Indian Currency Recognition and Verification Using Image Processing

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BONAFIDE CERTIFICATE

Certified that this project report entitled "**Indian Currency Recognition and Verification Using Image Processing"** is a bonafide work of

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ABSTRACT

Banknote identification systems, with their wide applications in Automated Teller Machines (ATMs), vending machines and currency recognition aids for the visually impaired, are one of the most widely researched fields today. The present paper proposes a novel technique for recognition of Indian currency banknotes by adopting a modular approach. The proposed work extracts distinct and unique features of Indian currency notes such as central numeral, RBI seal, colour band and identification mark for the visually impaired and employs algorithms optimized for the detection of each specific feature. The proposed technique has been evaluated over a large data set for recognition of Indian banknotes of various denominations and physical conditions including new notes, wrinkled notes and non-uniform illumination.

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PRIYANKA **ROHIT**

INTRODUCTION :

All economic activities relating to production, distribution, consumption etc. can be motivated by money. Savings and investments can be made in the form of capital information. Thus, money is important in the dynamic society for everything. As our economy is moving towards the development there are many other things which are downsizing it. One of those things is production and usage of forged bank notes.

The worst hit of this action is mostly average citizen as fake banknotes have become so deeply embedded in the Indian economy that even bank branches and ATMs are disbursing counterfeit currency. From petrol stations to the local vegetable vendor, everybody is wary of accepting banknotes in denominations of Rs.500 and Rs.1, 000 as a majority of them are almost impossible to tell from genuine banknotes. The usual effect of counterfeit on economy is inflation.

The only solution that is presently available for common man to detect counterfeit currency is Fake Note Detector Machine. This machine is mostly available only in banks which is not reachable every time by average citizen. All these scenarios need a kind of solution for common people to judge a forged bank note and to refrain our currency from losing its value.

A Digital Image processing is an area characterized by the need for extensive experimental work to establish the validity of proposed solutions to a given problem. It encompasses processes whose inputs and outputs are images encompasses processes that extract attributes from images up to and including the recognition of individual objects.

Characteristic extraction of images is challenging work in digital image processing. It involves extraction of visible and some invisible features of Indian currency notes. A good characteristic extraction scheme should maintain and enhance those characteristics of the input data which make distinct pattern classes separate from each other

SYSTEM OVERVIEW

2.1 Features of Indian Currency

There are too many features present in Indian currency which is decided by Reserve Bank of India. Figure 2.1 gives the idea about currency features of 1000 Rs note.

1. See through Register The small floral design printed both on the front (hollow) and back (filled up) of the note in the middle of the vertical band next to the Watermark has an accurate back to back registration. The design will appear as floral design when seen against the light.

2. Water marking The Mahatma Gandhi Series of banknotes contain the Mahatma Gandhi watermark with a light and shade effect and multi-directional lines in the watermark.
3. Optically Variable Ink (OVL) This is a new feature included in the Rs.1000 and Rs.500 notes with revised color scheme introduced in November 2000. The numeral 1000 and 500 on the obverse of Rs.1000 and Rs.500 notes respectively is printed in optically variable ink viz., a color-shifting ink.
4. Fluorescence Number panels of the notes are printed in fluorescent ink. The notes also have optical fibers. Both can be seen when the notes are exposed to ultra-violet lamp.
5. Security Thread The Rs.500 and Rs.100 notes have a security thread with similar visible features and inscription ‘Bharat’ (in Hindi), and ‘RBI’. When held against the light, the security thread on Rs.1000, Rs.500 and Rs.100 can be seen as one continuous line.

6. Intaglio Printing The portrait of Mahatma Gandhi, the Reserve Bank seal, guarantee and promise clause, Ashoka Pillar Emblem on the left, RBI Governor's signature are printed in intaglio i.e. in raised prints, which can be felt by touch
7. Latent image On the obverse side of Rs.1000, Rs.500, Rs.100, Rs.50 and Rs.20 notes, a vertical band on the right side of the Mahatma Gandhi’s portrait contains a latent image showing the respective denominational value in numeral.
8. Micro lettering This feature appears between the vertical band and Mahatma Gandhi portrait. It always contains the word ‘RBI’ in Rs.5 and Rs.10. The notes of Rs.20 and above also contain the denominational value of the notes in micro letters. This feature can be seen well under a magnifying glass.
9. Identification Mark Each note has a unique mark of it. A special feature in intaglio has been introduced on the left of the watermark window on all notes except Rs.10/- note. This feature is in different shapes for various denominations (Rs. 20-Vertical Rectangle, Rs.50- Square, Rs.100-Triangle, Rs.500-Circle and Rs.1000-Diamond).

PROPOSED SYSTEM :

In Currency Recognition, Feature such as Identity Mark And optical variable link are used. Pixel value for each feature is calculated. Based on that pixel value histogram is plotted. Currency feature such as Id mark and Optical variable link will be using for recognition. Currency features such as watermark, security thread, Fluorescence and latent image will be using for currency verification.

3.1 Image Acquisition:

Performing image acquisition in image processing is always the first step in the workflow sequence because, without an image, no processing is possible. After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks. There are various ways to acquire image such as with the help of camera or scanner. Acquired image should retain all the features [2].

3.2 Pre-processing:

The main goal of the pre-processing to enhance the visual appearance of images and improve the manipulation of data sets. Image preprocessing, also called image restoration, involves the correction of distortion, degradation, and noise introduced during the imaging process. Interpolation is the technique mostly used for tasks such as zooming, rotating, shrinking, and for geometric corrections. Removing the noise is an important step when processing is being performed. However noise affects segmentation and pattern matching [2].

3.3 Binarization:

The image acquired is in RGB color. It is converted into gray scale because it carries only the intensity information which is easy to process instead of processing three components R (Red), G (Green), B (Blue). To take the RGB values for each pixel and make as output a single value reflecting the brightness of that pixel. One such approach is to take the average of the contribution from each channel: (R+B+C)/3. However, since the perceived brightness is often dominated by the green component, a different, more "human oriented", method is to take a weighted average, e.g.: $0.3R + 0.59G + 0.11B$ [2].

3.4 Edge Detection:

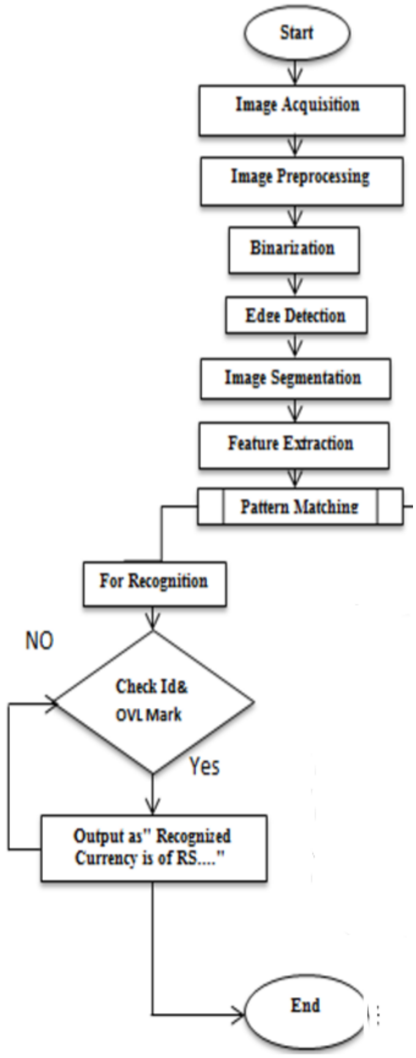
Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has these continuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision [2].

3.5 Image Segmentation:

Image segmentation is the process of partitioning a digital image into multiple Segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images [7]. Segmentation algorithm for images generally are based on one of the two basic properties of image intensity values- 1) Discontinuity: Based on abrupt changes in intensity such as edges in an image. 2) Similarity: Based on partitioning an image into regions that are similar according to a set of predefined criteria [1].

3.6 Feature Extraction:
Feature extraction is a special form of dimensional reduction. When the input data to an algorithm is too large to be processed and it is suspected to be very redundant then the input data will be transformed into a reduced representation set of features. Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input [2].

Flowchart for Currency Recognition System



LITERATURE SURVEY :

There are different methods of the paper currency recognition system using image processing techniques.

Shahbaj Khan et.al [4] explain about the authentication of different currency notes with basic image processing techniques. The image is converted from RGB to Grayscale for easy preprocessing of the acquired image. The edges are detected using Sobel operator and edge-based segmentation is applied to the image. Features are extracted using ORB feature detector. Extracted features include security thread, intaglio printing, micro-lettering etc. It may face many challenges such as old notes, worn out notes, image quality etc. the features are compared with the features of original currency which is templated in the dataset. Template matching is performed to obtain the output.

S Surya et.al [5] describes the process of image preprocessing by using two techniques: image smoothening and image adjusting. Removing the noise is the important step in image smoothening. A median filter by calculating the median of the neighbor pixels that build up a matrix which is odd sized and the target pixel is located in the middle of the pixel. The median filter is more effective than other methods and thus the pattern becomes clearer. In image adjusting process, useless part is recognized and removed RGB color model is one of the important methods for the recognizing the currency in this system. For performing edge detection, Sobel methods compute the gradient of image brightness function. Mainly two Sobel operators: one for to detect x-direction and other for to detect y-direction.

Sushma R G et.al [6] present that note can be identified by silver bromide thread. The real note contains ‘RBI’ marking in English and Hindi. In this paper, mobile application IP Webcam is used to capture an image. This application helps to get a high-resolution image without using an additional light sources filtering, histogram equalization and image conversion techniques are performed in image preprocessing step. Median filtering improves the result by removing noise. Histogram equalization increases the global contrast of the image. Conversion consists of two types: RGB to grayscale and RGB to YCbCr. Segmentation helps to extract the region of interest from the image of a currency note. Threshold has a good role in feature extraction.

R Bhavani et.al [7] discuss the recognition of banknotes using a novel feature extraction technique SURF which is a combination of both interest point detector and descriptor. Step included in this are reading image, pre-processing, feature extraction, classification and result. The system will extract the feature of the test image and then match with the features stored in the database. SURF performs image segmentation and feature extraction. Feature extraction is based on the region of interest. Obtained result shows the effectiveness of SURF method and currency recognition. This system activates an accurate recognition of currency. It displays the recognition output by testing images and matching with the features of template images.

B Vanajakshi et.al [8] proposes a 'Currency sorting machine' for bankers. The input is an image and JPEG format. It consists of two strategies namely image analysis and image processing techniques. Digital image processing techniques are used to analyze the image and obtain information about the image input. The image is analyzed preprocessed and segmented. The authentication process is achieved by counting the lines on the processed image of the currency. The image is smoothened and adjusted to give better results.

Vishnu R et.al [9] describes currency recognition using principal component analysis. No test currencies are used. Mahalanobis distance is computed between training and test instance to test the currency. In this paper, they select five security features for the determining the closeness of currency. The steps of investigation are dataset preparation, prepare train and test set feature extraction projection of features in eigenspace construct classification model using principal components and finally predict unseen samples. The front side of 50 currencies is scanned in 300 Dots Per Inches (DPI). In feature extraction, the features inside the ROI are cropped and saved in a separate image file. For reducing the high dimension of images, PCA is used. The probabilistic classifier Naïve Bayes requires only a minimal amount of training sample for computing classification parameters. Random vector generation uses two methods such as bagging and random split selection. Support vector machine is a supervised learning algorithm works based on the concept of determining the hyperplane which separates the training data.

Ingulkar Ashwini Suresh et.al [10] explains that image restoration involves the correction of distortion, degradation and noise removal. Interpolation is a technique that performs the tasks such as zooming, rotating, shrinking and for geometric corrections. RGB color is changed to grayscale to get a single value output. Edge detection helps to find boundaries of objects within images. The aim of segmentation is to simplify the representation of the image. Segmentation algorithm for images is generally based on properties of image intensity value such as discontinuity and similarity. An extracted feature of currency image helps for currency recognition and verification.

Trupti Pathrabe et.al [11] explains that characteristics extraction use size, color, and template. These characteristics are used in a decision tree to differentiate between different banknote denominations. Size is reduced, the image is transformed into grayscale. Markov chain concept helps to recognize the template. The negative correlation learning is to generate the diversity of the individual network using a penalty term. NCL trained the network to produce diversity among individual networks in the ensemble. The negative correlation learning finds errors what all networks are learned.

CODE:

detect.py

```
from utils import *
from matplotlib import pyplot as plt

import subprocess
from gtts import gTTS


max_val = 8
max_pt = -1
max_kp = 0

orb = cv2.ORB_create()

#test_img = read_img('files/test_100_2.jpg')
test_img = read_img('files/test_2000_2.jpg')
#test_img = read_img('files/test_2000_3.jpeg')
#test_img = read_img('files/test_100_3.jpg')
#test_img = read_img('files/test_20_4.jpg')

# resizing must be dynamic
original = resize_img(test_img, 0.4)
display('original', original)

# keypoints and descriptors
# (kp1, des1) = orb.detectAndCompute(test_img, None)
(kp1, des1) = orb.detectAndCompute(test_img, None)

training_set = ['files/20.jpg', 'files/50.jpg', 'files/100.jpg', 'files/500.jpg','files/
50_1.jpg','files/2000.jpg','files/100_1.jpg','files/10.jpg','files/10_1.jpg']

for i in range(0, len(training_set)):
	# train image
	train_img = cv2.imread(training_set[i])

	(kp2, des2) = orb.detectAndCompute(train_img, None)

	# brute force matcher
	bf = cv2.BFMatcher()
	all_matches = bf.knnMatch(des1, des2, k=2)

	good = []
	# give an arbitrary number -> 0.789
	# if good -> append to list of good matches
	for (m, n) in all_matches:
		if m.distance < 0.789 * n.distance:
			good.append([m])

	if len(good) > max_val:
		max_val = len(good)
		max_pt = i
		max_kp = kp2

	print(i, ' ', training_set[i], ' ', len(good))
```

```
if max_val != 8:
	print(training_set[max_pt])
	print('good matches ', max_val)

	train_img = cv2.imread(training_set[max_pt])
	img3 = cv2.drawMatchesKnn(test_img, kp1, train_img, max_kp, good, 4)

	note = str(training_set[max_pt])[6:-4]
	print('\nDetected denomination: Rs. ', note)

	(plt.imshow(img3), plt.show())
else:
	print('No Matches')
```

utils.py

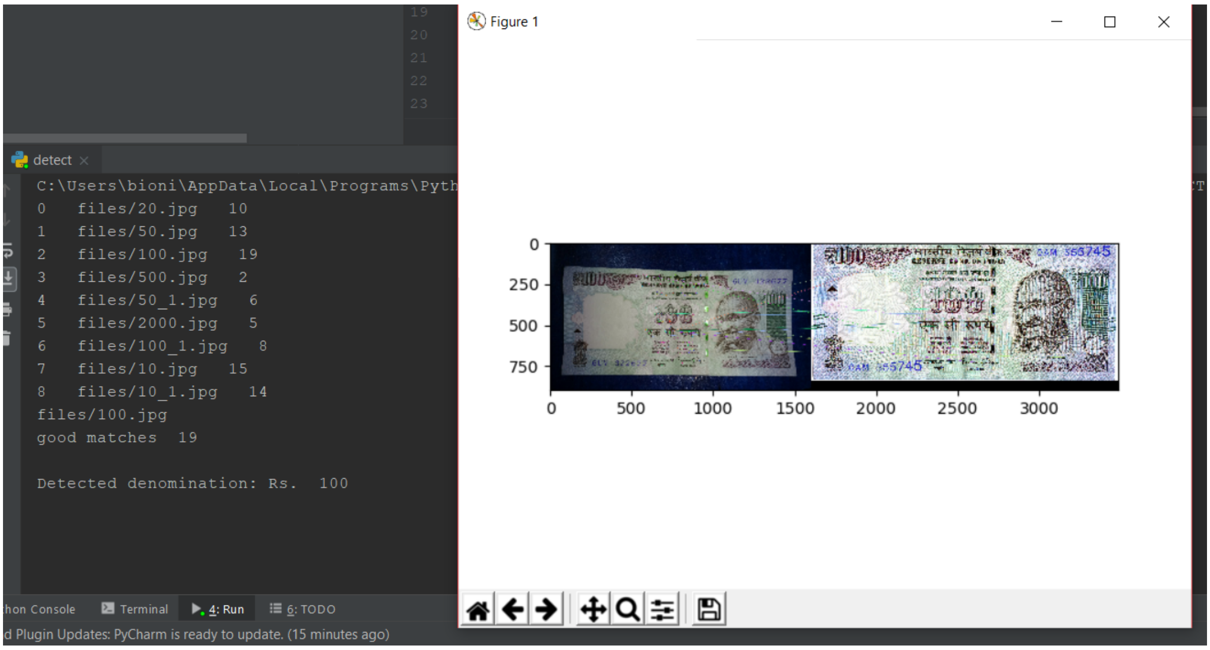
```
import cv2
import math
import numpy as np
import matplotlib.pyplot as plt
from pprint import pprint


# read image as is
def read_img(file_name):
	img = cv2.imread(file_name)
	return img


# resize image with fixed aspect ratio
def resize_img(image, scale):
	res = cv2.resize(image, None, fx=scale, fy=scale, interpolation = cv2.INTER_AREA)
	return res


# convert image to grayscale
def img_to_gray(image):
	img_gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)
	return img_gray


# gaussian blurred grayscale
def img_to_gaussian_gray(image):
	img_gray = cv2.GaussianBlur(img_to_gray(image), (5, 5), 0)
	return img_gray


# convert image to negative
def img_to_neg(image):
	img_neg = 255 - image
	return img_neg


# binarize (threshold)
# retval not used currently
def binary_thresh(image, threshold):
	retval, img_thresh = cv2.threshold(image, threshold, 255, cv2.THRESH_BINARY)
	return img_thresh


def adaptive_thresh(image):
	img_thresh = cv2.adaptiveThreshold(image, 255, cv2.ADAPTIVE_THRESH_GAUSSIAN_C,
cv2.THRESH_BINARY, 11, 8)
	# cv2.adaptiveThreshold(src, maxValue, adaptiveMethod, thresholdType, blockSize,
```

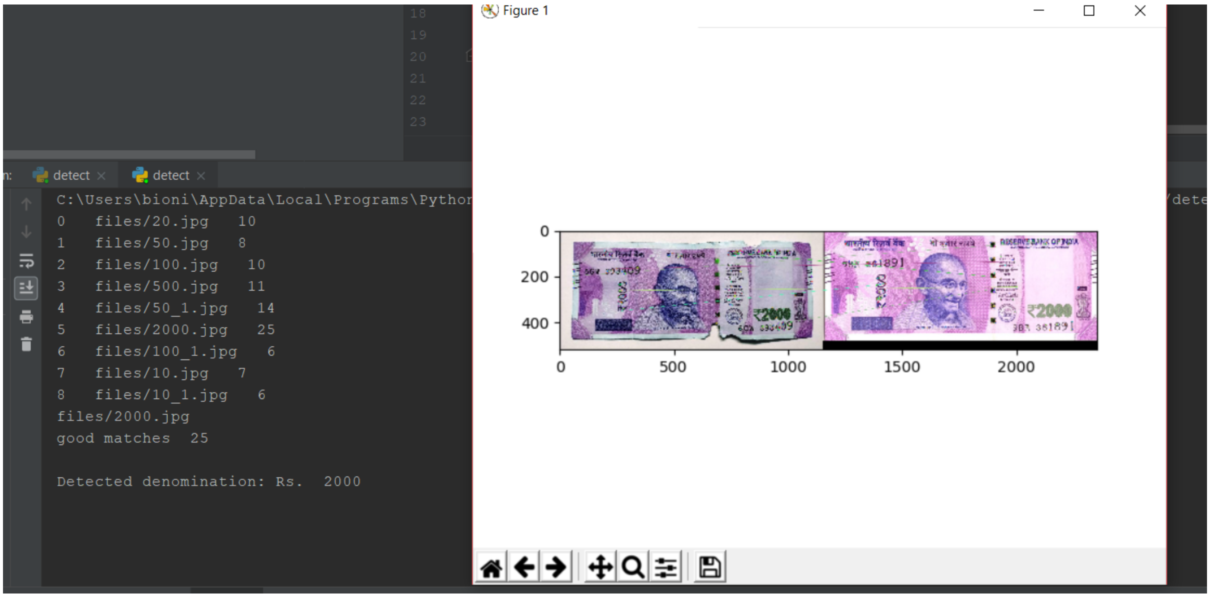
```
C[, dst]) → dsta
        return img_thresh


# sobel edge operator
def sobel_edge(image, align):
        img_horiz = cv2.Sobel(image, cv2.CV_8U, 0, 1)
        img_vert = cv2.Sobel(image, cv2.CV_8U, 1, 0)
        if align == 'h':
                return img_horiz
        elif align == 'v':
                return img_vert
        else:
                print('use h or v')


# sobel edge x + y
def sobel_edge2(image):
        # ksize = size of extended sobel kernel
        grad_x = cv2.Sobel(image, cv2.CV_16S, 1, 0, ksize=3, borderType =
cv2.BORDER_DEFAULT)
        grad_y = cv2.Sobel(image, cv2.CV_16S, 0, 1, ksize=3, borderType =
cv2.BORDER_DEFAULT)

        abs_grad_x = cv2.convertScaleAbs(grad_x)
        abs_grad_y = cv2.convertScaleAbs(grad_y)

        dst = cv2.addWeighted(abs_grad_x, 0.5, abs_grad_y, 0.5, 0)
        return dst


# canny edge operator
def canny_edge(image, block_size, ksize):
        # block_size => Neighborhood size
        # ksize => Aperture parameter for the Sobel operator

        # 350, 350 => for smaller 500
        # 720, 350 => Devnagari 500, Reserve bank of India

        img = cv2.Canny(image, block_size, ksize)
        # dilate to fill up the numbers
        #img = cv2.dilate(img, None)
        return img


# laplacian edge
def laplacian_edge(image):
        # good for text
        img = cv2.Laplacian(image, cv2.CV_8U)
        return img


# detect countours
def find_contours(image):
        (_, contours, _) = cv2.findContours(image, cv2.RETR_LIST,
cv2.CHAIN_APPROX_SIMPLE)
        contours = sorted(contours, key = cv2.contourArea, reverse = True)[:5]
        return contours


# median blur
def median_blur(image):
        blurred_img = cv2.medianBlur(image, 3)
        return blurred_img


# dialte image to close lines
```

```
def dilate_img(image):
        img = cv2.dilate(image, np.ones((5,5), np.uint8))
        return img


# erode image
def close(image):
        img = cv2.Canny(image, 75, 300)
        img = cv2.dilate(img, None)
        img = cv2.erode(img, None)
        return img


def harris_edge(image):
        img_gray = np.float32(image)

        corners = cv2.goodFeaturesToTrack(img_gray, 4, 0.03, 200, None, None,
2,useHarrisDetector=True, k=0.04)
        corners = np.int0(corners)

        for corner in corners:
                x, y = corner.ravel()
                cv2.circle(image, (x, y), 3, 255, -1)
        return image


# calculate histogram
def histogram(image):
        hist = cv2.calcHist([image], [0], None, [256], [0, 256])
        # cv2.calcHist(images, channels, mask, histSize, ranges[, hist[, accumulate]])
        plt.plot(hist)
        plt.show()


# fast fourier transform
def fourier(image):
        f = np.fft.fft2(image)
        fshift = np.fft.fftshift(f)
        magnitude_spectrum = 20 * np.log(np.abs(fshift))

        plt.subplot(121), plt.imshow(image, cmap='gray')
        plt.title('Input Image'), plt.xticks([]), plt.yticks([])

        plt.subplot(122), plt.imshow(magnitude_spectrum, cmap='gray')
        plt.title('FFT'), plt.xticks([]), plt.yticks([])

        plt.show()


# calculate scale and fit into display
def display(window_name, image):
        screen_res = 1440, 900      # MacBook Air

        scale_width = screen_res[0] / image.shape[1]
        scale_height = screen_res[1] / image.shape[0]
        scale = min(scale_width, scale_height)
        window_width = int(image.shape[1] * scale)
        window_height = int(image.shape[0] * scale)

        # reescale the resolution of the window
        cv2.namedWindow(window_name, cv2.WINDOW_NORMAL)
        cv2.resizeWindow(window_name, window_width, window_height)

        # display image
        cv2.imshow(window_name, image)

        # wait for any key to quit the program
```

```
cv2.waitKey(0)
cv2.destroyAllWindows()
```

SCREENSHOTS:





RESULTS:
A test data set consisting of 300 images of Indian banknotes (50 images of each denomination),including new and wrinkled notes was created for the evaluation of the proposed algorithms for the detection of currency-note features. The proposed methods for recognition of currency denomination through identification mark detection and colour matching techniques were evaluated over the data set of 300 images of Indian Currency Notes. For both the features, the system recognized the currency denomination with 100% accuracy.

CONCLUSION:
An innovative model for currency recognition system using digital image processing has been discussed to improve efficiency by producing more accurate results and increase success rates. The proposed technique has been evaluated over various denominations and physical conditions including new notes, wrinkled notes and non-uniform illumination. Various image processing methodologies have been adopted to design and build an efficient recognition system. By using digital image processing, analysis of paper currency is more efficient on the basis of cost and time consuming other than existing system.

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