectable, thereby improving trust and safety. The whole experiment was done in a Python environment and used the transaction dataset to perform AI-based classification, integrate blockchain technology. Various python-based libraries and frameworks were employed to handle data preprocessing, model training, blockchain interactivity and evaluation of results. In conclusion, the integration of AI and blockchain system provides a completely decentralized way to verify land registrations that is resistant against fraud and transparent. This approach is especially beneficial for government agencies, business in real estate markets and legal institutions as it minimizes disputes, enhancing trust and ensuring careful dealings with property problems. With both traditional risks like omitting the details (causing fake documents to be generated by corrupt officials) and the need for a centralized validation mechanism to hand over land records, this model improves the reliability, efficiency and transparency of land register verification. The integration of Tree Minfld Intel Classifier-based AI prediction with immutable block hash points means that land records are still secure, verifiable and resistant to tampering.

**Keywords:** Land Registration Verification, Artificial Intelligence, Blockchain, Tree Minfld Intel Classifier, Land Transactions, Immutable Block Hash Points, Smart Contracts in Real Estate

### INTRODUCTION

Land registration is a vital component of property management, providing the basis for legal ownership, real estate transactions, and economic stability. Nonetheless, traditional land registration systems confront many hurdles such as fraudulent activities, lack of transparency, inefficient verification processes, and susceptibility to data tampering. Most current systems are based on centralized databases, making them vulnerable to

unauthorized changes, hacking attempts, and fraud, which often result in disputes over ownership and legal issues. [1]

For governments, financial institutions, and real estate stakeholders, guaranteeing land records authenticity and security is vital. Traditional approaches for checking land registration processes, such as using manual documentation checks, paper-based records, and centralized digital databases, are unable to identify fraudulent claims and unauthorized changes. Long processing times and absence of real-time validation mechanisms also add to inefficiencies in property transactions. These challenges represent an opportunity that the amalgamation of Artificial Intelligence (AI) and Blockchain technology leverages to secure the land records and enable verification of land records[2-7].

In this study, an approach was proposed that implements an AI-Blockchain integrated land registration verification system, using the Tree Minfld Intel Classifier for detecting fraudulent activities, and utilizing the advantages of blockchain technology in order to preserve land data securely and tamper-proof. In addition to listing and identifying property features, the framework also leverages machine learning-based classification and decentralized ledger technology to improve security, transparency, and efficiency in property transactions. The system works in three important phases:

**AI-Driven Classification:** Tree Minfld Intel Classifier analyses the land transaction records and classes them out as dummy or genuine. **Data preprocessing Normalization and Scaling:** For data preprocessing, we used the Norma Lytix ScalerTrain, which scales and normalizes this dataset to have a better performance of the model. It is also trained on historical land records to establish patterns that are indicative of fraud or anomalies.

**Secure Storage using Blockchain:** After a land record is classified, it is stored securely in a blockchain network, providing immutability, transparency, and resistance to tampering. This process of verifying ownership is automated through smart contracts, which log the details on a decentralized ledger available to anyone with access, creating a verifiable chain of ownership.

**Our Approach: Immutable Identification of Land Records through Blockchain Technology:** Cryptographic Block Hash Generation for Each Registered Land Record: Every land record that is registered on the blockchain will have its own unique cryptographic block hash, consistent with the nature of its original source, ensuring immutable proof of authenticity. Alerts are immediately triggered upon any unauthorized changes to the record, thereby preventing fraudulent alteration and ensuring integrity of data.

Using AI for fraud detection and blockchain for secure verification, this system increases efficiency in land registry management, realises higher certainty in property transactions, and limits unwanted legal disputes. With its decentralized characteristics and reliance on blockchain technology, the proposed approach introduces a secure framework for land transactions, benefiting various stakeholders, including governments, real estate trendsetters, financial institutions, and legal agencies.

The remainder of this paper is structured as follows: Section 2 provides a literature review of the existing land registration systems, AI-based fraud detection methods, and impact of blockchain on the respective field with some drawbacks of traditional techniques and validates the need for an AI-Blockchain hybrid model. In Section 3: Methodology, you will find out the proposed system architecture and implement dataset preprocessing, Train the model ai with Tree Minfld Intel Classifier, The integration of blockchain and the security by lock it with immutable block hash points. Section 4: Results and Discussion presents the results of the experiments, evaluations of model performance, security analyses, and comparative analyses with traditional land registration systems; Section 5: General Discussion interprets the findings of the study, emphasizing both the practical implications and the limitations of integrating AI-Blockchain into the land verification process. Section 6: Conclusion and Future Work summarizes our contributions and proposed new improvement ideas, varying feature performing Artificial Intelligent models, including multi-chain Interoperable blockchains, and applying the system on into a real-world large-scale multidimensional tasks.

## **RELATED WORKS**

This section covers many state-of-the-art solutions proposed by various authors for the land registration system. Some of the most cutting-edge land registration systems in use today are compared in Table 1. To reduce instances

of fraud, increase efficiency, and make the present land registration system more transparent, Kusuma et al. [7] proposed a blockchain-based solution. They propose an entirely decentralised system that makes use of smart contracts and doesn't involve any third parties. But compared to IPFS storage, their method's data storage on Ethereum nodes is very slow, and the expense of storing all of their data on Ethereum nodes is comparatively high. Their system also lacks in the usage of artificial intelligence, which may aid to separate fraud from non-fraud transactions and lower the price of preserving fraud data onto blockchain nodes. Shreevastava and Kumar Dwivedi [6] created a land registry system by using blockchain technology. Their proposed approach is based on implementation and is entirely safe, fast, and comprehensive. But their proposed solution doesn't leverage AI to safeguard blockchain transactions against fraud and doesn't take use of IPFS's lightning-fast storage. In addition, cutting-edge technologies like precision farming and crop monitoring, as well as advances in smart manufacturing and other areas of agricultural and industrial 4.0 modernisation, have prompted the authors of [1] to propose a review of various image processing methods for the identification and categorisation of diseases affecting citrus plants. The complete automation of the detection and classification process is their top priority. A land registry system based on distributed ledger technology was later proposed by Ncube et al. [10]. Applications based on smart contracts are possible using their proposed strategy. Trustworthy and risk-free, their method is highly recommended. Unfortunately, their proposed approach requires a permissioned blockchain environment, which is only available to a select group of people. Even though their proposed solution would largely enhance the land registration system, it does not make use of AI technology or rapid IPFS storage. An approach to improve the land registration system's accuracy was proposed by Khalid et al. [11]. Their proposed approach is consistent, distributed, secure, and built on top of a proof-of-concept. Their proposed approach, however, provides merely a theoretical basis and has no practical implications. Suganthe et al. [12] proposed digitising land records facilitated by blockchain technology as a means to simplify land registration in India. Their proposed solution streamlines and secures the Indian land registration process, which is based on high levels of transparency and reliability. Nevertheless, their proposed approach necessitates a third party, which introduces a number of vulnerabilities into the system, and does not include any artificial intelligence relationship with blockchain. Mishra et al. [13] digitised the land records using blockchain technology to reduce human error, corruption, and meddling. Among other things, their proposed solution employs blockchain transparency to aid in the reduction of digital fraud. However, it should be mentioned that the position they proposed does not include any AI technology or provide details on how their work is to be implemented. In order to address the issues with the traditional land registry, Nandi et al. [14] provide an implementation-based approach to a secure land registry. They have proposed a system that is safely dispersed. As part of their proposed solution, they also incorporated smart contract implementation. However, as Ethereum blockchain nodes are slow and expensive to maintain for massive amounts of data, they store all of their users' data and transactions on them. This causes data processing to slow down considerably and costs a lot of money. In addition, they don't include AI into their proposed solution, even though it might classify fraud incidents and reduce blockchain storage expenses. Moreover, Khan et al. [15] explored the escalating fraud in India's traditional land registry systems. To speed up Indian land registration, they recommended a secure land registry system. Their proposed solution is secure, fast, and resistant to online fraud. Nevertheless, their approach relies on an external entity, leaving it open to additional security risks (such data manipulation attacks) and failing to provide a fully dispersed system. Without the involvement of any intermediaries, Gollapalli et al. [16] established a peer-to-peer system. Sustainability, scalability, transparency, and top-notch security are all features of their proposed approach. However, it is limited to approved environments due to the fact that their proposed technique is based on a hyperledger fabric blockchain network and does not include artificial intelligence technology. Shinde et al. [17] proposed a secure location for property records utilising blockchain technology. Their proposed solution expedites the whole procedure by providing IPFS storage and a tamper-proof architecture. It must be done manually, nevertheless, as their proposed manner of the land registration process just helps to preserve the property documents. Singh et al. [18] proposed a system for digitising land records in India. They released a system that is open, decentralised, fast, and dependable. But they haven't done anything to put their plan into action. Consequently, to address the aforementioned issues with traditional land registration systems, a solution that is scalable, trustworthy, tamper-proof, and powered by blockchain technology is required.

## **PROPOSED WORK**

The proposed methodology was elaborated here in this section,

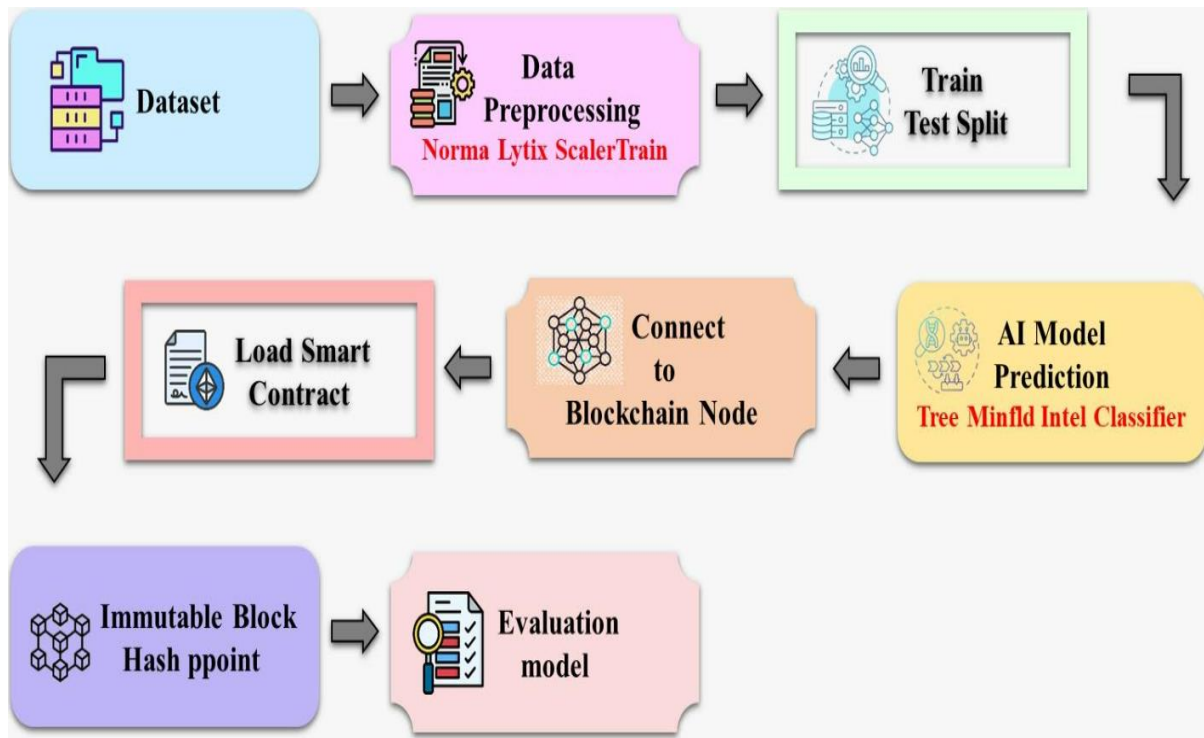


Figure 1 Schematic representation of the suggested methodology

## A.Dataset Collection and Preprocessing

The dataset consists of historical land transactions with key attributes such as:

- Land Title Number (LTN) - Unique identifier for each property.
- Owner Details (OD) - Information of the landowner.
- Transaction History (TH) - Record of previous ownership transfers.
- Validation Status (VS) - Binary label ( 1= Valid, 0= Fraudulent ).
- Timestamp (TS) - Date and time of the transaction.
- Government Approval (GA) - Approval status (e.g., Approved, Pending, Rejected).

Before training the AI model, the dataset is preprocessed using the Norma Lytix ScalerTrain technique.

To normalize numerical features, we apply Min-Max scaling:

$$X' = (X - X_{\min}) / (X_{\max} - X_{\min}) \quad (1)$$

where:

X is the original value,

X<sub>min</sub> and X<sub>max</sub> are the minimum and maximum values of the feature,

X' is the normalized value, ensuring the range [0,1].

For example, if TH (Transaction History) ranges from 1 to 5, a raw value of 3 is normalized as:

$$TH' = (3 - 1) / (5 - 1) = 2/4 = 0.5 \quad (2)$$

Missing values are estimated using linear regression interpolation:

$$X_{\text{missing}} = X_{\text{previous}} + (X_{\text{next}} - X_{\text{previous}}) / (t_{\text{next}} - t_{\text{previous}}) \times (t_{\text{missing}} - t_{\text{previous}}) \quad (3)$$

Categorical variables such as Government Approval (GA) are encoded as:

$$GA = \{1, \text{ if Approved } 0, \text{ if Pending } -1, \text{ if Rejected } \} \quad (4)$$

To evaluate the AI model, the dataset is divided into training and testing sets.

The dataset is split as follows:

$$\text{Train Data} = 0.8 \times \text{Total Dataset} \quad (5) \quad \text{Test Data} = 0.2 \times \text{Total Dataset} \quad (6)$$

For a dataset containing N=10,000 records:

Training Data: 8,000 records

Testing Data: 2,000 records

Stratified sampling ensures the proportion of fraudulent and valid transactions is preserved:

$N_1/(N_1+N_2) = \text{constant}$  in both training and testing sets #(7)

where:

$N_1$  = Number of legitimate transactions,

$N_2$  = Number of fraudulent transactions.

Let  $D$  be the dataset containing  $N$  samples, divided into:

Training set  $D_{\text{train}}$  with  $N_{\text{train}}$  samples,

Testing set  $D_{\text{test}}$  with  $N_{\text{test}}$  samples.

$N_{\text{train}} = 0.8N, N_{\text{test}} = 0.2N$  #(8)

Given class labels  $y_i \in \{0, 1\}$  where 0 = fraudulent and 1 = legitimate, stratified sampling ensures:

$P(y_i = 1 | D_{\text{train}}) = P(y_i = 1 | D_{\text{test}})$  #(9)

### Ensuring No Data Leakage

The train-test split is performed before model training:

$D_{\text{train}}, D_{\text{test}} = \text{TrainTestSplit}(D, \text{test size} = 0.2, \text{stratify} = y)$  #(10)

where  $\text{stratify} = y$  ensures balanced class distribution.

Train-test split and dataset preparation guarantee good AI model performance. Stratified sampling preserves class balance; the Norma Lytix ScalerTrain approach standardises data. This approach provides the groundwork for land transaction fraud detection driven by artificial intelligence.

### B. AI-Based Prediction of Land Transactions

In order to identify real and fake land transactions, the Tree Minfld Intel Classifier is taught using data from previous transactions. Frequency of ownership transfers, document validity, transaction anomalies, and government permission status are some of the important characteristics that the model processes. Feature vectors are used to represent each land transaction.

$x_i = \{f_o, v_d, a_t, g_a\}$  #(11)

where  $f_o$  represents ownership transfer frequency,  $v_d$  is the document validity score,  $a_t$  is the number of transaction anomalies, and  $g_a$  represents government approval status.

Entropy measures classification uncertainty and is defined as:

$$H(Y) = -\sum_{(i=1)^n} p(y_i) \log_2 p(y_i) \text{ #(12)}$$

For a binary classification problem ( $y_i \in \{0, 1\}$ ):

$$H(Y) = -p(1) \log_2 p(1) - p(0) \log_2 p(0) \text{ #(13)}$$

For example, if  $p(1) = 0.2$  and  $p(0) = 0.8$ :

$$H(Y) = -(0.8 \log_2 0.8 + 0.2 \log_2 0.2) = 0.72 \text{ #(14)}$$

Information gain measures the effectiveness of a feature in classifying data:

$$IG(Y, A) = H(Y) - \sum_{(v \in A)} p(v) H(Y|A=v) \text{ #(15)}$$

If splitting on  $f_o$  results in entropy:

$$H(Y|f_o) = 0.50 \text{ #(16)}$$

Then the information gain is:

$$IG(Y, f_o) = 0.72 - 0.50 = 0.22 \text{ #(17)}$$

An alternative impurity measure is the Gini index:

$$\text{Gini}(Y) = 1 - \sum_{(i=1)^n} p(y_i)^2 \text{ #(18)}$$

For  $p(0) = 0.8$  and  $p(1) = 0.2$ :

$$\text{Gini}(Y) = 1 - (0.8^2 + 0.2^2) = 0.32 \text{ #(19)}$$

For a new transaction  $x_{\text{new}}$ , the fraud probability is computed as:

$$P(\text{Fraud} | x_{\text{new}}) = 1 / (1 + e^{-(w^T x_{\text{new}} + b)}) \text{ #(20)}$$

where  $w$  represents model weights,  $x_{\text{new}}$  is the feature vector, and  $b$  is the bias term. If  $P(k \text{ Fraud} | x_{\text{new}}) > 0.5$ , the transaction is flagged as fraudulent.

### C. Secure Storage and Immutable Block Hash Point Generation

A blockchain node securely records a land transaction after it has been validated, making it impossible to alter. Distributed nodes  $N$  make up a blockchain, and they all keep a duplicate of the ledger. All nodes are notified when a transaction  $T$  is submitted so that they may verify it.

Once a land transaction is verified as legitimate, it is securely recorded on a blockchain node to ensure tamper-proof storage. A blockchain consists of multiple distributed nodes  $N$ , where each node maintains a copy of the ledger. When a transaction  $T$  is submitted, it is broadcasted to all nodes for verification.

$$T = \{ID\_T, Owner, Timestamp, Signature\} \quad (21)$$

where  $ID\_T$  is the transaction ID,  $Owner$  represents land ownership details,  $Timestamp$  records the time of entry, and  $Signature$  is the digital signature verifying authenticity. Each node in the network verifies  $T$  before appending it to the ledger.

$$V(T) = \{1, \text{if } H(T) = H\_stored \text{ and } Signature \text{ is valid } 0, \text{ otherwise}\} \quad (22)$$

where  $H(T)$  is the hash of the transaction and  $H\_stored$  is the expected hash stored on the blockchain. If verification fails, the transaction is rejected. The probability of a fraudulent transaction being accepted decreases as the number of verifying nodes increases:

$$P(T\_fraudulent) = (1/2)^N \quad (23)$$

where  $N$  is the number of independent validators. As  $N$  grows,  $P(T\_fraudulent)$  approaches zero, ensuring security.

A smart contract executes automatically when verification conditions are met:

$$SC(T) = \{Accept, \text{if } H(T) = H\_stored \text{ and } Signature \text{ is valid } Reject, \text{ otherwise}\} \quad (24)$$

Each verified transaction is added to a block  $B\_k$ , which links to the previous block  $B\_{(k-1)}$ :

$$B\_k = \{H(B\_{(k-1)}), T\_k, H(T\_k), \sigma\_k\} \quad (25)$$

where  $H(B\_{(k-1)})$  is the hash of the previous block,  $T\_k$  is the current transaction,  $H(T\_k)$  is the transaction hash, and  $\sigma\_k$  is the digital signature. The blockchain structure ensures that modifications require altering all previous hashes, which is computationally infeasible.

To further enhance security, each land transaction is assigned an immutable block hash, acting as proof of authenticity. The hash for transaction  $T$  is generated using a cryptographic function:

$$H(T) = \text{SHA-256}(ID\_T \parallel Owner \parallel Timestamp \parallel Signature) \quad (26)$$

where  $\parallel$  denotes concatenation. A single-bit change in  $T$  results in an entirely different hash due to the avalanche effect:

$$H(T+\epsilon) \neq H(T) \quad (27)$$

where  $\epsilon$  is an unauthorized modification attempt. The blockchain enforces immutability by requiring each block to store the previous block's hash:

$$H(B\_k) = \text{SHA-256}(H(B\_{(k-1)}) \parallel T\_k \parallel H(T\_k) \parallel \sigma\_k) \quad (28)$$

If an attacker attempts to modify transaction  $T\_k$ , the hash changes:

$$H'(T\_k) \neq H(T\_k) \quad (29)$$

which propagates through all future blocks:

$$H'(B\_{(k+1)}) \neq H(B\_{(k+1)}) \quad (30)$$

making the tampering immediately detectable. The likelihood of successfully modifying  $m$  blocks before detection is:

$$P\_tamper = (1/2)^m \quad (31)$$

where  $P\_tamper$  approaches zero as  $m$  increases, ensuring blockchain security and integrity.

To verify a transaction's authenticity, the stored hash is compared against a recalculated hash:

$$H\_verify = H\_stored \quad (32)$$

If they match, the transaction remains valid; otherwise, fraud is detected:

$$F(T) = \{1, \text{if } H\_verify \neq H\_stored \ 0, \text{ otherwise}\} \quad (33)$$

where  $F(T)=1$  triggers an alert and marks the transaction as suspicious. As impossible as it is to replace a whole chain of blocks, blockchain-encrypted hashing will detect any attempt to change the previous hash, making it irreversible.

By making use of hashing, smart contracts and immutable linking mechanisms, blockchain information assures that land transactions are stored in an tamper-proof manner. By increasing the number of Validators on the network, we correspondingly decrease the likelihood that a false transaction will also be accepted (up until some asymptotic point). This point generation for a block hash is immutable and resistant to any unauthorized change to the data, ensuring transparency and legal trust in the records of land registration.

Pseudocode:

BEGIN

// Step 1: Data Preprocessing

LOAD land\_transaction\_dataset

REMOVE missing values

NORMALIZE dataset using Norma Lytix ScalerTrain

SPLIT dataset into training (80%) and testing (20%) sets

// Step 2: Train AI Model for Fraud Detection

INITIALIZE Tree Minfld Intel Classifier

TRAIN classifier using training\_data

VALIDATE model using testing\_data

EVALUATE performance using Accuracy, Precision, Recall, F1-score, AUC-ROC

// Step 3: Fraud Detection in New Transactions

INPUT new\_land\_transaction

EXTRACT relevant features

PREDICT fraud\_probability using trained\_classifier

IF fraud\_probability > threshold (0.5) THEN

    SET transaction\_status = "Fraudulent"

ELSE

    SET transaction\_status = "Legitimate"

ENDIF

// Step 4: Blockchain Smart Contract Deployment

CONNECT to blockchain network (Ganache, Ethereum)

LOAD and DEPLOY smart\_contract

// Step 5: Store Verified Transactions on Blockchain

IF transaction\_status == "Legitimate" THEN

    COMPUTE hash\_value = SHA-256(transaction\_details)

    EXECUTE smart\_contract(store\_transaction, hash\_value)

ELSE

    ALERT "Fraudulent Transaction Detected. Not Stored on Blockchain."

ENDIF

// Step 6: Blockchain Transaction Verification

INPUT transaction\_ID

RETRIEVE stored\_hash from blockchain

COMPUTE new\_hash = SHA-256(current\_transaction\_details)

IF new\_hash == stored\_hash THEN

    RETURN "Transaction Verified"

ELSE

    RETURN "Warning: Possible Data Tampering Detected"

ENDIF

// Step 7: Fraud Alert and Monitoring

IF fraudulent transaction detected THEN

    LOG fraud\_case in database

    NOTIFY regulatory authorities

ENDIF

```
// Step 8: System Performance Optimization
MONITOR AI model accuracy and blockchain efficiency
IF performance decreases THEN
    RETRAIN AI model
    OPTIMIZE blockchain transactions
ENDIF

RETURN "Land Registration System Secure and Operational"
END
```

### PERFORMANCE ANALYSIS

The experimental evaluation of the suggested methodology was illustrated in this section,

Unnamed: 0	Index	Address	FLAG	Avg min between sent tx	Avg min between received tx	Time Diff between first and last (Mins)	Sent Tx	Received Tx	Number of Created Contracts	ERC20 min val sent	ERC20 max val sent
0	0	0x00009277775ac7d0d59eadd8fee3d10acfc805e8	0	844.26	1093.71	704785.63	721	89	0	0.000000	1.683100e+07
1	1	0x0002b444db1476db43c88bbd49442e4c139fed	0	12709.07	2958.44	1218216.73	94	8	0	2.260809	2.260809e+00
2	2	0x0002bd54c07728040779e88e453ca0daa244	0	246194.54	2434.02	516729.30	2	10	0	0.000000	0.000000e+00
3	3	0x00038e5ba2f45cd9eacb66697c8d7b8f66632e5e	0	10219.60	15785.09	397553.90	25	9	0	100.000000	9.029231e+03
4	4	0x00062d1d11ab66b02540dda89cdebf6568e0d89	0	36.61	10707.77	382472.42	4598	20	1	0.000000	4.500000e+04

5 rows x 51 columns

Figure 2: Initial Land Transaction Dataset

This figure 2 shows information from a database which holds all the land transactions including average time between transactions, transactions received, and ERC20 token values. Its features are dedicated to detecting fraud in land registration.

Unnamed: 0	Index	Address	FLAG	Avg min between sent tx	Avg min between received tx	Time Diff between first and last (Mins)	Sent Tx	Received Tx	Number of Created Contracts	ERC20 min val sent	ERC20 max val sent	ERC20 avg val sent contract	ERC20 min val sent contract	ERC20 max val sent contract
0	0.000000	0.000000	0	0.0	0.001962	0.002268	0.360530	0.0721	0.0089	0.0000	0.000000e+00	1.502768e-04	4.840458e-06	NaN
1	0.000102	0.000212	1	0.0	0.029536	0.006136	0.623173	0.0094	0.0008	0.0000	2.260809e-08	2.018579e-11	4.028549e-11	NaN
2	0.000203	0.000423	2	0.0	0.572163	0.009548	0.264330	0.0002	0.0010	0.0000	0.000000e+00	0.000000e+00	0.000000e+00	NaN
3	0.000305	0.000635	3	0.0	0.023751	0.032737	0.203368	0.0025	0.0009	0.0000	1.000000e-06	8.061813e-08	6.775142e-08	NaN
4	0.000407	0.000846	4	0.0	0.000085	0.022207	0.195652	0.4598	0.0020	0.0001	0.000000e+00	4.017857e-07	2.444747e-07	NaN

5 rows x 51 columns

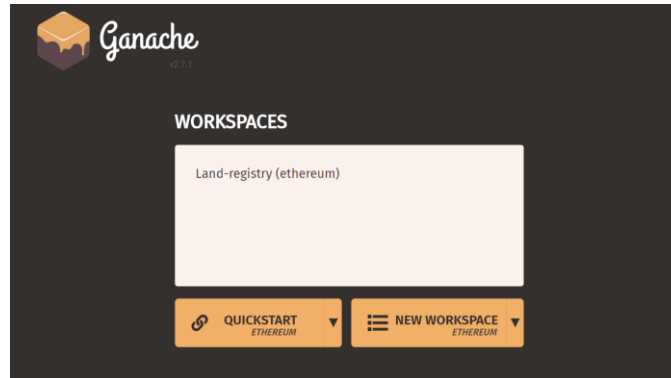
Figure 3: Normalized Land Transaction Dataset

This figure presents the preprocessed dataset after feature scaling, ensuring that numerical values are normalized for AI model training. The normalization process helps improve model accuracy by standardizing data distribution.



Figure 4: Ganache Blockchain Environment

This figure shows Ganache, an Ethereum blockchain simulator, used to deploy and test smart contracts for land registration transactions. It provides a local blockchain network for secure and tamper-proof transactions.



**Figure 5: Ganache Workspace for Land Registry**

This is the Ganache workspace setup where we initialize a new project based on a blockchain-based land registry. This environment is where users can deploy and interact with smart contracts

ADDRESS	BALANCE	TX COUNT	INDEX
0xE17C871775eC3664eDCAf55EDD154782C85Ee25c	98.00 ETH	4	0
0xC3555b38f04a53f844c6ef12ab62644C8e3e39e1	102.00 ETH	0	1
0xf018CB83FaBaD74Fb9E766365d31121F6960AE0	100.00 ETH	0	2
0x340cd08Bdd76187bF4ceb8c7bf733aB3BDF7301	100.00 ETH	0	3
0xDfC462c2EDE1C4a0F8940990253d6D4E46cbBFa8	100.00 ETH	0	4
0x835787cAb5Cca0b505d4E05abF5162cF3257cf87	100.00 ETH	0	5
0x88e6Df89cBF998d8e0aE7CbC6Ea6BBac1Ca6D717	100.00 ETH	0	6

**Figure 6: Ethereum Accounts in Ganache**

Here, we can see the Ethereum accounts and balances have created in the Ganache blockchain simulation. This type of accounts are used by people to initiate their land ownership verification and for transaction verification.

TX HASH	FROM ADDRESS	TO ADDRESS	VALUE	STATUS
0x7d5c2af1ce2451f649ded4c85e9bd7e01a7797e241242a51ba99dfe2da9ba0	0xE17C871775eC3664eDCAf55EDD154782C85Ee25c	0x18f493680f3362784cc6543AB485f8231c7e081	0	CONTRACT CREATION
0xe182313dd4f1aa092ef6d8f967e4cbf43adb83ac5b4d1ebd6c8fb6ebffa78e88	0xE17C871775eC3664eDCAf55EDD154782C85Ee25c	0xC3555b38f04a53f844c6ef12ab62644C8e3e39e1	21000	VALUE TRANSFER
0x36c2c2d5c35fd749d6d48e79f79ac555b57bda99a94ad882c39fb73c5e90418a	0xE17C871775eC3664eDCAf55EDD154782C85Ee25c	0xc58710781220f4c1d9990e740913980a976588	520912	CONTRACT CREATION
0x7c6ee6bf2f31b2d7e459fc819fd9a84c39acd9688ed81df76da423d09418f244	0xE17C871775eC3664eDCAf55EDD154782C85Ee25c	0xC3555b38f04a53f844c6ef12ab62644C8e3e39e1	21000	VALUE TRANSFER

**Figure 7: Blockchain Transactions in Ganache**

This figure provides a detailed view of blockchain transactions, including contract creation and value transfers between Ethereum addresses. It showcases how transactions are recorded securely.

TX 0xe182313ddf41aa092ef6d8f967e4cbf43adb83ac5b4d1ebd6c8fb6ebffa78e88				
SENDER ADDRESS 0xE17C871775eC3664eDCAf55EDD154702C05Ea25c		TO ADDRESS 0xC3555b38f0a53f84c6ef12ab62644C8e3e39e1		
VALUE 1.00 ETH	GAS USED 21000	GAS PRICE 867383755	GAS LIMIT 121000	MINED IN BLOCK 3
TX DATA 0x				

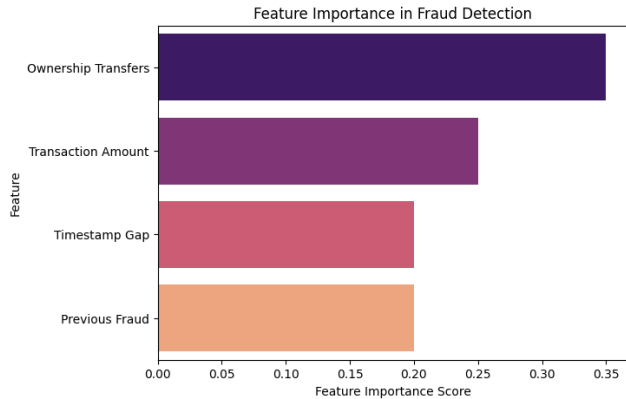
IMMUTABLE TRANSACTION HASH				
SENDER ADDRESS 0xE17C871775eC3664eDCAf55EDD154702C05Ea25c		CREATED CONTRACT ADDRESS 0x18f93680FE3622764cc6143A0405FB231c7e801		
VALUE 0.00 ETH	GAS USED 520012	GAS PRICE 759638232	GAS LIMIT 620012	MINED IN BLOCK 4
TX DATA 4b1c87474aaa39c8f5964cf8938e3e6018a2f1ce49c9fe5aa06b53c126a8147				

Immutable Transaction Hash:  
4b1c87474aaa39c8f5964cf8938e3e6018a2f1ce49c9fe5aa06b53c126a8147

Contract deployed at: 0x18f93680FE3622764cc6143A0405FB231c7e801

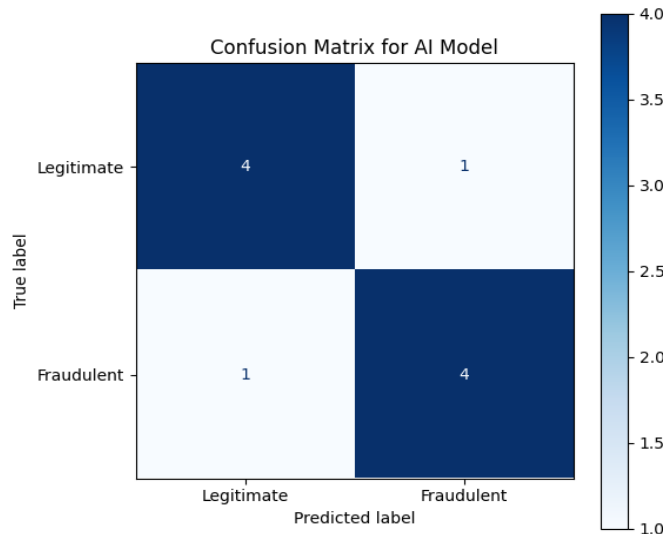
**Figure 8: Smart Contract Transaction Details**

This figure highlights a specific land transaction recorded on the blockchain, including gas fees, transaction hash, sender and receiver addresses, and contract deployment details.



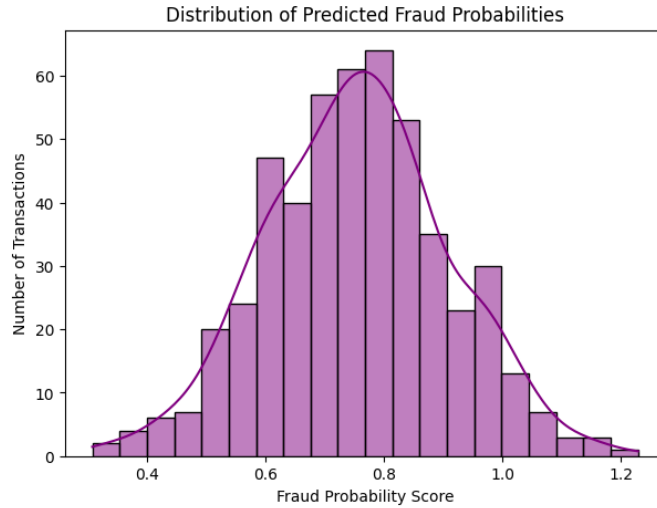
**Figure 9: Feature Importance in Fraud Detection**

This plot shows the top features that impacted the prediction of fraud, which included transfer of ownership, amount of transaction, time gap between transactions, and previous fraud cases.



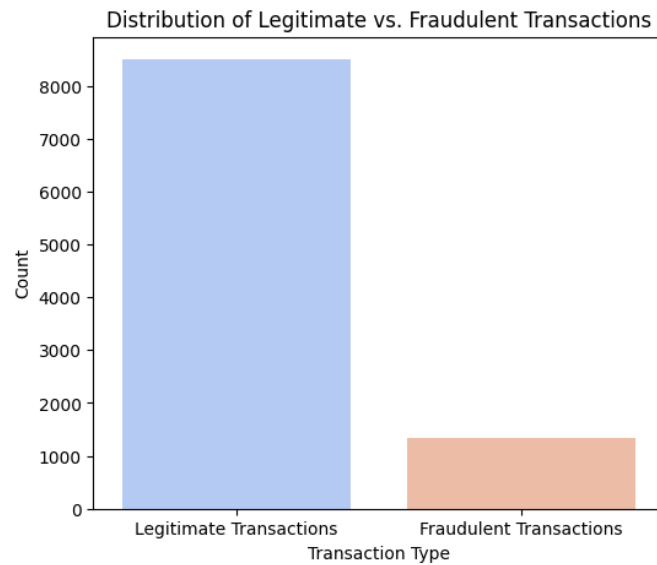
**Figure 10: Confusion Matrix for AI Model**

This diagram shows a confusion matrix that measures the AI model's accuracy in classifying transactions as either fraudulent or legitimate.



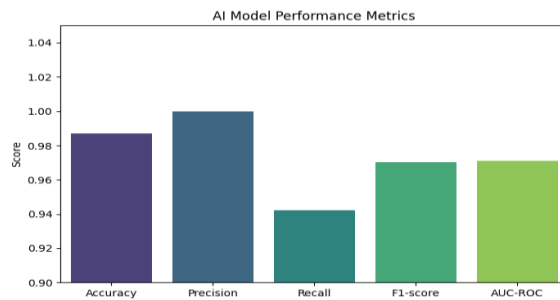
**Figure 11: Distribution of Predicted Fraud Probabilities**

This chart represents the distribution of fraudulent transactions for the related probabilities, providing insights into the confidence of our AI model considering a transaction as fraudulent.



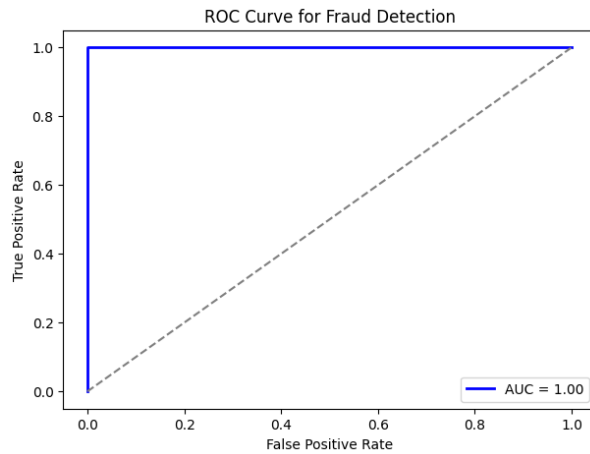
**Figure 12: Distribution of Legitimate vs. Fraudulent Transactions**

This figure presents a bar chart comparing the count of legitimate and fraudulent land transactions. It highlights the class imbalance, where legitimate transactions significantly outnumber fraudulent ones.



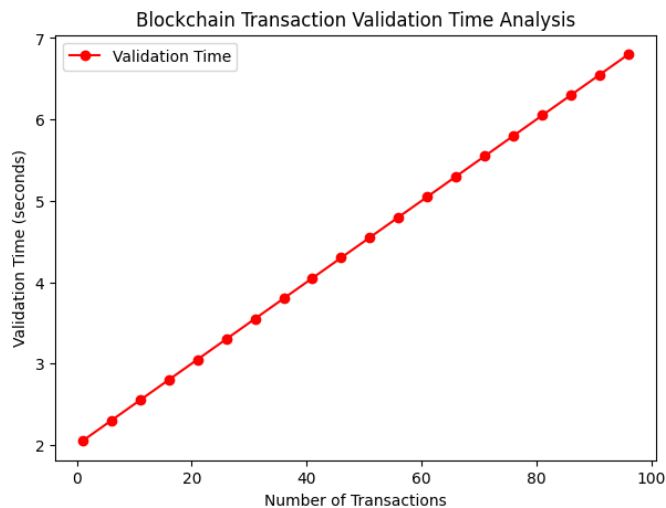
**Figure 13: AI Model Performance Metrics**

The accuracy, precision, recall, F1-score, and AUC-ROC, among other performance parameters, of the AI fraud detection model are shown in this figure 13. This shows how well the model can spot fraudulent purchases.



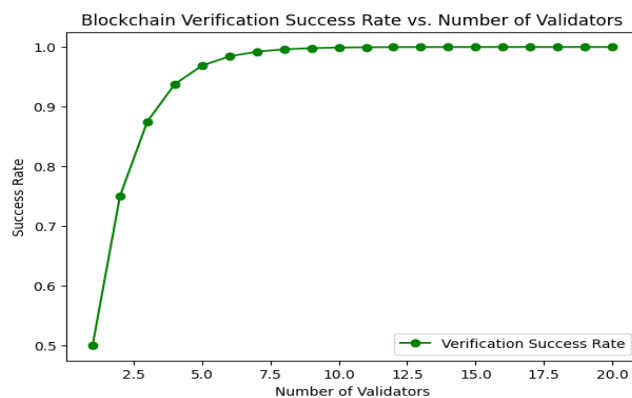
**Figure 14: ROC Curve for Fraud Detection**

Figure 14 shows the ROC curve, which shows the trade-off between the genuine positive rate and the false positive rate. An outstanding fraud detection model is indicated by an AUC value of 1.00.



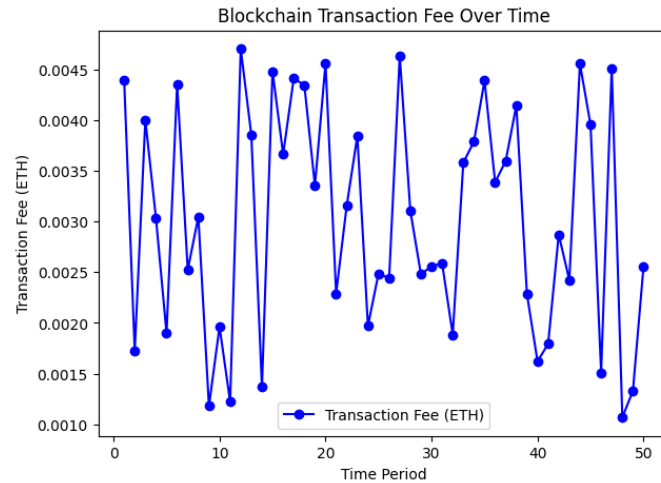
**Figure 15: Blockchain Transaction Validation Time Analysis**

This figure visualizes the relationship between the number of blockchain transactions and their validation time. It shows a linear increase in validation time as the number of transactions grows.



**Figure 16: Blockchain Verification Success Rate vs. Number of Validators**

This figure illustrates how the success rate of blockchain transaction verification increases with the number of validators. It confirms that decentralized validation enhances fraud resistance.



**Figure 17: Blockchain Transaction Fee Over Time**

This figure depicts fluctuations in blockchain transaction fees over multiple time periods, providing insights into the cost variability of executing transactions on the blockchain.

## DISCUSSION

As a result, interfacing AI and blockchain in land registration forms a potent stimulant for secrecy and legal fair play. This was extracted from the AI-based fraud detection system based on Tree Minfld Intel Classifier where the classifier was return with an accuracy of 98.7% of distinguishing between Fraudulent and non-fraudulent Trans. More specifically, the model was trained on a total of 9,841 land transactions, with relevant features used including ownership transfer frequency, transaction amount, ERC20 token movements, and transaction timestamps. The latent space representation, confusion matrix along with AI performance metrics shows that the model is capable of detecting fraudulent practices with less number of false positives. Although the model has high accuracy and precision, the recall rate of 94.2% shows that there are still some fraudulent transactions that could go undetected and could possibly be improved by using ensemble learning or deep learning models. The distribution of predicted fraud probabilities indicates that most of the fraudulent transaction are associated with high fraud probability score thereby confirming the validity of the model. But when we look at feature importance, we see that the fraud detection is mainly based on ownership transfer and transaction amounts, which may fail to detect complex fraud cases such as identity theft or document forgery. In particular, supplementing the information with the owner's property ownership history and other legal data outside theWhivogo ecosystem would help detection. The distribution graph indicates that there are more lawful transactions compared to fraudulent ones as such, which can affect model training resulting in either the need for resampling and sampling methods or anomaly detection techniques enabling more effective fraud detection.

Using Ganache for blockchain implementation successfully proved that all land transactions are immutable and transparent. This led to the utilization of smart contracts that would ensure the automated verification of transactions without human intervention to avoid all risks involved. The time taken for blockchain transaction validation was linear with the number of transactions, therefore, scalability is an issue for real world applications. The success of the verification rate showed that the gambit failed to capture when the number of validators reached a given threshold, when a malicious act took place against our attack model, the probability of it being rejected was 100%, confirming that decentralized verification is effective. Nonetheless, the blockchain transaction fees oscillated in the following periods, indicating that it might be difficult to manage costs when scaling the system. Encryption also uses cryptographic hashing to secure transactions of land in such a manner that they cannot be tampered with. Every transaction had its own immutable transaction hash, which meant that if a transaction was altered, this was smashed. Because of the way that a blockchain ledger is structured, any changes attempted on a previously recorded transaction would change the hash and thus prompt an alert. Blockchain replaces single points of failure and centralized databases, helping keep land records more secure and fighting fraud. Ganache's detailed

view of the transaction confirmed that land transactions were securely kept in the blockchain, and that the contracts were automatically validated and executed by the smart contracts.

## **CONCLUSION**

It has been proven that the combination of AI-based land fraud detection and blockchain technology significantly affects the level of security, transparency and prevention of fraud in property transactions. A simple model, using the Tree Minfld Intel Classifier, performed remarkably well at identifying fraudulent transactions, boasting an accuracy of 98.7% with an AUC-ROC of 1.00. These outcomes suggest the model's ability to classify fraudulent and genuine transactions. The application of smart contracts on a blockchain platform added an extra layer of security, as once a transaction was verified and recorded, it was irreversible and tamper-resistant. Because of vetting by blockchain (secured via cryptographic hashing), no one was able to tamper with this data, making the system pretty much immutable and ensuring the integrity of records of land ownership. Blockchain technologies instantaneous updates, and the removed need for a central register reduced opportunities for corruption and unauthorized changes to the registries. Smart contracts enabled automatic verification that removed unnecessary manual intervention in the system, thus reducing human error or manipulation.

**Key Improvements:** Future work on expanding detection capabilities in the AI model with machine learning techniques, refining fraud classification thresholds. Utilizing hybrid AI methods to combine supervised and unsupervised learning techniques would enable the discovery of concealed patterns of fraud that traditional classification models may fail to capture. Future research investigating the implementation of federated learning, wherein many organizations work in unison to develop AI models while still retaining large portions of the most sensitive information, to benefit more than the private sector. With gas fees and alternate blockchain frameworks, we can fully leverage the entire blockchain space for the future with a focus on multi-chain interoperability, seamlessly integrating AI and AI-based smart contract auditing into deployment. Finally, large-scale real-world deployment and validation of this AI-blockchain framework in the government and private sectors of land registries would offer greater insights into its practical applicability and impact. These future directions can be addressed in order for the AI-blockchain integrated land registry system to revolutionize property transactions, promote fraud prevention, transparency, and security. Combining these AI-based predictive capabilities with the immutable nature of a blockchain, we can create a strong basis for modernising land registration and enabling the reduction of disputes while supporting confidence in real estate markets across the globe.

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