



Fake Indian paper Currency Note Recognition System Using Image Processing

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Abstract:

Fake cash is impersonation money delivered without the legitimate approval of the state or government. Delivering or utilizing this fake cash is a type of extortion or fraud. Copy notes are one of the most concerning issues happening in cash exchanges. Distinguishing fake notes physically gets to be tedious and chaotic process thus there is need of computerization methods with which cash acknowledgment procedure can be effectively done. Numerous systems have been proposed with the utilization of MATLAB, highlight extraction and different uses of picture handling. Two qualities of Indian paper money are chosen for fake discovery included recognizable proof imprint and coin serial number. The attributes extraction is performed on the picture of the coin and it is contrasted and the qualities of the certified money. The money will be checked by utilizing picture preparing methods. The procedure of shrewd edge discovery calculation is utilized for edge recognition. The methodology comprises of picture handling, dim scale change, edge recognition, picture division, trademark extraction, looking at pictures.

Keywords: Fake currency; Canny Operator; Digital image processing; imitation detection.

1. Introduction

Fake cash is impersonation money created without the legitimate assent of the state or government. Creating or utilizing Fake coin is a type of misrepresentation or fabrication. Duplicating is very nearly as old as cash itself. Prior to the presentation of paper cash, the most common strategy for falsifying included blending base metals with immaculate gold or silver. A type of

duplicating is the generation of records by real printers in light of fake directions.

Imitation notes are one of the most concerning issues happening in coin exchanges. It is turning out to be huge impediment. Due to the advances in printing, examining advances it is effectively workable for a man to print fake notes with utilization of most recent equipment apparatuses. Mechanized paper cash acknowledgment framework can be a decent utility in keeping money frameworks and other field moreover. In India for the most part fake notes of Rs.100, 500 and 1000 are being submerged into the framework. Because of the mechanical advances in shading printing, copying, and checking, creating issues have turned out to be more genuine. A portion of the impacts that fashioned cash has on society incorporate a drop in the estimation of genuine cash and swelling because of more cash getting coursed in the general public or economy which thus decreases our economy and development.

There are numerous kind of monetary forms on the planet, with each of them looking changed with their elements i.e. vary in the measure of the banknotes, shading, surface and so on the general population who work in the cash trade need to separates all the sort of monetary standards. They need to keep every one of the elements of the every one of the banknotes that may bring about a few issues, so they require an effective and careful framework to help their work. As said early, the point of framework is to help the general population who need to perceive distinctive monetary forms and

with persuades and productivity. There are machines assists the general population with recognizing various types of monetary standards. Be that as it may, for most working staff in cash trade need to keep a variety of qualities and hostile to fakes mark for distinctive generally utilized monetary standards as a part of their psyche. Nonetheless, everybody has a handbook that about the qualities and hostile to fakes marks of come generally utilized monetary forms. Nobody can ever be 100 percent certain about the manual acknowledgment.

Our framework depends on picture preparing which incorporate numerous systems to perceive the coin. So as to make framework complete, we have to keep up a database for putting away the attributes of the coinage. In this framework, we take Indian coin as case. The framework will be customized in light of MATLAB which is easy to understand interface.

Effect on society:-

Some of the ill-effects that imitation money has on society are

1. Drop in the estimation of genuine cash
2. Increase in costs (expansion) because of more cash getting coursed in the economy - an unlawful manufactured increment in the cash supply
3. Decrease in the agreeability of cash - payees may request electronic exchanges of genuine cash or installment in money and installment in a valuable metal, for example, gold
4. Companies are not discounted for impersonations. This drives them to expand costs of supplies.

In the meantime, in nations where paper cash is a little portion of the aggregate cash available for use, the macroeconomic impacts of mirroring of money may not be huge. The microeconomic impacts, for example, trust in cash, in any case, may be substantial.

2. COMMONLY USED METHODS TO DETECT FAKE NOTES

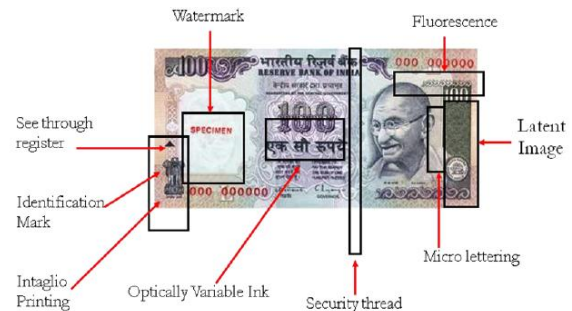


Figure: 1 Security features of Indian currency notes[1][2]

2.1. See through Register

The little botanical configuration printed both on the front (empty) and back (topped off) of the note in the middle of the vertical band alongside the Watermark has an exact consecutive enrollment. The configuration will show up as one flower outline when seen against the light.[3]

2.2. Water marking

The Mahatma Gandhi Series of banknotes contain the Mahatma Gandhi watermark with a light and shade impact and multi-directional lines in the watermark window. [3]

2.3. Fluorescence

Number boards of the notes are imprinted in fluorescent ink. The notes additionally have optical strands. Both can be seen when the notes are presented to ultra-violet light. [3]

2.4. Security Thread

Rs.1000 notes presented in October 2000 contain an intelligible, windowed security string then again noticeable on the front-side with the engravings "Bharat" (in Hindi), "1000" and 'RBI', however perfectly installed on the reversal. The Rs.500 and Rs.100 notes have a security string with related obvious components and engraving "Bharat" (in Hindi), and 'RBI'. At the point when held against the light, the security string on Rs.1000, Rs.500 and Rs.100 can be optically observed as one unending line. The Rs.5, Rs.10, Rs.20 and Rs.50 notes contain a clear, completely installed windowed security string with the engraving "Bharat" (in Hindi), and 'RBI'. The security

string appears to one side of the Mahatma's representation. Notes issued proceeding the prelude of the Mahatma Gandhi Series has a plain, non-comprehensible completely implanted security string. [3]

2.5. Intaglio Printing

The picture of Mahatma Gandhi, the Reserve Bank seal, ensure and guarantee statement, Ashoka Pillar Emblem on the left, RBI Governor's mark are imprinted in intaglio i.e. in raised prints, which can be felt by touch, in Rs.20, Rs.50, Rs.100, Rs.500 and Rs.1000 notes. [3]

2.6. Latent image

On the front side of Rs.1000, Rs.500, Rs.100, Rs.50 and Rs.20 takes note of, a vertical band on the right half of the Mahatma Gandhi's picture contains an idle picture displaying the particular denominational worth in numeral. The latent image is visible only when the note is held horizontally at ocular perceiver level. [3]

2.7. Micro lettering

This component shows up between the vertical band and Mahatma Gandhi picture. It contains "RBI" in Rs.5 and Rs.10. The notes of Rs.20 or more additionally contain the denominational estimation of the notes in micro letters. This element can be seen well under an amplifying glass. [3]

2.8. Identification Mark

An uncommon element in intaglio has been presented on the left of the watermark window on all notes with the exception of Rs.10/- note. This component is in distinctive shapes for different sections (Rs. 20-Vertical Rectangle, Rs.50-Square, Rs.100-Triangle, Rs.500-Circle, and Rs.1000-Diamond) and encourages the outwardly weakened to recognize the category. [3]

2.9. Optically Variable Ink

This is another security highlight consolidated in the Rs.1000 and Rs.500 notes with reexamined shading plan presented in November 2000. The numeral 1000 and 500 on the front of Rs.1000 and Rs.500 notes separately is imprinted in optically variable ink viz., a shading moving ink. The shade of the numeral 1000/500 seems green when the note is held level

however would change to blue when the note is held at an edge. [3]

3. SYSTEM ARCHITECTURE

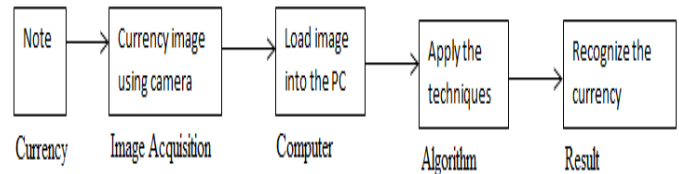


Figure: 2 Architecture of this system

4. Digital Image Processing Method to Detect Fake Currency

The outline stream of fake money location framework incorporates eight stages: Image obtaining, pre-handling, dark scale change, edge recognition, and picture division, highlight extraction, examination and yield [9]. This system is works on two images, one is test currency image on which authentication is too performed and other is the original currency image.

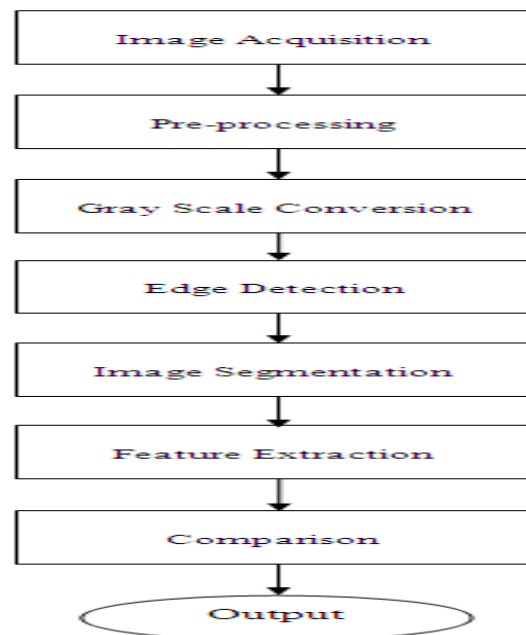


Figure: 3 Flow Chart of Digital Image Processing Method to Detect Fake Notes.

4.1. Image Acquisition

There are different approaches to gain picture, for example, with the help of camera or scanner. Procured picture ought to hold every one of the elements [9].

The primary phase of any vision framework is the picture securing stage. Different techniques for preparing can be connected to the picture to perform the wide range of vision assignments, after the picture has been gotten. In picture handling performing picture obtaining is dependably the initial step on the grounds that, without a picture, preparing is unimaginable. There are a few approaches to gain picture, for example, with the help of camera or scanner. Procured picture ought to save every one of the components.

4.2. Pre-Processing

Pre-handling of picture are those operations that are ordinarily required preceding the fundamental information investigation and extraction of data. The point of picture pre-handling is to stifle undesired contortions or improve some picture includes that are vital for further preparing or examination [9].

Picture preprocessing, likewise called picture rebuilding. Picture rebuilding includes the amendment of adjustment, corruption, and clamor presented amid the imaging procedure. Picture pre-handling can expand the dependability of an optical survey. With the assistance of picture interjection picture conforming is finished. Introduction is the system utilized for errands, for example, zooming, turning, contracting, and for geometric remedies. At the point when picture preparing is being performed, evacuating clamor is an imperative step. Commotion may influence division and example coordinating. The neighbor of the pixel is utilized to do some change, when smoothing procedure is performed on a pixel. After that another estimation of the pixel is made.

4.3. Gray-scale conversion

The picture gained is in RGB shading. It is changed over into dark scale in light of the fact that it conveys just the force data which is anything but difficult to prepare as opposed to handling three segments R (Red), G (Green), B (Blue) [8].

4.4. Edge detection

Edge discovery is a central instrument in picture handling and PC vision, especially in the zones of highlight recognition and highlight extraction, which go for recognizing focuses in an advanced picture at which the picture shine changes pointedly or, all the more

formally, has discontinuities. Edge location is one of the basic strides in picture preparing; picture examination, picture design acknowledgment, and PC vision strategies [6].

The edge identification calculations can be for the most part ordered taking into account the behavioral investigation of edges regarding the administrators. Diverse edge-recognition methodologies can be comprehensively characterized under Classical or Gradient based edge indicators (first subsidiary), Zero intersection (second subordinate) and ideal edge-locator. [7]

TABLE I
EDGE-DETECTION APPROACHES

METHODS	APPROACHES
First order derivative / Gradient methods	Roberts Operator Sobel Operator Prewitt Operator
Second order derivative / Zero crossing	Laplacian of Gaussian Difference of Gaussian
Optimal Edge Detection	Canny Edge Detector

Here presents the relative execution of different edge identification systems, for example, Roberts edge identifier, Sobel Edge Detector, Prewitt edge indicator, Kirsch, Robinson, Marr-Hildreth edge finder, LoG edge locator and Canny Edge Detector. [7]

The edge discovery methods were executed utilizing MATLAB R2009a, and tried with a picture (Bharathiar University). The goal is to deliver a perfect edge map by separating the central edge components of the picture. The first picture and the picture acquired by utilizing distinctive edge identification systems are given in figure. [7]



Figure: 4 Original Image with the result of various edge detection techniques.

Roberts, Sobel and Prewitt come about really veered off from the others. Marr-Hildreth, LoG and Canny deliver verging on same edge map. Kirsch and Robinson edge maps are verging on same. It is seen from the figure, Canny result is better by a long shot than alternate results. [7]

In a hypothetical investigation of edge based picture division systems which give knowledge into most broadly utilized edge discovery procedures of Gradient-based and Laplacian based Edge Detection. It portrayed Robert, Prewitt, Sobel, LoG, Canny location systems. Distinctive edge location systems can be actualized according to the need of division of picture. A versatile edge-location calculation is important to genius vide a powerful arrangement that is versatile to the differing clamor levels. The inclination based methodologies, for example, the Prewitt channel have a preminent drawback of being extremely delicate to clamor. Shrewd edge discovery calculation is less delicate to commotion yet is computationally more costly contrasted with Roberts, administrator Sobel, and Prewitt administrator. In any case, the Canny edge recognition methodology performs superior to every one of these administrators about under all situations.[5]

Process of Canny edge detection algorithm

The Process of Canny edge detection algorithm can be broken down to 5 different steps:

1. Apply Gaussian filter to smooth the image in order to remove the noise.
2. Find the intensity gradients of the image.
3. Apply non-maximum suppression to get rid of spurious response to edge detection.
4. Apply double threshold to determine potential edges.
5. Track edge by hysteresis: Finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

Each stride will be portrayed in points of interest as taking after. The presentation of methodology underneath is produced taking into account Prof Thomas Moeslund's address note for computerized picture handling in Indian Institute of Technology.[4]

1. Gaussian Filter

Since all edge detection results are easily affected by image noise, it is essential to filter out the noise to prevent false detection caused by noise. To smooth the image, a Gaussian filter is applied to convolve with the image. This step will slightly smooth the image to reduce the effects of obvious noise on the edge detector. The equation for a Gaussian filter kernel of size $(2k+1) \times (2k+1)$ is given by:

$$H_{ij} = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{(i-k-1)^2 + (j-k-1)^2}{2\sigma^2}\right)$$

Here is an example of a 5×5 Gaussian filter, used to create the image to the right, with $\sigma = 1.4$. (The asterisk denotes a convolution operation.)

$$B = \frac{1}{159} \begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} * A.$$

Understand that the determination of the span of the Gaussian bit will influence the execution of the indicator. The bigger the size is, the lower the identifier's affectability to clamor. Moreover, the confinement mistake to identify the edge will somewhat increment with the increment of the Gaussian channel part estimate. A 5×5 is a decent size for most cases, however this will likewise shift contingent upon particular circumstances. [10]



Figure: 5 The image after a 5×5 Gaussian mask has been passed across each pixel.

2. Finding the Intensity Gradient of the Image

An edge in a picture may point in an assortment of headings, so the Canny calculation utilizes four channels to recognize even, vertical and corner to corner edges in the obscured picture. The edge recognition administrator (Roberts, Prewitt, Sobel for instance) gives back a quality for the first subsidiary in the flat bearing (G_x) and the vertical course (G_y). From this the edge gradient and direction can be determined:

$$G = \sqrt{G_x^2 + G_y^2}$$

$$\Theta = \text{atan2}(G_y, G_x)$$

where G can be processed utilizing the hypot capacity and atan2 is the arctangent capacity with two contentions. The edge heading point is adjusted to one of four edges speaking to vertical, level and the two diagonals (0° , 45° , 90° and 135° for instance). An edge bearing falling in every shading district will be set to a particular point values, for instance alpha lying in yellow locale (0° to 22.5° and 157.5° to 180°) will beset to 0° . [10]

3. Non-maximum Suppression

Non-maximum suppression is an edge thinning technique.

Non-Maximum concealment is connected to "thin" the edge. Subsequent to applying angle count, the edge removed from the inclination worth is still entirely obscured. As for criteria 3, there ought to just be one precise reaction to the edge. Along these lines non-greatest concealment can smother all the inclination qualities to 0 aside from the nearby maximal, which demonstrates area with the most sharpest change of intensity value. The algorithm for each pixel in the gradient image is:

1. Look at the edge quality of the present pixel with the edge quality of the pixel in the positive and negative inclination headings.
2. On the off chance that the edge quality of the present pixel is the biggest contrasted with alternate pixels in the veil with the same bearing (i.e., the pixel that is indicating in the y heading, it will be looked at the pixel above and beneath it in the vertical hub), the worth will be safeguarded. Something else, the quality will be smothered.

In a few executions, the calculation classifies the persistent slope bearings into a little arrangement of discrete headings, and afterward moves a 3x3 channel over the yield of the past step (that is, the edge quality and angle headings). At each pixel, it stifles the edge quality of the inside pixel (by setting its worth to 0) if its size is not more noteworthy than the size of the two neighbors in the angle heading. For example,



- If the balanced incline edge is 90° (i.e. the edge is in the east–west course) the point will be thought to be on the edge if its slant degree is more unmistakable than the sizes at pixels in the north and south,

- In the event that the adjusted slope edge is 90° (i.e. the edge is in the east–west course) the point will be thought to be on the edge if its inclination extent is more prominent than the sizes at pixels in the north and south directions,

- In the event that the adjusted slope point is 135° (i.e. the edge is in the northeast–southwest heading) the point will be thought to be on the edge if its inclination size is more noteworthy than the sizes at pixels in the North West and south east directions,

- On the off chance that the adjusted inclination point is 45° (i.e. the edge is in the north west–south east course) the point will be thought to be on the edge if its inclination extent is more noteworthy than the sizes at pixels in the north east and south west directions.

In more precise usage, straight introduction is utilized between the two neighboring pixels that straddle the angle course. For instance, if the inclination point is somewhere around 45° and 90° , interjection between slopes at the north and north east pixels will give one inserted worth, and introduction between the south and south west pixels will give the other (utilizing the traditions of last section). The angle size at the focal pixel must be more noteworthy than both of these for it to be checked as an edge.

Note that the indication of the course is unessential, i.e. north–south is the same as south–north etc. [10]

4. Double Threshold

After use of non-most extreme concealment, the edge pixels are entirely exact to exhibit the genuine edge. Be that as it may, there are still some edge pixels as of right now created by clamor and shading variety. Keeping in mind the end goal to dispose of the spurious reactions from these irritating components, it is crucial to sift through the edge pixel with the feeble angle

esteem and save the edge with the high inclination esteem. Subsequently two edge qualities are set to elucidate the diverse sorts of edge pixels, one is called high edge esteem and the other is known as the low edge esteem. In the event that the edge pixel's angle worth is higher than the high edge esteem, they are checked as solid edge pixels. In the event that the edge pixel's slope quality is littler than the high limit esteem and bigger than the low edge esteem, they are checked as frail edge pixels. On the off chance that the pixel worth is littler than the low limit esteem, they will be stifled. The two limit qualities are observationally decided qualities, which should be characterized when applying to diverse pictures. [10]

5. Edge Tracking by Hysteresis

In this way, the solid edge pixels ought to absolutely be included in the last edge picture, as they are extricated from the genuine edges in the picture. Be that as it may, there will be some level headed discussion on the frail edge pixels, as these pixels can either be removed from the genuine edge, or the clamor/shading varieties. To accomplish an exact result, the feeble edges brought on from the last reasons ought to be uprooted. The criteria to figure out which case the feeble edge fits in with is that, for the most part the frail edge pixel brought about from genuine edges will be associated with the solid edge pixel. To track the edge association, Binary Large Object-investigation is connected by taking a gander at a frail edge pixel and its 8-joined neighborhood pixels. For whatever length of time that there is one solid edge pixel is included in the BLOB, that frail edge point can be distinguished as one that ought to be saved. [10]

4.5. Image segmentation

Picture division sub isolates the picture into its constituent locales or articles. The level to which sub division is conveyed relies on upon the issue being settled. Division calculation for monochrome pictures by and large depend on one of the two fundamental properties of picture force values-

- Discontinuity
- Similarity.

In the first class, the methodology is to parcel a picture in light of sudden changes in force, for example, edges in a picture. The methodology in the second classification depends on dividing a picture into locales that are comparative as per an arrangement of predefined criteria [6].

4.6. Feature Extraction

In pattern recognition and in picture handling, highlight extraction is the exceptional type of dimensionality diminishment. It is the technique for catching the visual substance of pictures for indexing and recovery. At the point when the info information to a calculation is too substantial to ever be handled and it is suspected to be famously excess (much information however very little data) then the info information will be changed into a lessened representation set of components (additionally named highlight vector). In the event that the qualities removed are painstakingly picked, it is normal that the traits set will separate the important data from the info information keeping in mind the end goal to perform the wanted assignment utilizing this diminished representation rather than the full size data. Highlight extraction includes disentangling the measure of assets required to depict the expansive arrangement of information.

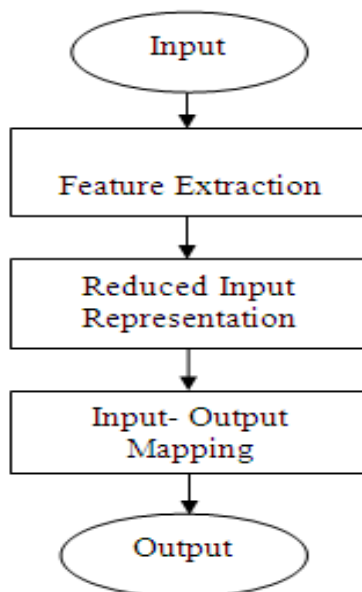


Figure: 6 Feature Extraction Approach

Visual attributes of images are of two types-

- Domain specific attributes which include fingerprints, human faces.

- General attributes which include color, texture, and shape.

There are two types of attributes categorized under the shape attribute extraction-

- Global attributes include moment invariant, aspect ratio and circularity.
- Local attributes include boundary segments [8].

4.7. Comparison

Finally the separated elements of test coin picture are contrasted and the extricated components of unique money picture, in the event that it coordinates then the cash is unique generally fake[5]. It is finished by figuring the quantity of dark pixels of divided picture. On the off chance that the pixels of fragmented picture of test coin are almost equivalent to the pixels of portioned picture of unique cash then the money is observed to be completely forthright generally manufactured.

4.8 Output

The result will be either "The note is Genuine" or "The note is fake" at once anyone will be show.

5. Result

1. Image Acquisition



2. Gray-scale conversion



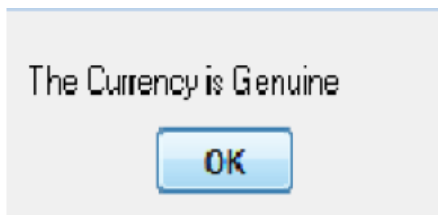
3. Edge detection



4. Image segmentation



5. Comparison and output



6. Conclusion

This paper proposed image processing for fake cash identification. At first picture Acquisition is done then pre-preparing is finished. The picture was trimmed, balanced and smoothed in picture pre-handling. At that point the picture is changed into dim scale. After it the edges are identified. In edge recognition we utilized the Canny administrator. At that point the picture division is connected. After division the elements are removed. At long last examination is performed and yield is delivered that the money is unique or fake.

7. Future Development

We have built up a framework that creates Currency Recognition System utilizing some procedure of MATLAB. The Indian paper cash notes have been perceived. The future study should be possible by applying diverse channels. In this paper the pictures were filtered on a level plane later on the pictures can be examined with diverse points and distinctive elements can be utilized for acknowledgment.

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