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Recognition of Counterfeit Currency Using OpenCV and Python

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***Abstract*: The Currency Recognition System was developed for the purpose of fraud detection in paper currency, so this system is used worldwide. The uses of this framework can be recognized in banking frameworks, cash observing gadgets, cash trade frameworks, and so forth. This framework is significant in the advanced universe of today and should be available easily in hand. This paper proposes an automatic paper currency recognition system through an application developed. The algorithm implemented is simple, robust and efficient. The methodology comprises of various segments including picture preparing, characteristic extraction and contrasting test pictures and the prepared ones. The result produced consists of the denomination of the currency, whether it is actual or forged note and translation of the currency to other countries' currency. The aim is also to develop a mobile app using the flutter plugin. Flutter is a cross-platform for creating both Android and iOS-based applications. The mobile app created here is well-designed and user-friendly. The proposed system's performance has been calculated providing challenging dataset with different constraints. The app is accurate, fast, reliable and low cost in comparison with currently available systems.**

***Keywords*: Characteristic extraction, Comparing images, Cross platform, Flutter plugin, Image processing.**

1. Introduction

A currency is a form of money, issued by the public authorities in a particular jurisdiction. It is a unit of account, a store of value and a medium of exchange. It is a monetary denomination, such as the dollar, euro or pound, that is accepted in payment within a given area or among a specific group of people. Extensive usage of this paper cash can lead to problems in this era of modernization. Counterfeit notes are one such example. To increase the circulation of notes, people tend to produce imitated paper currency which looks exactly like the original notes. To identify the difference between the original and look alike note is a challenge. When such forged notes get into the cycle of circulation, the economy of the country rapidly decreases. Also, these notes are used in terrorist activities. The terrorists use it to cripple the economy of a nation and create an economic terror. Although this fake currency is being printed with precision, there is a chance to detect them with some effort. The local racketeers use photographic methods, hand engraved blocks, lithographic process and color scanning process to manufacture the fake notes. In fake notes, the watermark is made by painting with the picture of Mahatma Gandhi. later oil or grease is applied to give translucent feel for the fake note. In original notes, the watermark is made using water coated metal stamp or dandy roll. In fake notes, the security thread is imitated by printing a line using grey ink, or by using aluminium thread while pasting two paper sheets but in case of real notes security thread is incorporated into the paper in the way as woven at the time of manufacture it consists of micro lettering or individual numbers. Forgers find it difficult to reproduce with the accuracy as the shape of individual numbers and alignment of figures is difficult to imitate. This can be taken as a lead to identify the lookalike notes. This brings motivation to design a system that can detect such counterfeit notes. Currency Recognition System is a technique that aims at identifying the forged notes easily and efficiently. When brought in the form of a mobile application that can be simply downloaded, with one touch the common people can detect the invalid currency. A combination of image processing techniques and OpenCV along with python programming language has been used to develop the system. A mobile application is developed using the flutter platform, so that the app is compatible for both android and iOS devices. This app, when passed to all the people of a country, will quickly eradicate the fake notes and aid to the growth of a nation by decreasing the movement of the counterfeit notes and increasing the economy of the country.

In the following section, we provide a detail description about recognizing the original and fake notes. In section II we describe the research work performed for building the current system. In Section III we describe in detail the problem, Design and Architecture of the system. In Part IV, we describe algorithms and methods for detecting the denomination of the note. In Section V the experimental analysis and results obtained by the system is discussed, In Section VI the conclusion along with the future work for the system is provided.

2. Related Works

The progressions in the field of PCs, printers and scanners have made copying cash note exceptionally basic subsequently the tremendous store of phony monetary forms have been accounted for in everyday news. Kamesh Santhanam, Sairam Sekaran, Sriram Vaikundam and Anbu Mani Kumarasamy [1]

proposed a framework where they included two types of system to distinguish counterfeit currency. First type using Ultra Violet (UV) recognition through lab see, second type using the light polarization after passing through currency. Only if both the results are positive the output is resulted as positive. This technique has far more superior approach than previous methods existed in reliability, automation and accuracy. This technique is used for document verifications. Polarization method constitutes for physical property of the currency note making it more reliable method than magnetic ink detectors and UV detectors which uses the chemical properties of note. Hence, it can be claimed as innovative approach of currency detection. Kedar Sawant, Chaitali More [2] proposed a system where the software interface has been used for recognition. Digital Image processing the widely used technique is followed to identify counterfeit Indian currency. The Indian currency is classified based on a unique features set like, dimension, latent image dominant color and Identification Mark. This is used to recoginize the currency by extracting and performing segmentation. Using image processing techniques this process becomes more software oriented rather than machines. This system will help visually impaired people finding difficulty in distinguishing different currency denominations and recognize counterfeit currency. The system focuses more on security features present in Currency notes and using those the Indian Currency is verified and validated. Experimental results show that the accuracy of the system proposed is close to 90%. Ankush Roy, Utpal Garain, Biswajit Halder, and David S Doermann [3] proposed a framework which uses Image preparing and design acknowledgment methods for identifying counterfeit monetary forms. Genuine examples are utilized in the analysis which mirrors the capacity to build up a high-exactness machine for verification of paper currency. Thorough assessment of the technique utilizing genuine examples bolsters the capability of the methodology. The multifaceted nature of the general framework is kept negligible to get minimal effort equipment acknowledgment of the proposed strategy is achievable as ease framework is sought after the huge scope organization of such a framework gets conceivable. It has gotten hard to recognize expertly conveyed counterfeit banknotes causing the need to execute logically propelled features in banknotes. Sangwook Baeka, Euison Choib, Yoonkil Baekb, Chulhee Lee [4] proposed a technique which consolidates powerful phony banknote disclosure figuring's. The algorithm proposed were tested utilizing 20 distinct categories of Indian rupee (INR), European Euro (EUR), and US Dollars (USD). At the point when neural systems were utilized, the trial results demonstrated 100% characterization exactness for fake banknotes, and 99.9% order precision for certifiable banknotes. At the point when the probability test strategy was utilized, 99.8% grouping exactness for certified banknotes and 100% order precision for fake banknotes was gotten. Ch. Rupa, T. Sumanth [5] proposed the methodology for perceiving the personality of the monetary standards with decline in the preparing time of confirmation by design acknowledgment strategies is utilized which enhances the exactness of phony note identification. Preprocessing, shading identification, division, edge location and layout coordinating procedures are utilized as acknowledgment stages. The application advises that whether the cash is unique or phony to the end client. Indian cash dataset is utilized for testing the proposed framework. The primary qualities of the model are execution examination which is performed by approaches like quantitative strategy histogram and quality measurements correlation alongside experiment study reports. Various calculations are utilized for perceiving the money utilizing picture handling. The algorithm utilizes the essential shading and a piece of money for acknowledgment. The means included are picture preprocessing utilizing commotion location, shading change, division, edge discovery, and example coordinating. Y. Neeraja, B. Divija and M. Nithish kumar [6] proposed a methodology where the ID of cash relies on various advances, including edge location, highlight extraction, picture division, picture obtaining, dim scale change, and correlation of pictures. By apply some productive pre-preparing and highlight extraction procedures, we can in any case improve the exactness of money recognizable proof framework. The methodology gives a proficient strategy for counterfeit money identification dependent on physical appearance of notes. The work will be valuable for decreasing the fake money. The missing boundaries which are missing in the phony notes are distinguished. Unique Currency is recognized utilizing Image Processing Technique.

3. Problem Definition and System Architecture

The paper monetary standards are the focal point of focus to forgers. Fake discovery can be executed utilizing the Physical or Chemical properties of monetary paper forms. The inaccessibility, significant expense and absence of user-friendliness makes trouble end clients. Consequently, highlight based fake discovery framework is currently the focal point of dynamic exploration.

A. System architecture

As shown in the below figure 1, the work flow starts with an input image, this image can be either a train image or a test image. In first step the input images are taken from the dataset, then images are pre-processed to strike out the disastrous data in the images. Once the pre-processing is completed the preprocessed image that can be either an inculcate (train) image or an examine (test) image. Inculcate (train) image is used for inculcating(training) or while modelling the dataset and the examiner (test) image is the input given by the user to test the accurateness of the model. Train image is used for training or while modelling the dataset and the test image is the input image given by the user to detect the type of note. The input image is passed through a number of steps. Figure 1 describes the detailed steps under this process. The output states whether

the note is counterfeit or valid. If the note is valid, then a output is displayed which says that the note is real and also gives the value of the currency. Along with that, the equivalent value of Indian Rupee in other country's currency will be produced.

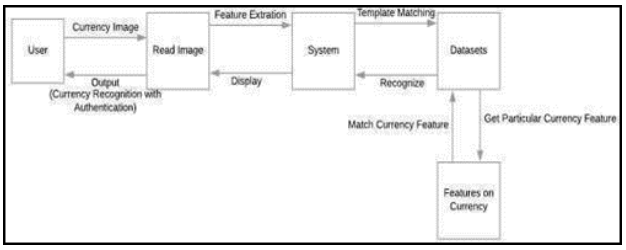


Fig. 1. Workflow of Currency Detector

The image acquisition stage is the first stage of the system Where the image is captured or obtained this image is later used for processing. Image is captured using a camera of mobile or through gallery. The selected image will be displayed on the screen after resizing and rotating image. Image processing is the next stage where the image is made suitable for the testing purpose with the trained set. In include extraction stage we remove the diverse key focuses and descriptors of picture utilizing OpenCV ORB. In next stage layout coordinating is performed for test picture with the prepared set utilizing KNN calculation and Brut Force matcher. In the end the result obtained will conclude if the given test image of note was fake or real and if real it performs real time conversions and provides it in result.

4. System Developed

A. Preprocessing

In PC vision, a picture content is deciphered as a lot of key points(features). The picture can be gained and spoken to with genuine information caught by the camera or the arrangement of certain models. In this way, recognition of picture intrigue focuses is utilized to find and recognize protests in multi-media records. Algorithms for feature detection must be efficient. They should have the option to acquire results in close to continuous prerequisite and repeatable guaranteeing that a similar element will be recognized in various pictures Algorithms with binary bitstring descriptors, BRISK and ORB, use Hamming separation calculations with quick execution. Then again, SIFT and SURF utilize Euclidean separation among descriptors and they are generally strong and require progressively computational time. Since ORB is quick and open source, we will utilize this calculation for the discovery of highlights on the cash note.

- ORB (Oriented FAST and Rotated BRIEF) Oriented FAST and Rotated BRIEF, developed at OpenCV labs is a well-planned alternative to SIFT and Surf. It executes as good as SIFT in the task of feature detection and is almost twice as fast as the older one. ORB is a combination of FAST key point detector and the BRIEF descriptor. The efficiency of these two techniques is exceptional while being inexpensive. Orientation component and multiscale features are not present in the features from Accelerated Segment Test algorithm. This leads to the utilization of multiscale image pyramid. This pyramid consists of multiple profiles of same image captured at different resolutions and orientation.

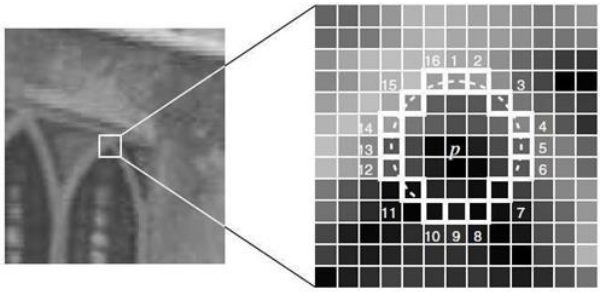


Fig. 2. Fast key point

On building the pyramid, orb applies fast algorithm to identify key points in the image. At each and every level, the key points.

Are detected thus concluding that ORB is a partial scale invariant for each key point, orientation such as right or left is assigned depending on the intensity level around it. Thus orientation patch is calculated and rotation is applied to compute the exact descriptor. Then the Binary robust Independent Elementary Feature algorithm converts all the keypoints to binary vector, thereby representing an object. This simply means that each keypoint is stored in the form of 0 and 1 in a vector (128-512 bit long). The image is then smoothened to prevent the exposure of descriptors to high frequency noise. At this point some pixel force correlations are done on these area sets. To put it plainly, BRIEF is a quicker technique highlight descriptor figuring and matching. It likewise gives a high acknowledgement rate except if there is a huge in-plane rotation.

- *Brute Force Algorithm*

FAST estimation of closest neighbors is a working district of exploration in AI. The closest neighbor search execution incorporates the savage power estimation of detachments between all arrangements of centers in the dataset. BruteForce matcher is a clear estimation. For BF matcher, first we have to make the BFMatcher object using cv2.BFMatcher(). It takes two optional params. Beginning one is normType. It decides the partition estimation to be used. For twofold string-based descriptors like ORB etc, VTA_K = 3 or 4, cv2.NORM_HAMMING2 is supposed to be used if those are ORB regards. Second param is Boolean variable, cross Check which is fake as usual. If it is substantial, Matcher returns only those matches with regard (i,j) to such a degree, that I-th descriptor in set A has j-th descriptor in set B as the best match and the reverse way around. That is, the two features in the two sets should facilitate each other. It gives solid result, and is a better than average choice rather than extent test proposed by

D. Lowe in SIFT paper. At the point when it is made the two huge procedures are BFMatcher.match() and BFMatcher.knnMatch(). Beginning one returns the best match. Second procedure returns k best matches where k is controlled by the customer. It may be important when we need to achieve additional work on that.

- *Euclidean distance*

The distance between two separate positions forming part of Euclidean space is alluded to generally as Euclidean partition centers p and q is the length of the line area interfacing them. In Cartesian ways, if p = (p1, p2,..., pn) and q = (q1, q2,..., qn) are two concentrations in Euclidean n-space, by then the detachment (d) from p to q, or from q to p is given by the Pythagorean formula.

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1-p_1)^2+(q_2-p_2)^2+\cdots+(q_n-p_n)^2}$$
$$= \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}.$$

Utilizing this recipe that we will check the separation between one point and the other point in your dataset, individually in all your dataset, the littler the aftereffect of this computation is the most comparative between this two information. We will run this count commonly, until all the information has been navigated. The outcome will be a variety of your unclassified information to another information previously characterized.

- *Brute-Force Classification*

Fig. 3. KNN matches

The descriptor of one component in first set is coordinated with every other element in second set utilizing a separation computation and the nearest one is returned as the most coordinated one. For any two pictures it ascertains the Euclidean separation utilizing the descriptors and returns the point with least separation. BFMatcher.match() and BFMatcher.knnMatch() are the significant techniques. Initial one returns the best matchSecond method returns k best matches where k is controlled by the client. Like we used cv2.drawKeypoints() to draw keypoints, cv2.drawMatches() makes us draw the matches. It stacks two pictures equitably and draw lines from first picture to second picture demonstrating best matches. There is additionally cv2.drawMatchesKnn which draws all the k best matches. In the event that k=2, it will draw two match-lines for each keypoint. in this way, we need to pass a veil in the event that we need to specifically draw it. The figure underneath shows the matches drawn from picture in originally set to the picture in second set.

Along these lines, by utilizing this procedure, we can draw matches and see whether a given cash note is fake or original. The Circle calculation has solid ongoing execution and has an incredible improvement in registering speed. The exactness of picture coordinating is generally high utilizing this strategy.

- *Nearest Neighbours Classification*

Fundamental characterization calculations part of AI is referred as Closest neighbors. It has a spot with the coordinated learning region and discovers extraordinary application in structure affirmation, data mining and interference area. It is comprehensively nonessential, in fact, circumstances since it is non-parametric, which implies, it doesn't make any fundamental doubts about the scattering of data. It very well may be utilized to take care of both arrangement and relapse issues. Be that as it may, it is all the more generally utilized in characterization issues in the business. The KNN calculation expect that comparable things exist in closeness. At the end of the day, comparable things are close to one another. The data includes the k closest getting ready models in the segment space. The yield depends upon whether k-NN is used for gathering or backslide. In k-NN gathering, the yield is a class enrolment. A thing is requested by a larger part vote of its neighbors, with the article being given out to the class commonly normal among its k nearest neighbors (k is a positive whole number, normally little). In the event that k = 1, at that point the item is essentially doled out to the class of that solitary closest neighbour.KNN is a kind of model-based learning, or sluggish acknowledging, where the limit is simply approximated locally and all figuring is surrendered until work evaluation. Notice in the image underneath that as a rule, practically identical data centers are almost each other. The KNN computation relies upon this assumption that being veritable enough for the figuring to be useful. KNN gets the chance of similarity, to a great extent called detachment, proximity, or closeness, with some math like discovering the partition between centers around an outline. There are various techniques for finding out partition, and one way might be best dependent upon the troublesome we are clarifying. Regardless, the straight-line partition, in like manner called the Euclidean division is a well-known and normal choice.

5. Experimental Results

A. *Experiment requirements*

Software Requirements are Opencv, Android Studio, Windows 10 Home Single Language/MAC OS/Linux, python 3, Flutter Flask. Hardware Requirements are Processor Minimum 1 GHz and Recommended 2GHz or more, Hard ware Requirements are Hard Drive Minimum 32 GB and Recommended 64 GB or more, Memory (RAM) Minimum 1

GB and Recommended 4 GB or above. A camera of 13px or above. Plugins required for front end of the application are http, image picker, image cropper, Scaffold, Base64 String.

B. Stages in results

The dataset of training images given in the system for matching.

Fig. 4. Sample Training datasets

Loading the dataset: The orbDetectandCompute() function is used to train the dataset. The equation below shows how the dataset is loaded and the images are trained. The parameters kp and des refer to the key-points and descriptors. The function detectAndCompute takes the image as input, detects the key-points and computes the descriptors.

(keypoints,descriptors)=orb.detectAndCompute(image)

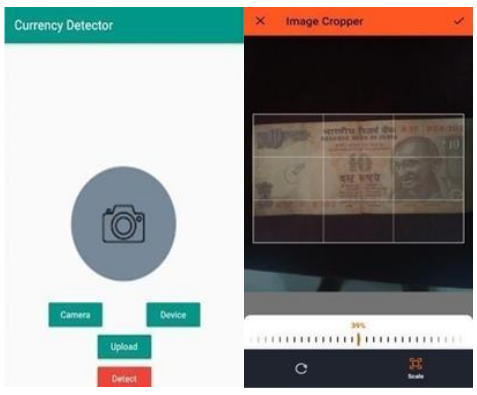
Keypoints: The points where the intensities vary in an image like region of interest.

Descriptor: finite vector which summarizes properties for the keypoint.

Image: Either a test or a train image.

Here the image can be a test or the trained image, keypoints and descriptors helps to obtain the feature of images performing training.

Flutter App Input: The Application UI of the system had three screens containing options to capture image, obtain from gallery upload and delete options.



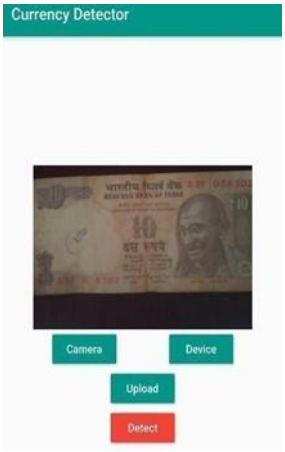


Fig. 6. Screens of application (Initial, Image cropper, Image display)

The submitted image will be sent to the flask server where the Image will be tested with the loaded trained images in later stages.

Evaluation of the image: If the note is not valid it will return a message which says the note if fake. If it's is not, then the denomination of the currency and its equivalent denomination in other currencies will be displayed. The below figure shows how the image will be detected for fake or real currency.

Matches=bf.knnMatch(descriptor1, descriptor2,k=2) Here,

descriptor1: Descriptor of test image descriptor2: Descriptor of trained image k: number of neighbors

KnnMatch() function gets the descriptors from both trained and test images and performs the matching operation using brute force approach.

Flutter app final output: The output from server will be sent back to the UI of the app.

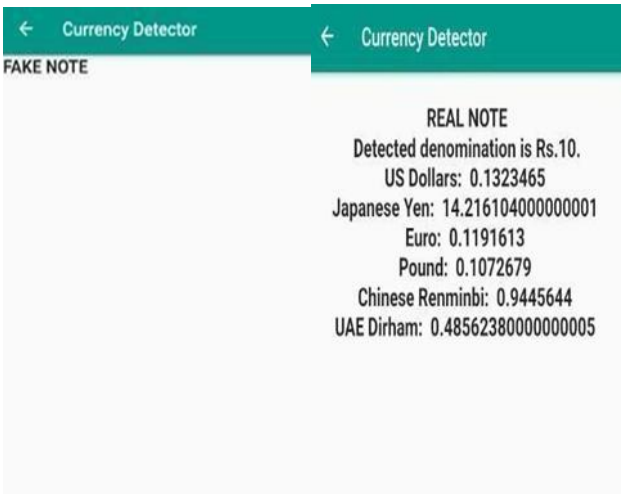


Fig. 8. The respective output for fake and real note

Algorithm:

Step-1: Obtain the image from user and perform preprocessing Operation.

Step-2: Train the image using ORB model and obtain key points and descriptors.

Step-3: Perform matching operations for the descriptors obtained from testing and trained images using KNN matcher

Step-4: Perform Euclidian distance operation to find the minimum distance and identify good matches.

Step-5: Considering the number of good matches obtained return the result as fake or real note. If real note returns the denomination along with the real time conversions.

6. Conclusion and Future Scope

In this currency recognition system, the validation of Indian paper currency is outlined by applying opencv techniques

In python language. The ORB model, brute force matcher and KNN matching techniques used resulted in an efficient approach for currency detection. The judgement is obtained in a jiffy. The App designed is a low-cost system. It is a very efficient and useful for everyone. A perfect cropping of the image and uploading is done neatly. The App can extract features even when there is variation is size between the test images and the input images provided by the user. The App also is successful in detecting the denominations of paper currency accurately. This also does real time conversions of Indian currency to other country currencies such as Dollar, Euro, Yen, Renminbi, Dirham etc. The mobile application designed is economical, efficient, and handy. As future work the coins can be given in the dataset and make the complete system work for coins and notes. To improve more we can create masks to extract only the certain parts/features/ segments to give importance to such as the part that says what denomination this is and certain watermarks to find correct match. We can make this system available for every citizen of the country. We can implement the system to recognize other country's currency notes as well.

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