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A STUDY ON BANKNOTE AUTHENTICATION USING MACHINE LEARNING

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Abstract: The functioning of a currency is essential for the economy of a country, and banknotes are a major component of the Indian economy. Counterfeiting currency is an attempt to imitate a real currency with the intention of deception. Most of the methods used to detect counterfeit currency are based on hardware or image processing techniques, which are less efficient and time- consuming. As technology advances, the methods used to counterfeit currency have become more sophisticated, and the circulation of such notes has a significant impact on the economy. Therefore, the detection of counterfeit notes is of paramount importance. There are numerous commercial methods for detecting fake notes, however, they are not accessible to the general public. People who acquire counterfeit currency are often victims, and there is usually no government policy to reimburse them for the counterfeit notes that are confiscated. To design an automated system, it is necessary to develop an efficient algorithm that can accurately predict whether the banknotes are genuine or forged, as counterfeit notes are designed with great accuracy.

Keywords: Banknote Authentication, Fake-notes, Skewness, Logistic regression , XG boost, Decision tree classifier, Pre- processing.

INTRODUCTION

The field of banknote authentication has been of greatest importance in ensuring the principle of financial systems and anticipating forger notes from circulating in the economy. The advancement in printing technologies has made it gradually difficult to differentiate actual or real notes from forger ones, which required the development of robust and exact verification techniques. The proliferation of fake banknotes has grown more dangerous in recent years as a result of advancements in counterfeiting technology. This has made the creation of sophisticated methods that can consistently tell real notes from fake ones with little assistance from humans necessary. The manual inspection procedures used in traditional methods take a lot of time and are prone to human mistake, which makes them unsuitable for big volume requirements. By using historical data on both real and fake banknotes to find minute patterns suggestive of authenticity, machine learning presents a possible answer. The well-known for its simplicity, logistic regression offers a baseline model for an instant viability assessment.

To answer this developing need, this paper explores the application of machine learning algorithms particularly Logistic Regression, XGBoost and Decision Trees.Forger note not only poses a significant risk to economic stability but also weakens the community trust in the financial system. Relying on traditional methods like human expertise and manual checking of real or fake notes, have proven to be insufficient in addressing the complication of present banknotes. The arrival of machine learning increased accuracy and efficiency for an authentication process of notes. Logistic regression, one of the widely-used machine learning algorithms for prediction and classification problems in various fields due to its simplicity and interpretability. Decision Trees provide a comprehensible model in which decisions can be linked to certain banknote characteristics, revealing details about the authentication procedure. Because of its strong gradient boosting framework, XGBoost can train on complicated datasets and achieve better results over time.

Our goal is to create a complete authentication system that can adjust to changing counterfeiting strategies by incorporating these algorithms. By combining the advantages of each model, a system that is reliable and accurate is produced. In addition to financial institutions, other industries might benefit from such a system, which would shield the

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economy from the negative impacts of counterfeiting and boost public trust in the monetary system. Beyond financial institutions, a system like this might have an influence on a number of industries, including retail, where cash transaction verification is essential. By guaranteeing the genuineness of banknotes, we can defend the economy against the damaging consequences of counterfeiting and rebuild public trust in the financial system. To keep ahead of counterfeiters as we advance, it is crucial that we constantly improve these models and add fresh data. The significance of machine learning in developing resilient and flexible banknote authentication solutions is shown by this dynamic method.In this paper, we will explore into the mathematical support of Logistic Regression, Decision Trees, and XGBoost algorithms and debate how they can be adopt to address the challenges created by authentication of banknote. Further, the performance of each algorithm in different situations, and their strengths and limitations we will present experimental results and comparative analyses to estimate the performance of each algorithm.

The paper is organized as follows: After the introduction, the second section provides a detailed review of related literature, highlighting the role of machine learning approaches to banknote authentication. In the third section we explore the methodology, explaining the key concepts behind machine learning algorithms which are used along with their implementation for banknotes. The fourth section concludes the paper and outlines the significance of using machine learning techniques in banknote authentication. Finally, the fifth section is dedicated to references.

RELATED WORKS

We referred a few papers about what the others have implemented for fake currency detection.We referred to algorithms like Decision Tree,XG boost and logistic regression.We usually learn about the features like Image digitization feature extraction, preprocessing and classification[4].

There are two sets that we use one is for note detection and another one for model training.We got to know that we can analyze it by the formula in which four terms are mentioned one is True positive, True negative, False positive and the other one is False negative. We learnt the concept of supervised learning and deep learning[1].

The language one should know here is python, here they imported libraries like pandas, Numpy and seaborn Other than that the libraries and Datasets. Based on the 0/1 it will give us whether the note is real or fake. We will be getting the accuracy score by the algorithms mentioned.The Logistic Regression is more accurate than other algorithms[7].We observed the types in the logistic

Regression one is binomial,Multinomial and ordinal.The following steps are involved in the applying steps in logistic regression modeling. They are Define the problem Data Preparation

Exploratory Data Analysis Feature Selection

Model building

Model evaluation

Model improvement

Model Deployment[9].

METHODOLOGIES

Both supervised and unsupervised learning techniques can be used to direct a machine learning model. XG boost, decision tree classifiers, or logistic regression can be used to implement our model [7]. All three methods are used to test the model, and the algorithm that yields the highest accuracy is chosen.

Dependencies:

Logistic regression

Logistic regression is a ML algorithm used when the goal is to predict the probability of a dependent variable with the help or with respect to independent one or many independent variables [8]. It is used for binary classification problems.

Decision Tree Classifier:

Decision tree classifier is also a machine learning algorithm which is a supervised learning technique used for solving classification problems. It has two types of nodes: Decision node and Leaf node [11]. Decision nodes have multiple branches and leaf nodes are outputs of these decisions. XGBoost: XGBoost is a machine learning algorithm known for

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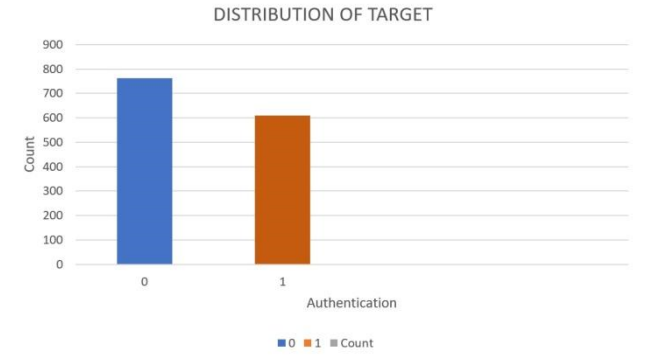
its high performance and also flexibility. It can also be used for both classification and regression problems [10]. XGBoost is also a decision tree algorithm along with Random Forest.

Dataset description:

The objective of this project is to create a machine learning model for predicting the genuineness of banknotes. The model leverages various features, including variance, skewness, kurtosis, and entropy, extracted from wavelet- transformed images of the banknotes. The target value is 0 for real banknotes and 1 for fake banknotes [7]. The dataset used in the project is the banknote authentication dataset from the UCI machine learning repository. It contains 1,372 instances of banknotes, each with five numeric input variables and one binary target variable [7].

Analysis of model:

After collection of the data preprocessing of the data is done. Then one of the models mentioned above is selected for further use [1]. Then the model is trained on the training data, using features as input and genuine labels as the target variable. The relation between the kurtosis, skewness, variance and entropy can be obtained by using a pairplot to plot it. Balancing of the data set is done if there are more notes having zero's or one's. Figure 1 shows the distribution of the notes in the dataset [1]. Figure 2 shows the distribution after balancing the dataset. After that comparison of the three algorithms is done to find the accuracy and the algorithm with high accuracy is selected to use in the model. Figure 3 shows the comparison of the three algorithms. Logistic regression gives the highest accuracy among three algorithms hence it is chosen for further implementation.



Attribute Name	Value Type	Description
Variance	Double	It is the measure of the spread of the distribution about its average value.
Skewness	Double	It is the direction of variation of the lack of summary.
Kurtosis	Double	It describes the peaked Ness of distribution.
Entropy	Double	It gives the amount of distribution to be coded for.
Class	Nominal	Class contains two values 0 and 1 where 0 represents genuine banknotes and 1 represents fake banknotes.

Techniques	Accuracy	Specificity	Sensitivity
MLP	98.7864	98.6784	98.9189
RBF	57.0388	55.9471	58.3783
PNN	98.3	99.6	96.8
DT	99.5	99.1	100
Naive Base	85.9	87.2	84.3

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CONCLUSION

After examining different techniques used to detect banknotes real or fake, this paper provides authentication of banknotes as real or fake by using three machine learning algorithms, Logistic Regression, Decision Trees, and XGBoost. Depending on the particular requirements and restrictions of the task at hand machine learning algorithm to engage for banknote authentication.
In order to improve the accuracy and explaining skill of banknote authentication, future research may explore hybrid systems that combine the advantages of these algorithms. Decision Trees can be used for both classification and regression tasks, while XGBoost is best in estimated accuracy. Knowing logistic regression is simple and straightforward. In practice, selecting the right method for a given application requires consideration of both explicable and forecast performance.
Technological developments have brought about a significant change in the process of authenticating banknotes. Mint print, color-changing inks, holograms, and intricate watermarks are just a few of the highly sophisticated security measures that banknotes have been implemented to deter counterfeiters. tier-based approach Often used to create a sophisticated barrier against counterfeiting, a multi-layered technique combines multiple security components for accurate banknote authentication. These strata frequently possess characteristics that are both overt and covert, apparent only with particular instruments.

Persistent Innovation: To get beyond security measures, counterfeiters are always coming up with new and inventive ways to be creative. To keep ahead of counterfeiters and preserve public trust in the money, continuous innovation in banknote design and authentication technologies is therefore crucial. Training programs, instructional materials, and public awareness campaigns can help individuals and groups identify counterfeit money and report suspicious activity. International cooperation is needed to combat counterfeit money. International cooperation between law enforcement agencies, central banks, governments, and technology experts is required to combat transnational counterfeiters by exchanging resources, best practices, and intelligence. Typical Information It is essential to raise knowledge of the security measures on banknotes and the steps involved in verifying cash.

Thieves are always coming up with new and inventive ways to get around security measures. The designs of banknotes and authentication processes must be continuously improved in order to preserve public trust in money and stay ahead of counterfeiters.
To stop counterfeit money from spreading, there needs to be a deeper understanding of the importance of educating the public about banknote security features and validation methods. Training courses, reference books, and public awareness campaigns can help people and organizations spot fake currency and report questionable activity.
To get over streaming security measures, counterfeiters are always coming up with new ways to produce. It is crucial to continuously innovate banknote design and authentication technologies in order to remain ahead of counterfeiters and preserve public confidence in cash. General Knowledge: Public education about the security features of banknotes and how to authenticate them is a crucial tactic in the fight against the spread of counterfeit money.
Strong legislative protections and enforcement mechanisms are required to deter counterfeiters and prosecute those involved in the production and distribution of counterfeit money. With the harsh penalties and unwavering enforcement, it is made quite clear that counterfeiting will not be tolerated. In conclusion, the battle against counterfeiting continues despite notable advancements in banknote authentication. Continued research, collaboration, innovation, public awareness campaigns, and enforcement measures are essential to protect the integrity of currency systems and protect economies from the negative effects of counterfeit money.Raising Public Awareness: Educating the public about the security characteristics of banknotes and how to authenticate them is one of the most crucial steps in halting the proliferation of fake money. Training programs, instructional materials, and public awareness campaigns can help individuals and groups identify counterfeit money and report questionable activity. In order to get beside streaming security measures, counterfeiters are always coming up with new ways to create. To keep ahead of counterfeiters and preserve public confidence in the currency, constant innovation in banknote design and authentication technologies is required. Public Awareness: A key strategy in preventing the distribution of counterfeit money is educating the public about the security characteristics of banknotes and how to validate them.
Strong legislative protections and enforcement mechanisms are required to deter counterfeiters and prosecute those involved in the production and distribution of counterfeit money. With the harsh penalties and unwavering enforcement, it is made quite clear that counterfeiting will not be tolerated. In conclusion, the battle against counterfeiting continues despite notable advancements in banknote authentication. Continued research, collaboration, innovation, public awareness campaigns, and enforcement measures are essential to protect the integrity of currency systems and protect economies from the negative effects of counterfeit money.

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