IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 10, May 2023

Counterfeit Currency Detection

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Abstract: *Bank notes are currencies used by any nation to carryout financial activities and are every Country's asset which every nation wants it to be genuine. Part of reprobates prompts counterfeit notes into the market which look like the very unique note. Information were separated from pictures that were taken from veritable and produced bank note like examples. For digitization, a modern camera generally utilized for printre view was utilized. The final images of the currencies have 400×400 pixels and resolution of 660dpi. Wavelet Transform tool is used to transform the images into Wavelet Transformed images. From these Wavelet Transformed images the features are extracted. The dataset has four attributes they are variance, skewness, curtosis and entropy which are extracted from the wavelet transformed images. We use Supervised Machine Learning algorithm which is Decision Tree Classifier and K- Nearest Neighbours to build the model and predict the class of the currency. This is a Binary Classification problem as we are predicting only two classes whether the currency is genuine .We fit the train data onto the model and predict the new data which is test data. The accuracy of this model reaches up to 98.3% by using Logistic Regression algorithm. That means we can predict whether the currency is fake or genuine with almost hundred percent accuracy which is lacking technology till now in the real world. We can also predict new data (new currencies) by taking the pictures of the corresponding currencies and applying the industrial tools and transforming the final images into wavelet transformed images and using this model*

Keywords: Machine learning; K-nearest neightbour(KNN); Decision Tree; Logistic regression

I. INTRODUCTION

All countries use banknotes as their primary form of currency. Every country relies on them as a resource to ensure that validated receipts represent legitimate transactions. Fake notes that resemble the really special note enter the market as a result of a bundle of reprobates. An effective verification process is required in order to reliably predict if a specific note is certifiable. Money, which comes in the forms of coins and banknotes and is imprinted with unique groups of information, is one of a nation's most valuable resources. Usually, banknotes are grouped higher than coins.

A fraction of the reprobates release counterfeit banknotes onto the market in an effort to control the financial sector and reduce the amount of a particular country's currency on the international market. As a result, there was a rise in the market's need for financial order acknowledgment devices.

Despite the fact that there are many different banknote authenticity checkers available, each one has a screening criterion. With the advent of copy machines and scanners, counterfeit bank notes are now easier to produce. Especially when there are numerous notes and identical features on each note, it may be difficult to distinguish between genuine and counterfeit cash. Consequently, a system is required that would allow the client to ascertain the authenticity of a given arrangement of notes based on its key points. We expanded our solution in response to this demand to incorporate a strong foundation for AI-based banknote verification.

II. BACKGROUND STUDY (LITERATURE)

Using specialist equipment to identify fraudulent or real cash notes. Due to the increased economic activity brought on by the use of counterfeit money, real money loses value and prices rise. currently there are no systems that can reliably distinguish between real and counterfeit currency, the fake cash detection system is a very useful project.As a result, there are less counterfeit notes on the market, which boosts the country's economy.

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Utilising machine learning algorithms with enormous data sets as inputs is the aim of the fake currency detection process. An analytical method that is useful is the KNN approach. These studies can be quite beneficial for discovering implicit information. In this chapter, we review the most recent research on the classification and clustering of sequential data. This chapter also covers a few of the major application areas for cash detection. In addition to machine learning, we are employing three distinct sorts of algorithms, including the KNN method, gradient method, and support vector, to help with widespread currency identification and rid India of such fraud.

The following are current methods for identifying fake currency:

- Whenever you go to bank, the cashier places bank notes in a machine that tells whether a bank note is real or not.
- But that is not the accurate way as miscreants will make the machine to give it as a real note even if it fake.
- There is no accurate way to find whether the note is forged or genuine.
- The present system which is proposed to be developed with the aim to give an accurate result on whether a note is Genuine or a Forged one.
- In this research we predict the note using two machine learning algorithms, they are Decision Tree Classifier and KNN Classifier.
- Unlike other presently used machines, this model accurately (99.9%) classifies the input currency.

III. METHODOLOGY

There are input and output attributes in every dataset. For some models, a big dataset needs be taken into account in order to produce accurate prediction. After reading the data set, we can see that the data is categorical, so we must use a variety of preprocessing techniques to turn all of the categorical data in the dataset into continuous. We must visualise the data after preprocessing the data. After being recovered from the database, the data set is sent for data preparation.

Preprocessing involves extracting the data, converting selected values to continuous values, and then fine-tuning the data. This information is utilised to develop a specific model using machine learning methods. Test the new data.

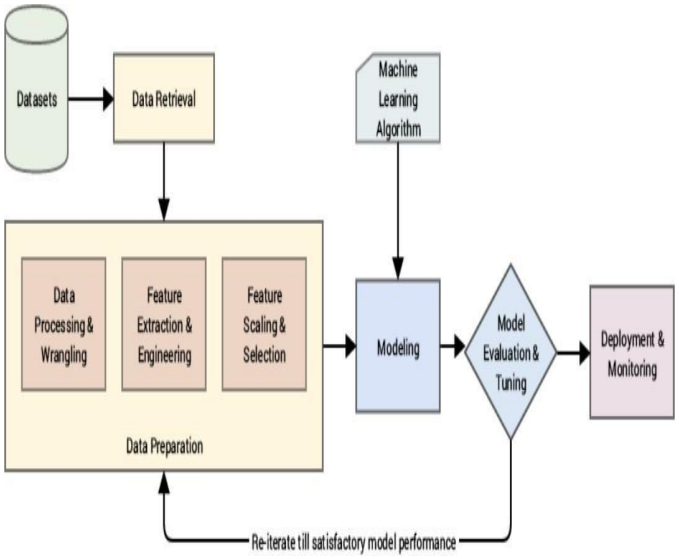

Fig.1: Software Architecture for proposed system

As seen in figure 1 above, deployment produces an end application that the end user can use when the model is given via a platform as a service application. The end user in this case is a project specialist who deals with currency. They enter information into the user app and decide if a note is authentic or fraudulent. A data flow diagram, which models a number of the information system's aspects, visualises the data flow of an information system. In order to construct a system overview without going too deeply, a DFD is typically utilised as a first step; they can be expanded subsequently.

DFD illustrates the types of data that will be input into and output from the system, how the data will move through the system, and where the data will be kept, as illustrated in Figure .It is not at all like a typical organised flowchart, which

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is focused on the control stream and does not include information about process timing or whether cycles will operate in grouping or in equal.

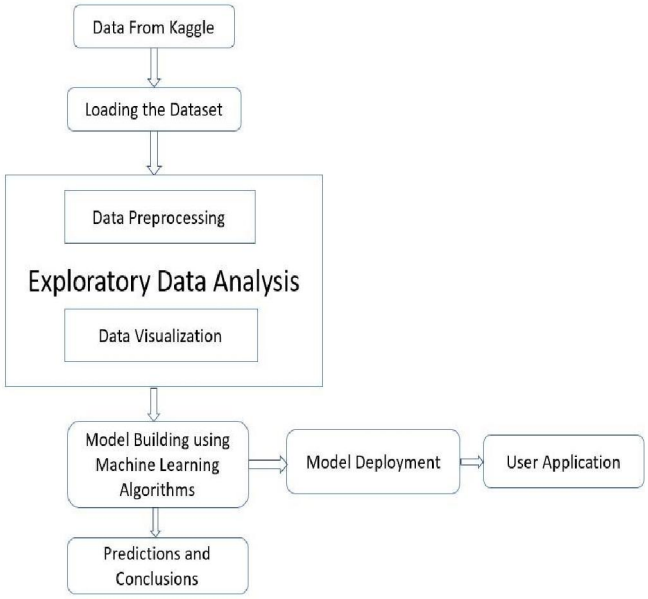

Fig.2: Data Flow Diagram of Fake Currency model

IV. IMPLIMENTATION

```
#Model buiding using Decision Tree Classifier
from sklearn.tree import DecisionTreeClassifier
from sklearn import metrics
#Storing the Classifier into a variable named model
model = DecisionTreeClassifier()
#Fitting the Train and Test data into the same variable which is named as model
model.fit(X_train,y_train)
#Predicting the Dependent variable y_pred
y_pred = model.predict(X_test)
y_test
y_pred
```

```
#Model building using KNN Classifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn import metrics
#Storing the Classifier into a variable named model2
model2 = KNeighborsClassifier()
#Fitting the Train and Test data into the same variable which is named as model2
model2.fit(X_train,y_train)
#Predicting the Dependent variable y_pred2
y_pred2 = model2.predict(X_test)
y_test
y_pred2
```

```
#Accuracy with Decision Tree Classifier
print("Accuracy_Decisiontree:",metrics.accuracy_score(y_test, y_pred))
```

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```
#Accuracy with K-Nearest Neighbors Classifier
print("Accuracy_KNN:",metrics.accuracy_score(y_test, y_pred2))
```

Figure. Decision Tree and KNN Classifiers

The above figure 3.6 shows the Decision Tree Classifier is imported from sklearn library and is stored in a variable. And That model is fitted with Train data. The model is then predicted with Test data and thus we obtain Predicted output variable. Similarly the same goes with K-NN classifier.

V. RESULTS

Box plot:

```
#Data Visualization
#box plots
print(df.boxplot(column=['variance']))
print(df.boxplot(column=['skewness']))
print(df.boxplot(column=['curtosis']))
print(df.boxplot(column=['entropy']))
```

```
Axes(0.125,0.11;0.775x0.77)
Axes(0.125,0.11;0.775x0.77)
Axes(0.125,0.11;0.775x0.77)
Axes(0.125,0.11;0.775x0.77)
```

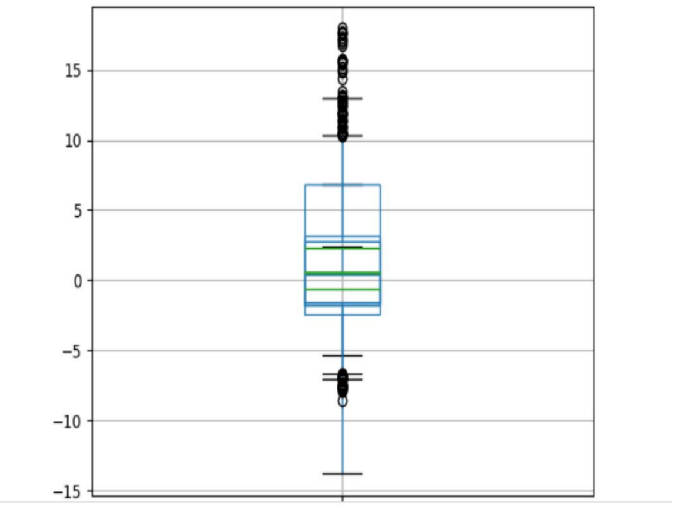

Fig Box plots of the features

In light of a five-number outline (least, first quartile (Q1), middle, third quartile (Q3), and "most extreme"), a boxplot is a normalised method of displaying the dissemination of information. It can identify your anomalies and their characteristics. Additionally, it can reveal whether or not your information is biassed, how firmly it was gathered, and to whatextent. You may discover that you actually need more data than the ratios of focal inclination (middle, mean, and mode) for some disseminations/datasets. Data about the information's mutability or dispersion is something you actually want. A boxplot is a graph that shows you a good indication of how the characteristics in the data are distributed. Boxplots have the advantage of taking up less space, which is useful when examining circulations across numerous groups or datasets, despite the fact that they may initially appear to be more rudimentary than a histogram or thickness plot.

KDE Plots

To see the probability density of a continuous variable, use the KDE Plot, also known as Kernel Density Estimate. It shows the probability density for various values of a continuous variable. Additionally, we can plot a single graph for numerous samples, which makes data visualisation more effective.

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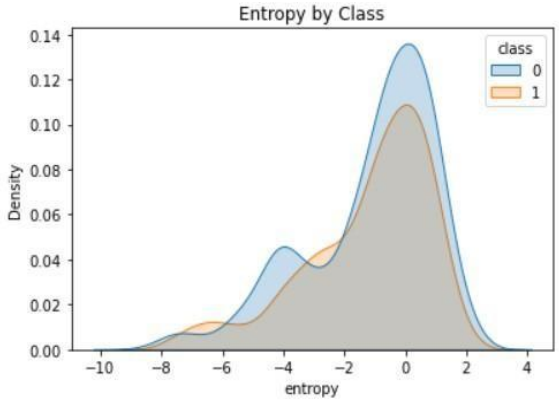

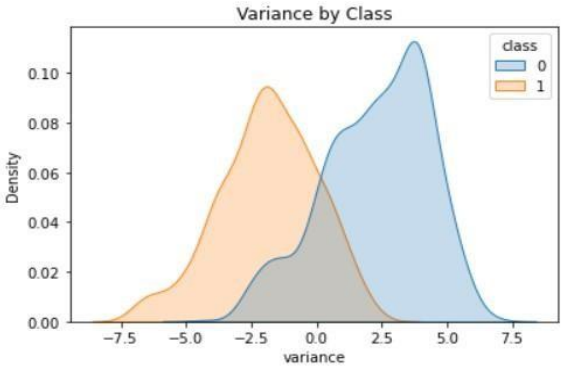

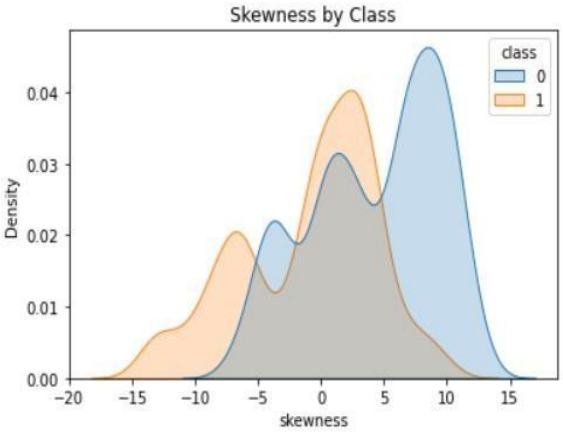

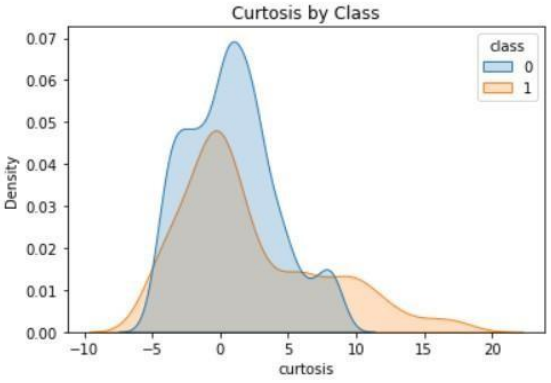

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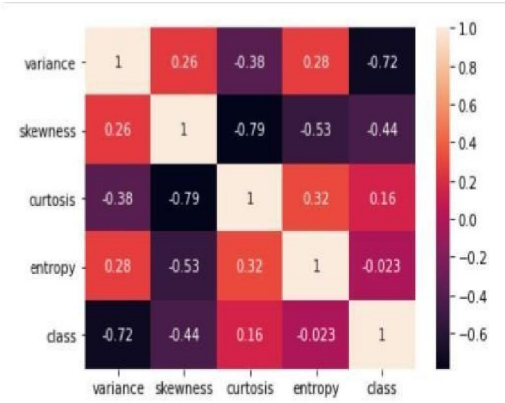
Similar to a histogram, a kernel density estimate (KDE) plot is a method for visualising how perceptions are conveyed in a dataset. It thereby shows the Probability Density in a continuous variable at various values. The density for four continuous variables is plotted by class in Figures 4.2.2, 4.2.3, 4.2.4, and 4.2.5.

Heat Map:

A heatmap is a graphic representation of data that addresses many qualities using a system of variation coding. Heatmaps are used in various forms of analysis, although they are most frequently employed to display user behaviour on clear-cut pages or page layouts. Heatmaps can be used to display where users have touched a page, how far they have scrolled, or the results of eye-following experiments.The variation in variation may be by force or shade, providing the viewer strong, unmistakable cues as to how the oddity is grouped or varies over space. The bunch heat map and the spatial intensity map are the two most fundamentally different types of intensity maps. In a group heat map, areas are dispersed into a framework of fixed cell size whose lines and segments are discrete characteristics and classes. The arrangement of lines and sections is purposeful and somewhat random, fully intended to propose groups or depict them as found by using factual examination. The cell is irregularly sized but large enough to be clearly seen.




```
#Accuracy with Decision Tree Classifier
print("Accuracy_Decisiontree:",metrics.accuracy_score(y_test, y_pred))
```

```
Accuracy_Decisiontree: 0.9781553398058253
```

```
#Accuracy with K-Nearest Neighbors Classifier
print("Accuracy_KNN:",metrics.accuracy_score(y_test, y_pred2))
```

```
Accuracy_KNN: 1.0
```

```
y_pred = np.array(clf.predict(x_test))
conf_mat = pd.DataFrame(confusion_matrix(y_test, y_pred),
                        columns=["Pred.Negative", "Pred.Positive"],
                        index=['Act.Negative', "Act.Positive"])
tn, fp, fn, tp = confusion_matrix(y_test, y_pred).ravel()
accuracy = round((tn+tp)/(tn+fp+fn+tp), 4)
print(conf_mat)
print(f'\n Accuracy = {round(100*accuracy, 2)}%')
```

```
              Pred.Negative  Pred.Positive
Act.Negative            225              7
Act.Positive              0            180

 Accuracy = 98.3%
```

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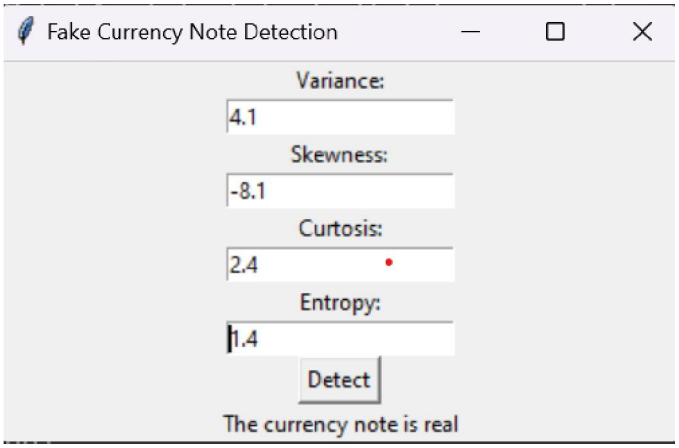
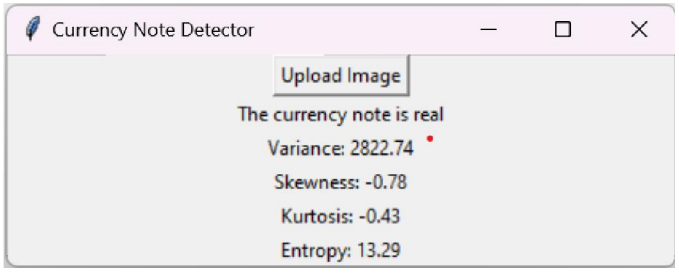
```
import tkinter as tk
def is_fake_note():
    variance = float(variance_entry.get())
    skewness = float(skewness_entry.get())
    curtosis = float(curtosis_entry.get())
    entropy = float(entropy_entry.get())
    new_banknote = np.array([variance, skewness, curtosis, entropy], ndmin=2)
    new_banknote = scalar.transform(new_banknote)
    result = clf.predict(new_banknote)[0]
    result_label.config(text="The currency note is " + ("fake" if result == 1 else "real"))

window = tk.Tk()
window.title("Fake Currency Note Detection")

variance_label = tk.Label(window, text="Variance:")
variance_entry = tk.Entry(window)
skewness_label = tk.Label(window, text="Skewness:")
skewness_entry = tk.Entry(window)
curtosis_label = tk.Label(window, text="Curtosis:")
curtosis_entry = tk.Entry(window)
entropy_label = tk.Label(window, text="Entropy:")
entropy_entry = tk.Entry(window)

detect_button = tk.Button(window, text="Detect", command=is_fake_note)

result_label = tk.Label(window, text="")

variance_label.pack()
```





DATASET: 5.3 Load the Dataset

```
df = pd.read_csv('bank_notes.csv')
df
```

	variance	skewness	curtosis	entropy	Target
0	3.62160	8.66610	-2.8073	-0.44699	0
1	4.54590	8.16740	-2.4586	-1.46210	0
2	3.86600	-2.63830	1.9242	0.10645	0
3	3.45660	9.52280	-4.0112	-3.59440	0
4	0.32924	-4.45520	4.5718	-0.98880	0
...	...	...	...	...	...
1367	0.40614	1.34920	-1.4501	-0.55949	1
1368	-1.38870	-4.87730	6.4774	0.34179	1
1369	-3.75030	-13.45860	17.5932	-2.77710	1
1370	-3.56370	-8.38270	12.3930	-1.28230	1

Figure 5.4: Loading the Dataset

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Extracting the info of the dataset:

To obtain a brief description of a dataframe, use the info() method in the pandas programming language. It provides all details about the dataframe 's memory use, the number of non-null values in each column, the column dtypes, etc.

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1372 entries, 0 to 1371
Data columns (total 5 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   variance  1372 non-null   float64
 1   skewness  1372 non-null   float64
 2   curtosis  1372 non-null   float64
 3   entropy   1372 non-null   float64
 4   Target    1372 non-null   int64  
dtypes: float64(4), int64(1)
memory usage: 53.7 KB
```

Figure 3.3 Extracting information of the dataset Plotting the graphs of Bivariate distributions:Usethe.pairplot() function to plot severalpairwise bivariate distributions in a dataset. The link between the (n, 2) combination of variables in a DataFrame is shown as a matrix of plots using the diagonal plots, which are known as univariate plots.

```
sns.pairplot(df, hue='Target')
plt.show()
```

Checking Missing values In my dataset there are some features which are categorical(gender, marriagestatus,smoking status, residence type) format. I need to convert it into numerical format as shown in Figure 3.4.

```
#checking for missing values
df.isnull().sum()
```

```
variance    0
skewness    0
curtosis    0
entropy     0
Target      0
dtype: int64
```

Sequence Diagram

A sequence diagram view how messages move in the system. It's also called an event diagram. It helps imagine many different possibilities that can change. This shows how two people communicated with each other during a certain period of time. It includes everything they said and did while talking. In UML, the lifeline looks like a tall line, and the message flow looks like a dotted line low down on the page. It uses loops and decision-making in the program. When you use the app, you start by uploading a picture of fabric. Then, the app checks the picture for any problems like tears or damage. If something is wrong with.

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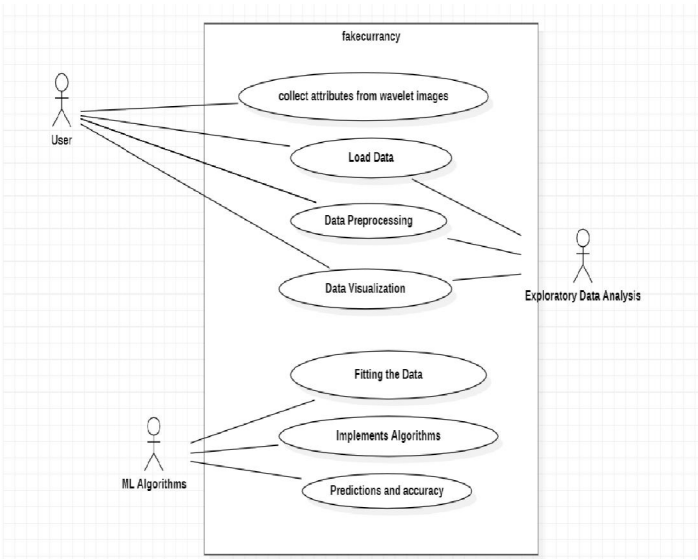


Figure 3.4 Checking Missing Values

UML Diagrams:

To describe the energetic behaviour of a framework, a use case chart is employed. By combining use scenarios, and their linkages, it shows the system's value. It models the errands, administrations, and capacities required by a system/subsystem of an application. It portrays the high-level usefulness of a framework additionally tells how the client handles a framework.

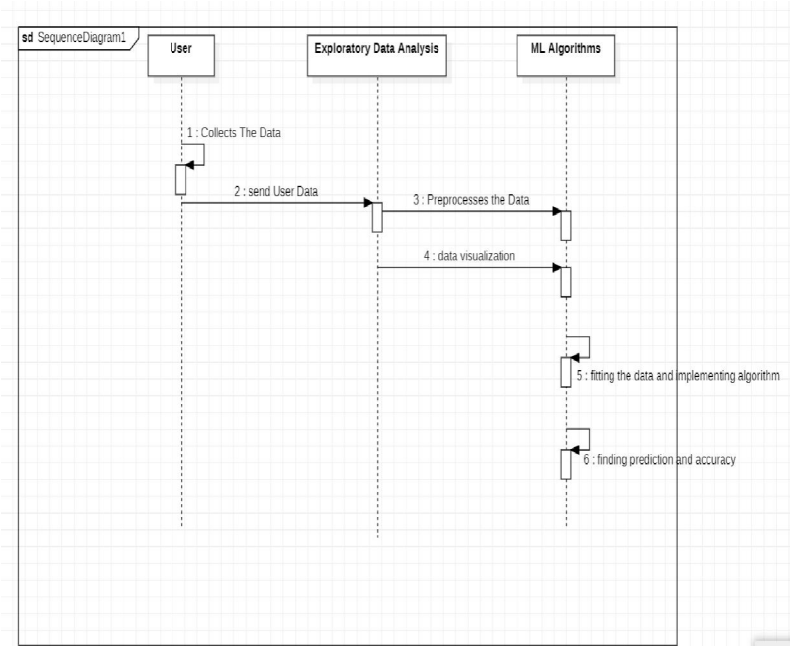
It portrays the usefulness and clients of the framework and it models the total conduct of a framework. So, use cases are organised and on-screen characters are identified when a framework is dissected to assemble its functionalities.

Use-Case utilized to assemble the prerequisites of a framework.

Use-Case utilized to urge an exterior see of a framework.

Recognize the outside and inside variables affecting the framework.

Appear the interaction among the requirements are on-screen characters.



We have modeled the most modules as on-screen characters and their behavior as utilize cases. There are two modules in our venture one is client and other is demonstrate. The client will transfer the picture of the texture and will press on

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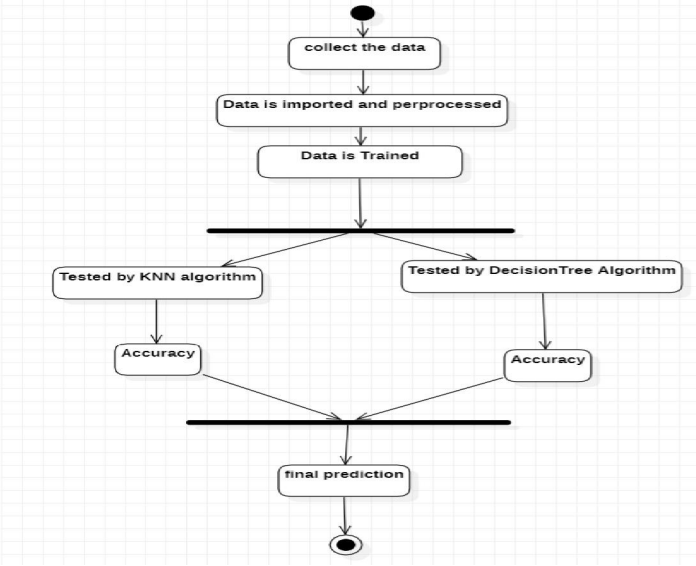
foresee the show will take the input as the picture which is given by the client and pre-processes the picture in like manner and the show will do two distinctive expectations neighborhood and worldwide and classify the result agreeing to the forecasts and result will be appeared.

Activity diagram

An activity diagram is a diagram used in UML to show how a system works. An activity diagram is like a map that shows how you move from one task to the next. The activity is like a task that the system does. Operations are connected and move from one to the next. This flow can happen in order, with choices, or all at once. Activity diagrams are charts that show how things happen step-by-step. They use symbols like forks and joins to show different parts of the process. Activity diagrams have similar goals to four other diagrams. It shows how the system moves and changes over time. There are four different pictures that show how messages go from one thing to another thing, but the activity diagram is used to show how messages go from one action to another action. Activity means a specific task that the system performs. Activity diagrams are drawings that show how a system moves and changes. They can help create a working system using different techniques. The activity diagram needs a message part added to it.



State Diagram

Pictures illustrating the construction of computer programmes are known as UML Component Charts. They help people understand how to design, explain, and build programs. With them, you can also create and test programs faster and easier.State diagrams show the different parts of a system and how they work together. They are like pictures that help people understand how a system is built.

The information (account and inspection ID) goes through the part from the right side and is changed into a kind that the inside parts can use. The boxes on the right are called required interfaces. They show what the component needs to do its job.

The information goes through different parts and cables before it comes out on the left side. The things on the left are called provided interface. It shows what services the component will offer. The insides of a machine are in a big box. The box could be the whole machine or just a part of it.

State chart uses include:

We utilise it to list the incidents that led to the state change (but we don't disclose the procedures that brought about those incidents).

It helps us simulate the system's dynamic behaviour.

To comprehend how various things or classifications respond to internal or external stimuli.

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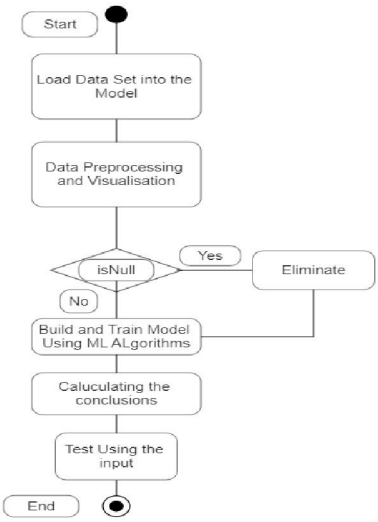


Class Diagram

Class diagrams doesn't change. This shows how an app looks without it doing anything.

A class diagram is a tool that helps people understand and explain how a system works.

It can also help create software that actually works.

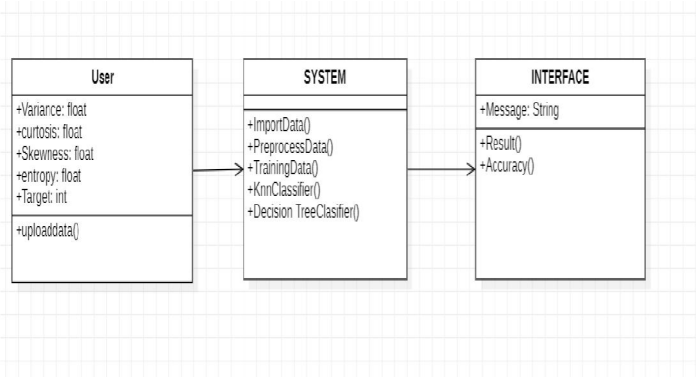
UML diagrams such as activity and sequence diagrams can only show the order of events. The way the application works is not the same as how the classes are organized in the diagram. This is widely liked by many people. UML diagram is a tool used by coders. The class diagram helps us understand how different things in a project are connected.

Analyzing and creating a plan for how an application looks when it's not moving or being used.

Explain what a system has to do. This is a foundation for pictures of parts and how they are put into use.

Forward engineering means creating something new from scratch. Reverse engineering means taking something that already exists, breaking it down to understand how it was made, and then using that knowledge to create something similar or improve upon.

There are totally 4 functionalities they are user upload class has user uploading image to the front end. User decision has choice to select. Model functionalities has predictions and classifications the predictions class has local and global predictions operations which specifies them according to the type of predictions. Image processing has processing of image based on predictions whether it has a defect or not. First we should upload an image of the fabric then inception v5 model which we are using will split the images and divided it in to local and global predictions and then will classify the type of defect and gives the result as defect predicted if any.



VI. CONCLUSION

We can conclude that the three algorithms utilised were incredibly accurate at categorising notes as genuine or counterfeit based on the used data set after applying them and analysing the results obtained. However, as discussed in the section above, KNN performed better than the other algorithm, a decision tree. Only 2 fake notes were classified

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 10, May 2023

incorrectly, giving it a classification accuracy of 99.9%.However, the accuracy of the decision tree is around 98%, which is not at all bad. But KNN When used for small datasets its prediction accuracy is higher .When we test with higher datasets Logistic Regression performed better All the machine learning algorithms used to categorise the class are supervised machine learning classifiers, which perform better when applied to smaller datasets like the one in question. Since we are basing our predictions on the same test data, our accuracy here is nearly 100%, but it might drop for the new data. In conclusion, we can predict the Class for this Dataset using the KNN Algorithm for smaller datasets for larger datasets we prefer using Logistic Regression model. So Our model helps in predicting whether a currency note is fake or real accurately by using the features extracted from wavelet transformation.

VII. FUTURE ENHANCEMENT

Future research can concentrate on various methods for anticipating Parkinson's disease utilizing various datasets. A notion that can classify every nation's money, whether it is authentic or counterfeit, and make it simple and portable for everyone is becoming one of the most important undertakings in the near future. You may add currencies from different countries and determine whether a note is authentic or phoney based on those four features. Future additions of different national currencies could increase the collection's scope. We should then employ deep learning techniques to forecast the model because they can handle greater datasets. Deep Learning approaches might produce more accurate results and productive machines.

VIII. ACKNOWLDEMENT

For her insightful suggestion, knowledgeable counsel, and moral support during the writing of this work, we would like to express our gratitude to Mrs. V. Sowmya Devi.

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