CURRENCY NOTE AUTHENTICATION, NOTE VALUE ESTIMATOR USING NB CLASSIFIER, SVM BY MATLAB

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Abstract— The Automatic systems for paper currency recognition have become crucial in various applications, such as automated teller machines and automatic goods seller machines, as a result of the development of modern banking services. Many academics were inspired to build strong and dependable solutions in response to the requirement for automatic banknote recognition systems. In such systems, processing speed and recognition accuracy are usually two of the most significant goals.

The modernization of the financial system is a watershed moment in preserving economic growth and social harmony. Automatic machines that can recognize banknotes are widely employed in automatic dispensers of a variety of products, from cigarettes to bus tickets, as well as numerous automated banking procedures.

Hence in our Project, we aim to build a system where notes are authenticated later estimated using SVM and NB classifier in Matlab.

Keywords: SVM, NB, Currency, Notes, Matlab

I. INTRODUCTION

Currency recognition technology tries to find and extract visible and hidden signs on paper currency for accurate classification. Until recently, various methods for recognizing paper currency have been proposed. The most straightforward method is to use the paper currency's apparent characteristics, such as its size and color. However, this method has significant limits because banknotes become worn and torn over time, and they become much dirtier when held in dirty hands or soil. If a banknote becomes soiled or is changed to a different hue, the color content of the banknote will alter dramatically.

Extensive experimental work is required in the field of digital image processing to establish the validity of offered solutions to a specific challenge. Many fields of study, as well as industrial and military uses, have found it to be cost-effective. Digital image processing includes procedures that use images as inputs and outputs, as well as processes that extract attributes from images up to and including object recognition. The examination of hidden marks on the image of paper currency inspired the method we suggested in this paper. In image processing, figuring out how to extract the hidden features of paper cash is a difficult task.

The algorithm we use here is quite straightforward and effective. The image of the paper cash is captured using a camera, with white illumination applied to the paper currency to reveal the hidden currency marks. Picture processing techniques such as image preprocessing, edge detection, image segmentation, and characteristics extraction are being used to further process the image.

Broad trial work is needed in the field of advanced picture handling to set up the legitimacy of offered answers for a particular test. It incorporates techniques that utilization pictures as sources of info and yields, just as cycles that concentrate credits from photographs up to and including object acknowledgment. For examination, advancement, and investigation, MATLAB is the favored computational apparatus. Trademark picture extraction is a troublesome undertaking in advanced picture handling. It involves the extraction of both apparent and concealed attributes from Indian cash notes.

A fruitful trademark extraction procedure should keep and work on the properties of the information that recognize diverse example classes. Picture procurement, grayscale change, edge location, highlight extraction, picture division, and picture correlation are altogether measures in the technique. Picture securing is the most common way of making computerized photos from a genuine circumstance. In the proposed exertion, the picture will be caught with a basic advanced camera and some brightening to guarantee that the entirety of the provisions of the coin show effectively on the picture. From that point forward, the picture is saved to the PC for additional preparation. The main exercises performed on the pictures are edge location and picture division.

A money note is a kind of debatable instrument gave by a bank that is receivable on request to the carrier. The Indian Rupee is the Republic of India's public money. Fake cash is fake cash made without the state's or alternately government's consent. Perhaps the most major issue in financial exchanges is fake notes. Thus, defilement has expanded, blocking the nation's development. Due to quick

advances in imaging, checking, and printing innovation, it is very easy to bring in fake cash notes utilizing complex programming and equipment devices. Recognizing fake notes physically is a tedious and messy activity, henceforth a programmed method with a cash acknowledgment measure that can be finished rapidly is required. This investigation is an endeavor to dissect the security components of Indian money to utilize picture handling in MATLAB to perceive and confirm certified cash notes.

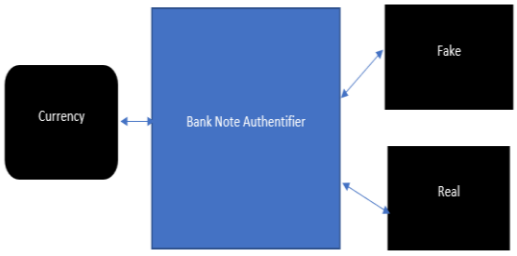
A. Significance of Currency-

It is huge because the conversion scale, or the cost of one money as far as another, impacts a country's financial wellbeing and, accordingly, the prosperity of every one of its residents. Cash plays a critical part in the public arena in an assortment of ways, including trade, business, and instruction. Cash permits individuals to have superior instruction, have a more prominent shot at beginning a business, and produce more work. It fills in as a benchmark for postponed installments. The main job of cash, in any case, is that it capacities as a method for trade, which separates it from different things. Cash, at the end of the day, is a mode of trade for items and administrations.

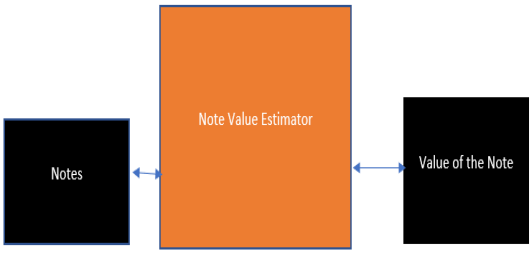
B. Functions of money-

To recapitulate, money has existed in numerous forms throughout history, but it has always served three purposes: as a store of value, a unit of account, and a medium of exchange. Individuals' economic activity determines the character of money, which acts to meet their wants to the greatest extent possible. Money is a commodity that is in great demand because of its significantly higher saleability compared to other commodities, and it circulates as a means of exchange in the economy. Central banks produce money by printing it or purchasing bonds on the secondary market. When central banks acquire bonds, they normally buy treasury bonds issued by their own country, and they buy them from banks that possess bonds.

C. BLOCK DIAGRAM OF MODULE 1



D. BLOCK DIAGRAM OF MODULE



II. LITERATURE SURVEY

B. Sai Prashanthi et al 2015 has recommended that the edge data on paper cash was recovered and hence perceived utilizing a three-layer BP NN. Even though NN innovation offers self-association, speculation, and equal handling abilities, just as a solid fit for design acknowledgment, it additionally has critical blemishes. To start, it requires a high number of preparing tests to stay away from overfitting and helpless speculation. Second, if the preparation test appropriation isn't uniform, the outcome will in all likelihood meet a neighborhood ideal or wander nonsensically.

B. Sai Prashanti et al 2015 cases that subsequently, the preparation set determination is a basic issue for the NN. Since paper money can get worn, indistinct, or even broken all through the dissemination, the first data on the cash can be lost. Moreover, programmed cash acknowledgment is hard to execute because of the confounded plans of a few kinds of paper monetary standards. To build cash acknowledgment exactness, it's vital to see how to separate trademark data from money photographs and utilize fitting acknowledgment calculations. The technique we offer here is clear, less complicated, and productive, and it is equipped for meeting high-velocity necessities in true applications.

Prasad Dinkarrao Deshpande et al 2018 recommended that-Money falsifying is not another wonder; it has existed since the Greeks initially started authoring cash around 600 B.C. During that time, coins' edges were managed off to get important metal, which was then used to make fake money. Mulberry tree wood was utilized to make paper cash in China during the 1200s. Watchmen was responsible for mulberry timberlands during the period, and fashioning cash was deserving of death. Cash falsifying is an old malicious, as indicated by history.

Prasad Dinkarrao Deshpande et al 2018 asserted that-To recognize genuine and fake monetary forms, cash safety efforts are vital. Watermarks, inactive pictures, security string, intaglio, optically variable ink, miniature composition, and fluorescence are generally normal security highlights. Actual assessments of money notes are incapable, and it is hard for anybody to recognize fake and

veritable cash. Accordingly, programmed banknote acknowledgment innovations are required. It's basic to extricate enough financial properties from the cash picture. The utilization of machines makes the most common way of perceiving notes simpler and more effective.

III. PROPOSED METHODOLOGY

A. Software and Technology Requirements

A Functional Requirement (FR) is a portrayal of the assistance that the product should offer. It portrays a product framework or its segment. A capacity is only a contribution to the product framework, its conduct, and yields. It very well may be a computation, information control, business measure, client connection, or whatever other explicit usefulness which characterizes which work a framework is probably going to perform. Utilitarian Requirements are likewise called Functional specifications.

- **FR: MATLAB 2014 A**

MathWorks created MATLAB, a multi-worldview programming language, and a numeric figuring climate. Network tasks, capacity and information perception, calculation execution, UI building, and interfacing with programs written in different dialects are altogether conceivable with MATLAB. Even though MATLAB is fundamentally intended for mathematical calculations, a discretionary tool kit utilizes the MuPAD emblematic motor to give representative figuring capacities. Simulink, different programming, adds graphical multi-space reenactment and model-based plan for dynamic and inserted frameworks to the blend. Clients of MATLAB come from an assortment of designing, logic, and financial matters disciplines. Practical Requirements ought to incorporate the accompanying things.

- **Other tools needed-**

- Microsoft Office
- Adobe Reader
- Octave

B. Hardware Requirements

- Computer/ Laptop
- Windows Os 8 or above or Ubuntu

	Medium	High-end
CPU	4 Physical Cores	12 Physical Cores
Memory	4 GB	24 GB
Disk	4 disks x 1TB = 4 TB	12 disks x 3TB = 36 TB
Network	1 GB Ethernet	10 GB Ethernet or InfiniBand

Table 1. Hardware Requirements

C. Implementation/Flow of the project

In this project, we proposed a solution to authenticate the notes via the SVM algorithm, and estimate the value of a supplied note. There are two modules in this project-

1. Authentifying the note using SVM by Matlab

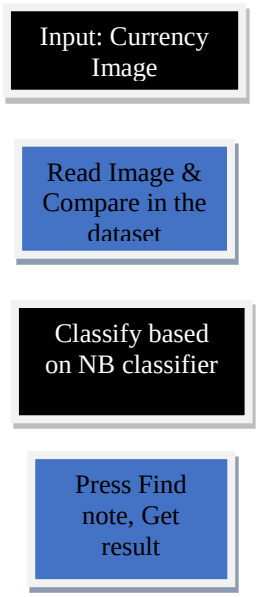
2. Estimating the value of a note by NB classifier.

Module 1:

Flowchart for module 1

Module 2:

- This module takes note of images as input
- It then reads the image and compares it to its dataset-based images.
- Based on the NB classifier it classifies into the available notes.
- Now, pressing the find note value gives the result of the note.



Flowchart for module 2

D. Dataset Information

As it is clear, our modules shall be executed in MATLAB 2014 A, in Matlab language, so for both SVM & NB classifiers, our dataset has not been borrowed from GitHub or Kaggle websites, but it is user-defined as we shall be storing the significant validated notes for comparison & reference inbuilt like the following-

Figure 1: Ten INR note

Figure 2: Fifty INR note

Figure 3: Hundred INR note

Figure 4: Two Hundred INR note

Figure 5: Five Hundred INR note

Figure 6: Two Thousand INR note

E. Character Feature Extraction

Prime Minister Narendra Modi canceled the previous Rs 500 currency note in November 2016, while the new one was released into the banking system in November 2016. The new Rs 500 note, as well as the Rs 2,000 note, were introduced with new and old security measures. Here are several characteristics that can help you tell the difference between a genuine Rs 500 currency note and a fraudulent one.

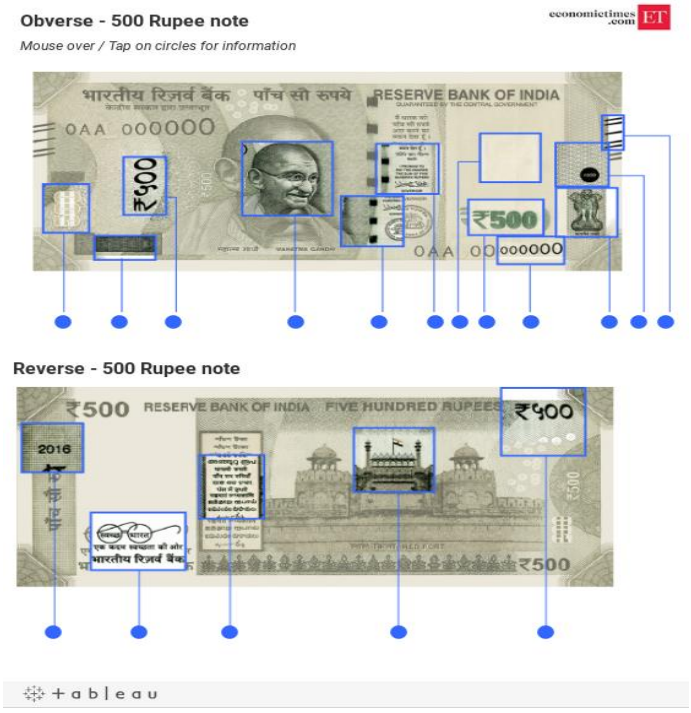


Figure 7: Feature Extraction data points of 500 note

- ***On one side-***

When held against the light, the number 500 can be seen through the see-through register. When held at a 45-degree angle at eye level, the number 500 can be seen through the latent image, Devnagiri's 500th number, In the center, there is a portrait of Mahatma Gandhi. When the note is tilted, the color shifts from green to blue in a windowed security thread. Guarantee clause, RBI governor's signature with Promise clause to the right, and RBI emblem, Watermark with a portrait and an electrotype, Number panels with small to large digits.Color-changing ink and a denominational number with a Rupee symbol (Rs 500). (green to blue),Symbol of the Ashok Pillar, Rs 500 in raised print on a circle (2) A raised image of Gandhi, the Ashok insignia, bleed lines, and identification markers are included for the visually handicapped.

- ***On the other side-***

In the year in which the note is printed, the slogan "Swachh Bharat" is included in the Swachh Bharat logo. A panel of language experts, Red Fort motif with the Indian flag, Devnagiri's 500th number shall be embossed.

F. Technology Insights

SVM-

A help vector machine is an AI model that can sum up across two classes if the calculation is given a bunch of marked information in the preparation set. The SVM's essential job is to search for a hyperplane that can recognize the two classes.

A few hyperplanes can play out this obligation, however, the objective is to find the hyperplane with the greatest edge, or most extreme distances between the two classes so that if another information guide needs to be arranged, later on, it very well may be done rapidly.

- **Information that can be isolated directly**

How about we take a gander at a model where we have two classes, class A: Circle and class B: Triangle, as shown in the picture underneath. Presently we'll utilize the SVM strategy to choose the best hyperplane that isolates the two classes.

SVM thinks about the entirety of the information focuses and produces a line called a "Hyperplane" that isolates the two gatherings. The expression "choice boundary" alludes to this line. Anything in the circle class will have a place with class An and the other way around.

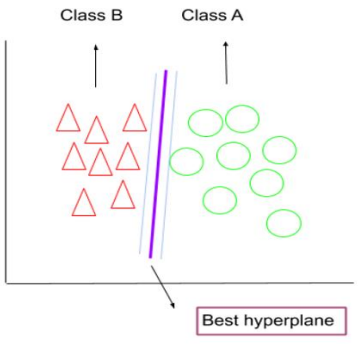


Figure 8: Hyperplane linear separation

There are different hyperplanes to browse, however, the ideal hyperplane for isolating the two classes is unified with a major distance between the hyperplanes of the two classes. The principal objective of SVM is to find the ideal hyperplanes. Various measurements might exist, contingent simply upon the attributes we have. When there are multiple perspectives, it's hard to envision.

Not many of the previously mentioned information focuses can be misclassified because of the delicate edge. It likewise means to strike a trade-off between finding a hyperplane that makes fewer misclassifications while augmenting the edge.

- **Information that isn't directly distinct**

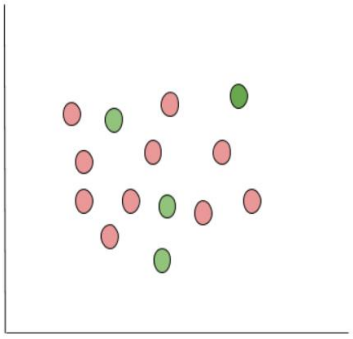


Figure 9: Inseparable hyperplane of 2 classes

On the off chance that the information isn't directly distinguishable, as in the model above, SVM utilizes piece strategies to make it straightly detachable. The idea of changing non-directly distinguishable information into straightly divisible information is known as Cover's hypothesis: "given a bunch of preparing information that isn't straightly detachable, it very well may be changed into a directly distinct preparing set with a high likelihood by extending it into a higher-dimensional space employing some non-straight change." Kernel techniques help in the projection of information focuses into higher-dimensional space, permitting them to be isolated all the more promptly.

Bit stunts, otherwise called Generalized speck items, are a sort of bit stunt. Piece stunts are a strategy for deciding the speck result of two vectors to perceive the amount they impact one another. The likelihood of straightly non-divisible informational collections being directly detachable ascents in expanding measurements, as per Cover's hypothesis. To tackle SVM restricted improvement, bit capacities are utilized to get the dab items.

- **In SVM, the level of resilience is estimated**

When managing both directly distinct and nonlinear arrangements, the punishment term that is passed as a hyperparameter in SVM is demonstrated as 'C,' which represents Degree of Tolerance. At the point when C is set to a high worth, SVM gets a higher punishment when it makes a misclassification. The choice limit will be founded on a little safety buffer and fewer help vectors.

Benefits of SVM

- Because of the dependence on help vectors as opposed to information focuses, there is an undeniable degree of strength.
- Exceptions don't influence it.
- The datasets were not exposed to any suppositions.
- SVM can be utilized to tackle mathematical expectation issues.

Bank Note Authentifier using SVM-

Banknotes are one of a country's most valuable assets. To create money differences in the financial market, some criminals issue fake notes that seem identical to the actual notes. Humans find it difficult to distinguish between genuine and counterfeit banknotes, especially because they have many characteristics. Fake notes are meticulously made, necessitating the development of an efficient algorithm that can precisely predict whether a banknote is real or not. Support Vector Machine and other supervised learning techniques are used to distinguish genuine banknotes from fakes. In our Project, the SVM algorithm can be utilized to detect the currency note authenticity. The output shall be in binary where it says if the picture is fake or real.

Code Snippets:

```
function colfet=color_luv(rgb_im)
%three color moments: mean ,variance , skewness skewness in each
channel
%(L,U and V respectively)
%total 9-D color moments
%Input image should be a rgb image,

%convert rgb to xyz colorspace
xyzTransformation = makecform('srgb2xyz');
xyzI = applycform(rgb_im,xyzTransformation);
%convert xyz to luv colorspace
warning('off');
luvTransformation = makecform('xyz2uvl');
luvI = applycform(xyzI,luvTransformation);
%figure,imshow(luvI,'initialmagnification','fit');

%seperate l,u,v
L=luvI(:,:,1);
U=luvI(:,:,2);
V=luvI(:,:,3);
%find mean,color variance and color skewness for each channel
colfet(1)= mean(L(:));
colfet(2) = std(L(:))^2;
colfet(3)= skewness(L(:));
colfet(4) = mean(U(:));
colfet(5) = std(U(:))^2;
colfet(6) = skewness(U(:));
colfet(7) = mean(V(:));
colfet(8) = std(V(:))^2;
colfet(9) = skewness(V(:));
colfet=colfet';
end
```

```
function [ currency_name ] = banknoteRecognition( im )
% This function is used to take the input image for testing
% The input image is preprocessed and its features are extracted
% The features are compared with the sample images in the
database and the output is given
clc;
if (exist('currency_db.mat')==2)

%resize image
im=imresize(im,[128 128]);
%remove noise;
%seperate channels
 r_channel=im(:,:,1);
 b_channel=im(:,:,2);
 g_channel=im(:,:,3);
 %denoise each channel
 r_channel=medfilt2(r_channel);
 g_channel=medfilt2(g_channel);
 b_channel=medfilt2(b_channel);
 %restore channels
 rgbim(:,:,1)=r_channel;
 rgbim(:,:,2)=g_channel;
 rgbim(:,:,3)=b_channel;
 %featureextraction
fet=getFeature(rgbim);

    load('currency_db.mat','-mat');
    msgbox('Searching in Database','Database result','help');
    k=length(currency);
    for j=1:k
        D(j)=dist(fet',currency(j,1));
    end
    [value,index]=min(D);
    if value<0.001
        currency_name=currency(index,2);

    else
        currency_name = 'No matches found';
    end
else
    msgbox('Database is empty.','Database result','help');
    currency_name = 'No database';
end
end
```

```
function [ features ] = getFeature( rgbim )
% The three features are stored as a row matrix
 %color feature
 fet1=color_luv(rgbim);
 %edge feature
 fet2=edgehist(rgbim);
 %texture feature
 %glcm-gray level co occurrence matrix
 glcm=graycomatrix(rgb2gray(rgbim));
 fet3=glcm(:);
 features=[fet1;fet2;fet3];

end
```

- **NB Classifier**

The Bayes Theorem is utilized to make an assortment of characterization calculations known as Naive Bayes classifiers. It is a group of calculations that share a comparative thought, specifically that each pair of provisions being ordered is autonomous of the others.

The Bayes Theorem computes the probability of an occasion happening given the likelihood of a past occasion. The accompanying condition communicates Bayes' hypothesis numerically.

$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$

where A and B are events and P(B) ? 0.

- Basically, we are trying to find probability of event A, given the event B is true. Event B is also termed as **evidence**.
- P(A) is the **priori** of A (the prior probability, i.e. Probability of event before evidence is seen). The evidence is an attribute value of an unknown instance(here, it is event B).
- P(A|B) is a posteriori probability of B, i.e. probability of event after evidence is seen.

Naive Bayes Classifier Types-

- ***Naive Bayes Multinomial***

This is regularly used to take care of archive grouping issues, for example, deciding if a report fits in the games, governmental issues, or innovation classifications. The recurrence of the terms remembered for the report is one of the components/indicators utilized by the classifier.

- ***Bernoulli Naive Bayes***

Like multinomial innocent Bayes, yet utilizing boolean factors as indicators. The boundaries we use to conjecture the class variable just acknowledge yes or no answers, for example, if a word shows up in the text or not.

- ***Naive Bayes Gaussian***

We accept these qualities are tested from a Gaussian conveyance when the indicators take up a nonstop worth and are not discrete. Since the circulation of qualities in the dataset changes, the contingent likelihood recipe changes to-

$$P(x_i|y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} exp\left(-\frac{(x_i-\mu_y)^2}{2\sigma_y^2}\right)$$

Opinion investigation, spam separating, proposal frameworks, and different applications utilize credulous Bayes calculations. They are fast and easy to execute, yet the need that indicators be free is their significant disadvantage. The indicators are generally dependant on genuine circumstances, which restricts the classifier's viability.

Note Value Estimator by NB

Now, to estimate the value of the note, we insert an image and the image shall be segmented, and the pages shall be verified & validated and be given an appropriate value.

Cash transactions remain very important in the worldwide market, despite a drop in the use of money due to the recent development in the use of electronic transactions. Banknotes are used to conduct financial transactions. The introduction of falsified banknotes into circulation should be preserved to maintain seamless cash transactions. The number of counterfeit notes on the market has risen dramatically. Fake money is a copy of real money that is made unlawfully for a variety of reasons.

Code Snippets-

```
if isempty(samplename)
    warndlg('Invalid Input',' Warning ');
else
    saveDB(sampleimage,samplename);
end

% --- Executes on button press in pushbutton3.
function pushbutton3_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton3 (see GCBO)
% eventdata  reserved - to be defined in a future version of
MATLAB
% handles    structure with handles and user data (see GUIDATA)
getDBInfo();

% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)

deleteDB();


function edit1_Callback(hObject, eventdata, handles)

% --- Executes during object creation, after setting all
properties.
function edit1_CreateFcn(hObject, eventdata, handles)

if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end


% --- Executes on button press in pushbutton5.
function pushbutton5_Callback(hObject, eventdata, handles)

image = getimage(handles.axes1);
result = banknoteRecognition(image);
set(handles.text6,'string',result);
```

```
function edhist= edgehist(rgb_im)

%edge directional histogram
%Input image should be a rgb image,
%a 1x5 edge orientation histogram is computed (horizontal,
vertical,
% 2 diagonals and 1 non-directional)

%convert rgb color space into ycbcr colorspace

new_im=rgb2ycbcr(rgb_im);

% define the filters for the 5 types of edges
f1 = zeros(3,3,5);
f1(:,:,1) = [1 2 1;0 0 0;-1 -2 -1]; %vertical
f1(:,:,2) = [-1 0 1;-2 0 2;-1 0 1];   %horizontal
f1(:,:,3) = [2 2 -1;2 -1 -1; -1 -1 -1];% 45 diagonal
f1(:,:,4) = [-1 2 2; -1 -1 2; -1 -1 -1];%135 diagonal
f1(:,:,5) = [-1 0 1;0 0 0;1 0 -1]; % non directional

%extract only y component
y=double(new_im(:,:,1));

% iterate over the posible directions
for i = 1:5
% apply the sobel mask
g_im(:,:,i) = filter2(f1(:,:,i),y);
end
% calculate the max sobel gradient and index  of the orientation
[m, p] = max(g_im,[],3);

%detect the edges using canny
edim = edge(y, 'canny');

%figure,imshow(edim,'initialmagnification','fit');
%multiply edge image with the types of orientations detected
% by the Sobel masks
im2 =(p.*edim);

%find histogram
edhist=hist(im2(:),5)';

end
```

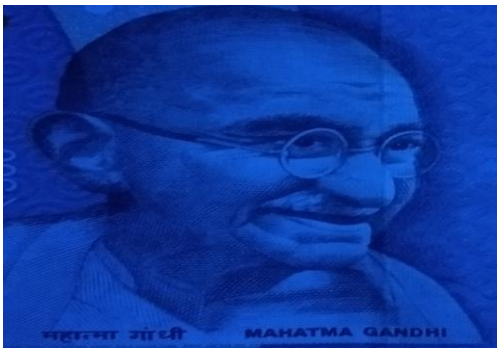
```
function [  ] = deleteDB(  )
%UNTITLED4 Summary of this function goes here
%   Detailed explanation goes here
clc;
if (exist('currency_db.mat')==2)
    button = questdlg('Do you really want to remove the
Database?');
    if strcmp(button,'Yes')
        delete('currency_db.mat');
        msgbox('Database was succesfully removed from the current
directory.','Database removed','help');
    end
else
    warndlg('Database is empty.',' Warning ')
end

end
```

These counterfeit notes are produced in all denominations, bringing the country's financial industry to a halt. The improvements in the field of scanners and copy machines have led to the creation of counterfeit banknotes by criminals. Because fake notes are meticulously constructed to resemble genuine notes, the human eye can't distinguish them. To combat fake cash, security issues of banknotes must be studied, and security features must be implemented. As a result, banks and ATMs urgently need to build a system that determines if a note is genuine or counterfeit.

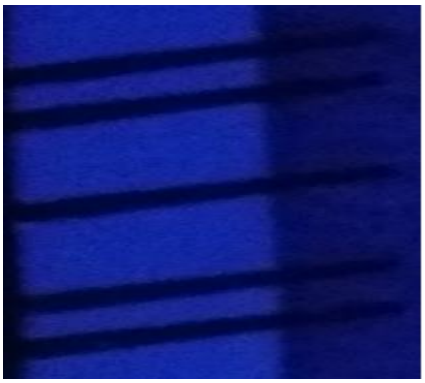
RESULTS

Output 1: Scanned Image of a currency

Output 2: Fake Image detected

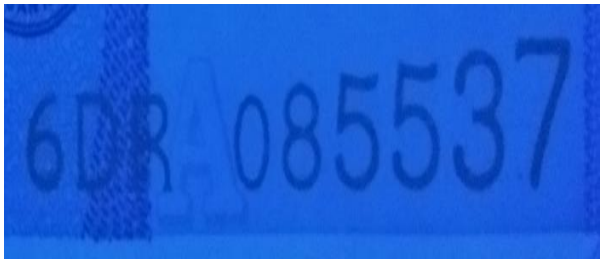


Output 3: Mahatma Gandhi Segmented Feature



Output 4: ID marks Feature

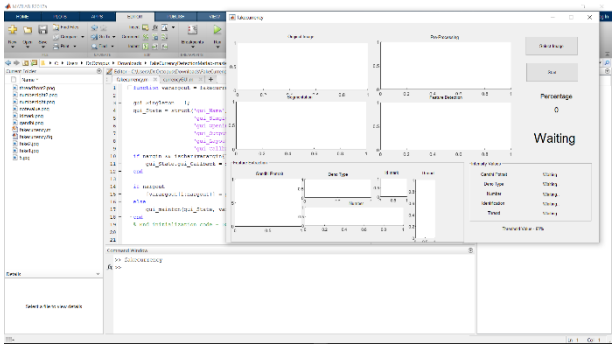
Output 5: Note Value Estimator



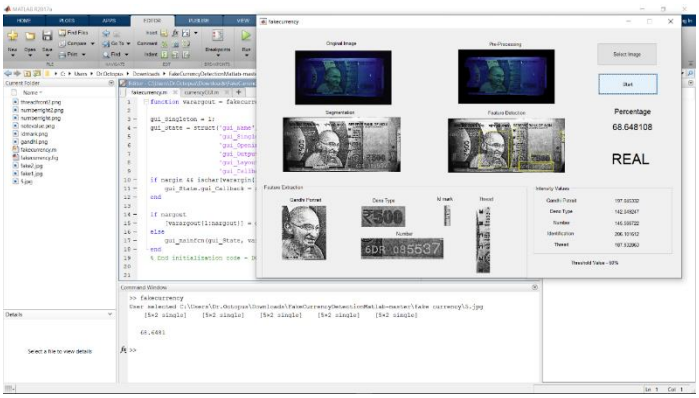
Output 6: Sequence Number right

Output 7: Sequence Number right

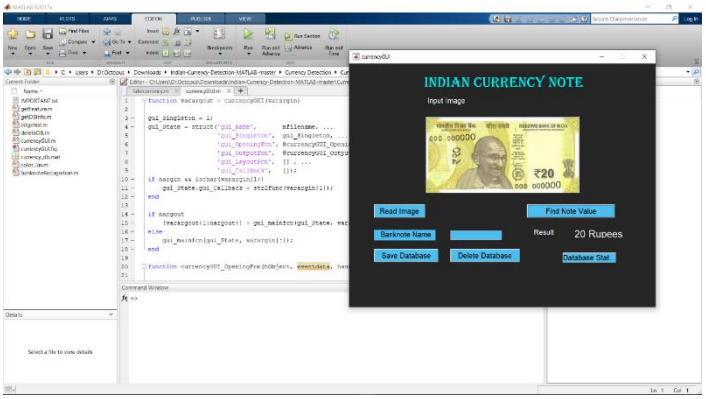
Output 8: Thread Font



Output 9: GUI Interface of Note Authentifier



Output 10: GUI Interface of Note Authentifier



Output 11: GUI Interface Note Value Estimator

These counterfeit notes are produced in all denominations, bringing the country's financial industry to a halt. The improvements in the field of scanners and copy machines have led to the creation of counterfeit banknotes by criminals. Because fake notes are meticulously constructed to resemble genuine notes, the human eye can't distinguish them. To combat fake cash, security issues of banknotes must be studied, and security features must be implemented. As a result, banks and ATMs urgently need to build a system that determines if a note is genuine or counterfeit.

CONCLUSION

To avoid money note counterfeiting, everyone should be aware of these security features. This effort will be expanded in the future to include many newly emerging denominations. Using Image Processing with MATLAB, this research provides a revolutionary approach for recognizing and authenticating Indian paper currency notes. The analysis of specific information about the different separate security features embedded in the original Indian currency note of denominational value 500 using multispectral imaging is also included in the report. This research also reveals traits that are absent from photocopied and scanned money notes, allowing for a clearer understanding of the differences between genuine and counterfeit currency. The work will undoubtedly be beneficial in reducing counterfeit cash.

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