DETECTION OF COUNTERFIET CURRENCY USING K-NN SUPERVISED ALGORITHM

A Project report submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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ANITS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES
(UGC AUTONOMOUS)
(*Permanently Affiliated to AU, Approved by AICTE and Accredited by NBA & NAAC with 'A' Grade*)
Sangivalasa, Bheemili mandal, Visakhapatnam dist.(A.P)
2020-2021

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CERTIFICATE

This is to certify that the project report entitled **"DETECTION OF COUNTERFIET CURRENCY USING KNN SUPERVISED ALGORITHM"** submitted **G.Vamsi Krishna (317126512135), K.Tarun Venkat sai kumar (317126512141) , R.Deepesh(317126512164) V.Charishma Devi (317126512178)** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Electronics & Communication Engineering** of Andhra University, Visakhapatnam is a record of Bonafede work carried out under my guidance and supervision.

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ABSTRACT

Since last few years, the banking and financial sectors all over the world were facing difficulties with counterfeit currency notes. By using great technological support, printing and scanning this fake currency is being produced. India is one of the upmost hitten country with this problem. Demonetization in India has led to high circulation of counterfeit currency into banks which results in suspicious transactions. Thus, there is need for a system for recognition of counterfeit currency notes with greater efficiency. In this paper, the system describes an approach using computer vision and KNN, which is a machine learning supervised algorithm. The approach implements image processing techniques, which involves changing the nature of the image to improve its visual information. This proposed system describes an approach for verification of Indian bank notes. The approach consists of processing of image, detection of edge, image segmentation, drawing out characteristics and comparing both images and to verify parameters with python software. The Brute force matcher algorithm is a part in the process of detection which helps to identify the best matches between the reference currency and currency to be tested. The overall process detects whether the currency is counterfeit or not.

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LIST OF SYMBOLS

x	Horizontal axis
σ	Standard deviation in gaussian distribution
$fx(x,y)$	Input image
$f(u,v)$	Spatial coordinates
x_1	Distance from point A
$y1$	Distance from point B
$\sum$	Summation of all expressions

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K-NN	k-Nearest neighbour
CVS	Currency verification systems
CCM	Currency counting machines
ORBD	Oriented Fast and Rotated Brief Detector
ATR	Automatic target recognition

CHAPTER-1

1.1 INTRODUCTION:

Today in the modern digitalization world, we are surrounded by technology and such technology is growing day by day in rapid manner. Of course, such technologies make our life very easy. Today people can do their work with minimum effort and such thing are only possible because of the technology. But some people utilizing the advantages of such technology to fulfil their bad purposes. There are a lot of such examples that are surrounded around us. Counterfeit note is the one of the most important examples of such things. Production of currency without the legal sanction of Government is termed as Counterfeit currency. Facing problem of counterfeiting money is not a new. This problem was found around 600 BC in Greek cities of Lydia. During that period paper currency was not introduced and counterfeit problem can be seen in the form of coin. Mixing base metals with pure silver or gold was used to make such coin as counterfeit coin. Shave the edges of a coin called clipping, to get precious metal and make the counterfeit coinage by using that metal. In 1200s in China the paper money was introduced using the wood of mulberry trees. Guards used to look after that tree during that time and counterfeiting of money were punished by death. The currency system is prevalent in India since a very long time. The Government of India introduced its first paper money issuing 10-rupee notes in 1861 and further year by year more currency were launched. In 1935, the Reserve Bank of India was established and issued the first paper currency note in January 1938. Authorization of printing currency in India is only done through Reserve Bank of India. But the corrupt people utilizing the latest scanning and printing techniques to print counterfeit currency. The production of such fake currency, affects the economy of any country. Indian is also the part of such undesirable things. During 2006-09, about 7.34 lakh of Rs100, 5.76 lakh of Rs500 and 1.09 lakh of Rs1000 notes have been seized as per the figure disclosed in Parliament due to found as fake notes. After the fake currency found in huge amount continuously year by year in rapid manner, The Government of India in 8th November 2016, announced that Rupees 500 and Rupees 1000 notes would no longer be legal in order to diminish the size of the order economy by rooting out black money and counterfeit currency used for funding illicit activities including terrorism and introduced new currency of Rupees 500 and Rupees 2000. But After Demonetization, counterfeit currency to the tune of Rupee 21.54 crore was seized by agencies include the recently introduced 2000, 500 and 200 currency notes. A total of 39,604 currency notes of 2000 denomination was seized across the country. Corrupted people involve in developing such fake note targeting such high denomination value notes. It leads major problem generally for common people to differentiate between real or fake note as they determine only on the basis of physical appearance of the note. Therefore, an automatic technique based on image processing is introduced So that common people can easily differentiate between the real or counterfeit note. The proposed scheme develops an Image processing technique for the pre-processing of images and further process is carried on the pre-processing of the images by using the K-nearest neighbour (KNN) algorithm for the calculation of matching points for the given input image and further classified as fake and genuine notes based on the matching points.

This proposed system has the potential of separating fake and genuine notes by giving inputs has Indian currency either it is fake or original

1.2 Classification of currency based on security features:

There are important security features in the currency in order to differentiate it has original or fake, the security features of the original currency are listed below:

- Security Thread
- Latent Image
- Micro lettering
- Intaglio
- Identification Mark
- Fluorescence
- Optically Variable Ink
- See through Register

Watermark:

The Mahatma Gandhi Series of banknotes contain the Mahatma Gandhi watermark with a light and shade effect and multi-directional lines in the watermark window There is also the watermark of the price of currency it visible in presence of light & glow in UV.

Security Thread:

Rs.1000 notes introduced in October 2000 contain a readable, windowed security thread alternately visible on the obverse with the inscriptions ‗Bharat ‘(in Hindi), ‗1000‘and RBI ‘, but totally embedded on the reverse. 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. The Rs.5, Rs.10, Rs.20 and Rs.50 notes contain a readable, fully embedded windowed security thread with the inscription ‗Bharat ‘(in Hindi), and RBI ‘. The security thread appears to the left of the Mahatma's portrait. Notes issued prior to the introduction of the Mahatma Gandhi Series have a plain, non-readable fully embedded security thread.

Latent image:

The latent image is visible only when the note is held horizontally at eye level. 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.

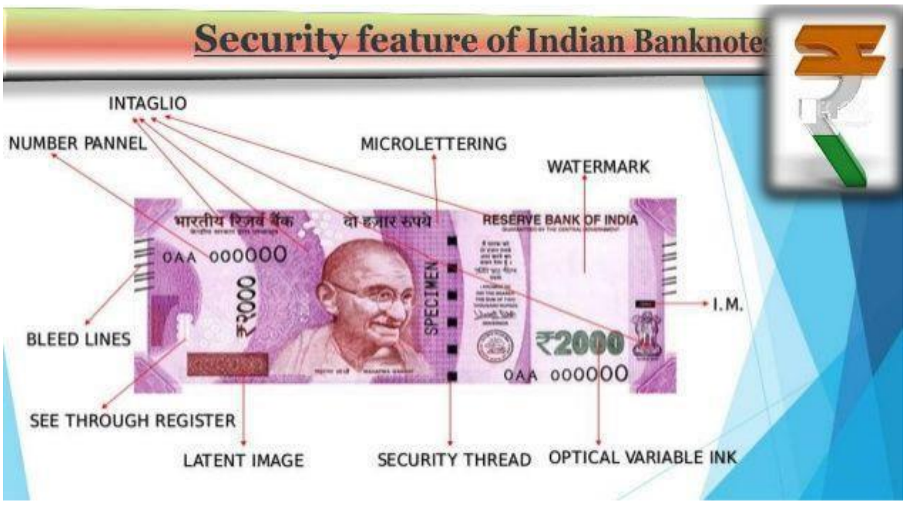


Fig1.1: Security features of currency

Micro lettering:

This feature appears between the vertical band and Mahatma Gandhi portrait. It 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 better under a magnifying glass.

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 is printed 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.

Identification Mark:

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, Rs.1000-Diamond) and helps the visually impaired to identify the denomination.

Fluorescence:

Number panels of the notes are printed in fluorescent ink. The notes also have optical fibres. Both can be seen when the notes are exposed to ultra-violet lamp. When there is fake note it ‘s letter and mainly the numeric values all are irregular in shape. For a genuine currency note, the number will be regular and when scrutinized against ultra violet rays, the letter printed with fluorescent ink shine, for fake note number will be comparatively smaller as compared the original one.

Optically Variable Ink:

This is a new security feature incorporated in the Rs.1000 and Rs.500 notes with revised colour 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 colour-shifting ink. The colour of the numeral 1000/500 appears green when the note is held flat but would change to blue when the note is held at an angle.

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 one floral design when seen against the light.

1.3 Present technology:

The currency counting machine or CCM is one of the miracles of the science. The CCM works on the principle on the breadth of the bundle of currency and there in a roller which has rods in a continuous pattern and the roller moves these rods with a particular speed.
The speed remains constant as like in the ATM machine counting machine and these rollers moves on the bundle of the currency and just move out the single currency one by one at a constant and high speed and there is a transducer which detect that how many single currencies has passed out in front of it. Different range of counting machines like Basic Note counter, Intelligent Counting cum counterfeit detection machines and Hi Speed Heavy duty cash counting machine are available to suit different type of customers. Highly dependable and ideal for Banks, Big & small business houses, Traders, retailers, jewellers and almost all types of business establishment can use them according to their suitability.

The machine meant for detection of fake notes as prime function invariably should be capable of not allowing any fake note to pass as genuine. It is possible only with the detectors specially developed considering the large number of intricacies concerning to Indian notes. The kind of machines Indian Banks at cash counters needed are the machine which can verify not only the images but also can check the chemical and physical properties of papers, inks, resins and other materials used in production of note

1.4 Inspection methods:

Counterfeiting, of whatever kind, has been occurring ever since humans grasped the concept of valuable items, and there has been an ongoing race between certifier (banks, for example) and counterfeiter ever since.

First-Line Inspection Methods:

- Varied-Density Watermarks
- Ultraviolet Fluorescence
- Intaglio Printing
- Microtext
- Holograms and Kinegrams (DOVIDs/ISIS)

Second-Line Inspection Methods:

- Isocheck/Isogram
- Fibre-Based Certificates of Authenticity
- Colour and Feature Analysis

1.4.1 First-Line Inspection Method:

First-line inspection methods are used on-the-spot by vendors and retailers to determine, at best guess, the authenticity of currency being exchanged. The disadvantages of these methods are that they are generally easier to counterfeit than second-line inspection characteristics, since they ‘re just as visible to the counterfeiter as to the verifier, and the methods used to apply them are usually inexpensive. However, the visibility of these features means that the general population is aware of the security measures and can spot many fraudulent notes quickly.

a) Varied-Density Watermarks:

By varying the density of the paper, a banknote is printed on in a controlled manner, thin watermarks can be applied. These are visible when a bright light shines onto the rear of banknote, and the varied paper density causes varying intensities of light to pass through, causing the watermarked image to appear on the other side of the note.

b) Ultraviolet Fluorescence:

Embedding fluorescent fibres into the paper, or printing ultra-violet ink onto the paper, creates a form of optical verification easily used at counters, checkouts, etc. By exposing the note to ultra-violet light, the ink or fibres fluoresce, revealing a coloured pattern not visible under natural light.

c)Intaglio Printing:

This gives a more complex and reliable first-line inspection method, since it is the printing process itself that serves to vouch for the authenticity of the document. The note is subjected to a high-pressure printing process that strengthens and slightly raises the paper ‘s surface structure. Using different alignments of lines printed in this manner, a latent image can be produced which changes appearance depending on the angle at which the note is viewed. This method can also be used with optically-variable ink to produce interference which shows different spectral colours when viewed from different angles.

d)Micro text:

It is very common for banknotes to have incredibly small text printed at much higher resolutions than most commercial copiers, scanners or printers are capable of. When a copying or scanning attempt is made, the insufficient resolution causes the text to become illegibly blurred, announcing the illegitimacy of the note. This method requires specialised printing equipment but ultimately adds very little cost to the manufacture of the currency.

e) Holograms and Kin grams (DOVIDs/ISIS):

These techniques are becoming more and more regularly used in modern anti-counterfeiting measures, once used mostly on credit/debit cards but now increasingly on new bank notes and cheques. In producing diffractive optically-variable image devices (DOVIDs), iridescent foils are added to the printed currency usually after printing. Kin grams and holograms used in DOVIDs are produced by embossing micro profiles with thermoplastic films.

The hologram itself is applied using the interference of light from different sources in a specific pattern, and kin grams are produced with achromatic and polarisation effects. The result is a seemingly 3D full-colour image when illuminated from different angles. ISIS uses stacked quantities of thin films to create a similar effect, with each layer having different refractive properties. The refraction of light when viewed is such that a spectral pattern has been extracted and a full-colour image is produced which varies under different viewing angles.

1.4.2 Second-Line Inspection Methods:

A second-line inspection method is one that cannot be verified by the naked eye alone, and requires an extra device to perform a verification function. These are more secure and harder to counterfeit than visual methods, but the extra security adds extra cost at both the manufacturing and verification ends

A) Isocheck/Isogram:

Related to intaglio printing (described above), these methods rely on a specific pattern of dots and/or lines to cause a moiré pattern when printed or scanned. Hidden watermarks can also be applied in these patterns such that when a special filter is placed between the viewer and the note, the hidden verification is revealed and verifies the note as genuine.

B) Fibre-Based Certificates of Authenticity:

Based on the characteristics of fibre-optic light transmission, this method makes use of unique configurations of fibres embedded in the paper. Using a scanner to illuminate one end of an embedded fibre, the other corresponding of that fibre will become illuminated. By using the position of both illuminated ends (the one deliberately illuminated, and the one illuminated as a result), the certifier has a ―fibre signature. This string can then be converted into a bit string and combined with any extra data that is required (e.g., value, serial number, source, etc.). This is in turn combined with a cryptographic hash of itself and is signed using a private key, with the corresponding public key made available. The final result of these steps can then be encoded onto the banknote (this method is suitable for certifying a wide range of other documents too) in the form of a barcode or verification number of some kind.

Verifying the authenticity merely involves inverting the above process. The control number is verified using the public key corresponding to the private key initially used. The hash function is inverted and the original data string extracted. The note is then scanned using the same fibre illumination method described above, and if the extracted data matches the scanning observations, the document is genuine. This technique can add a large cost to the manufacturing process of banknotes, but is highly secure and very difficult to illegitimately replicate. It may be excessive for smaller-value currencies, but for large-value notes, cheques or money orders this method provides a guarantee of the authenticity of the claim.

C) Colour and Feature Analysis:

Several image-processing software packages now include a secret detection algorithm to prevent banknotes from being manipulated in their applications. Possibly by searching for a specific geometric pattern—five 1mm-large circles arranged like a four-pronged star is the primary candidate, visible in Euro notes, pounds sterling notes and older now-obsolete European currency—they classify images of banknotes and refuse any further processing.

D) Touch & Feel Inspection & Visual Inspection:

In spite of such high complications involved with the notes whether genuine or fake it has been largely observed that validity of notes has been checked by the cashiers simultaneously while manual counting.

1.5 RBI Guidelines Concerning to Fake Note Detection:

It has necessitated for the Banks to deploy such authenticators which can support Banks to comply RBI guidelines concerning to fake notes detection. The machine should be 100% accurate in detection of Fake Notes. No fake note should pass as genuine in all case, have been the bottom lines for any machine which functions as authenticator unless the note is of extremely bad quality.

The extremely bad quality of note should be rejected by the authenticators with error codes ―No judgment‖ since the TRUE validity of such notes due to bad quality cannot be judged except at forensic lab. Such bad quality of notes generally reflects overlapping of features of genuine & fake note creating, uncertainty of accurate validation even though best authenticators for not permitting deep scanning of such notes. No sorter or Currency Verification Systems **(CVS**) possesses any separate pocket to separate fake notes except pockets for separating notes of opposite criterion. Sorters just separate the notes which are not matching with the sorting criterion set in the machine. Fit & unfit, oriented and non-oriented, face up & face down.

There are pockets for collecting opposite criterion notes but no separate pocket has been there for collection of fake notes; although it has been claimed that sorters are best suited for fake note detection. It is wrongly presumed that the opposite criterion pocket collects the fake notes. There is every chance that fake notes matching the various set criterion as may be set in the sorter will pass under such set criterion for many technical reasons.

The functions of AUTHENTICATION & SORTING are two mutually exclusive functions carrying wide difference in their respective weight ages and money values involved in the respective operations. Imperfect quality sorting of notes does not attract loss of value while as passing fake notes as genuine attracts direct loss of value and criminal procedures under I PC and other provisions. Authentication function needs detailed analyses of chemical & physical properties of Bank Note Paper, varied inks, resins, security threads, chemical used in the printing process.

It includes checking of all security features on the face of the note's images, emblems, portraits, logos, colours, designs, texts, covert and overt features etc Most accurate authenticity check only is possible if the notes are checked length wise. Authenticators must have capacity to scan the notes length wise back-to-back, to match with the large number of length wise prints, texts, emblems, portraits, horizontal lines; patterns etc for checking the continuity of such security features while as sorters are checking the notes width wise losing the continuity of scanning various lengthwise security features.

Most of the security features in any currency types are designed length wise and hence without lengthwise scanning of the notes scientifically difficult to obtained 100% accuracy during the detection of fake notes. Most of the note counting /sorting machines in the international market have failed to offer 100% authentication accuracy for not having facility to check notes length wise and scanning the notes width wise, as also have been dependent on light & image-based technology scanning the notes width wise, which have been scientifically unfeasible. It is scientifically impossible to check highly complicated, inter related security aspects in the notes with inter related large numbers of permutations and combinations of each and every element that constitutes a Genuine note at the high speeds of sorters which sorts the notes with Image & light sensor-based technology

Speed kills the authentication accuracy by note getting scientific time to pip into the minute differences between genuine and fabricated security features. At the most can detect very poorly fabricated notes but not skilfully fabricated fake notes being pumped in our country by other state supports that have been having total infrastructures and notes printing technology Authentication can only be carried out with high end light cum Image cum digital technology. The fastest fake note detector that is available in the international market takes minimum 3 seconds for thorough checking of notes. Such machines mostly have facility for single note manual feedings.

1.6 Segmentation: 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 analyse. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristic

1.6.1 Global thresholding: Suppose let the histogram of an image f (x, y) is composed of light objects on a dark background. The pixel intensity levels of the object and the background are grouped into two dominant modes. In global thresholding,30 a threshold value T is selected in such a way that it separates the object and the background.

The condition for selecting T is given as follows:

$$g(x,y) = 1 \text{ if } f(x,y) > T$$
$$0 \text{ if } f(x,y) <= T$$

This Equation has no indication on selecting the threshold value T. The threshold T separates the object from the dark background. Any point (x,y) for which $f(x, y) \geq T$ is called an object point. After thresholding operation, the image is segmented as follows: Pixels labelled 1 corresponds to object whereas pixels labelled 0 corresponds to the background. In global thresholding, the threshold value T depends only on Gray levels of f(x, y).

1.6.2 Threshold based segmentation method: The most intuitive approach to segmentation is global threshold, which has been performed on various types of images. One common difficulty with this approach is to determine the value of the thresholds. Gray scale segmentation methods are generally limited to relatively simple structures. ¬ Thresholding is probably the most frequently used technique to segment an image. Thresholding maps a gray valued image to a binary image. After the thresholding operation, the image has been segmented into two, identified by the pixel values 0 and 1 respectively. If we have an image which contains bright objects on a dark background, thresholding can be used to segment the image. Since in many types of images the gray values of objects are very different from the back ground value, thresholding is often a well-suited method to segment an image into objects and background

1.7 Objective of the Project:

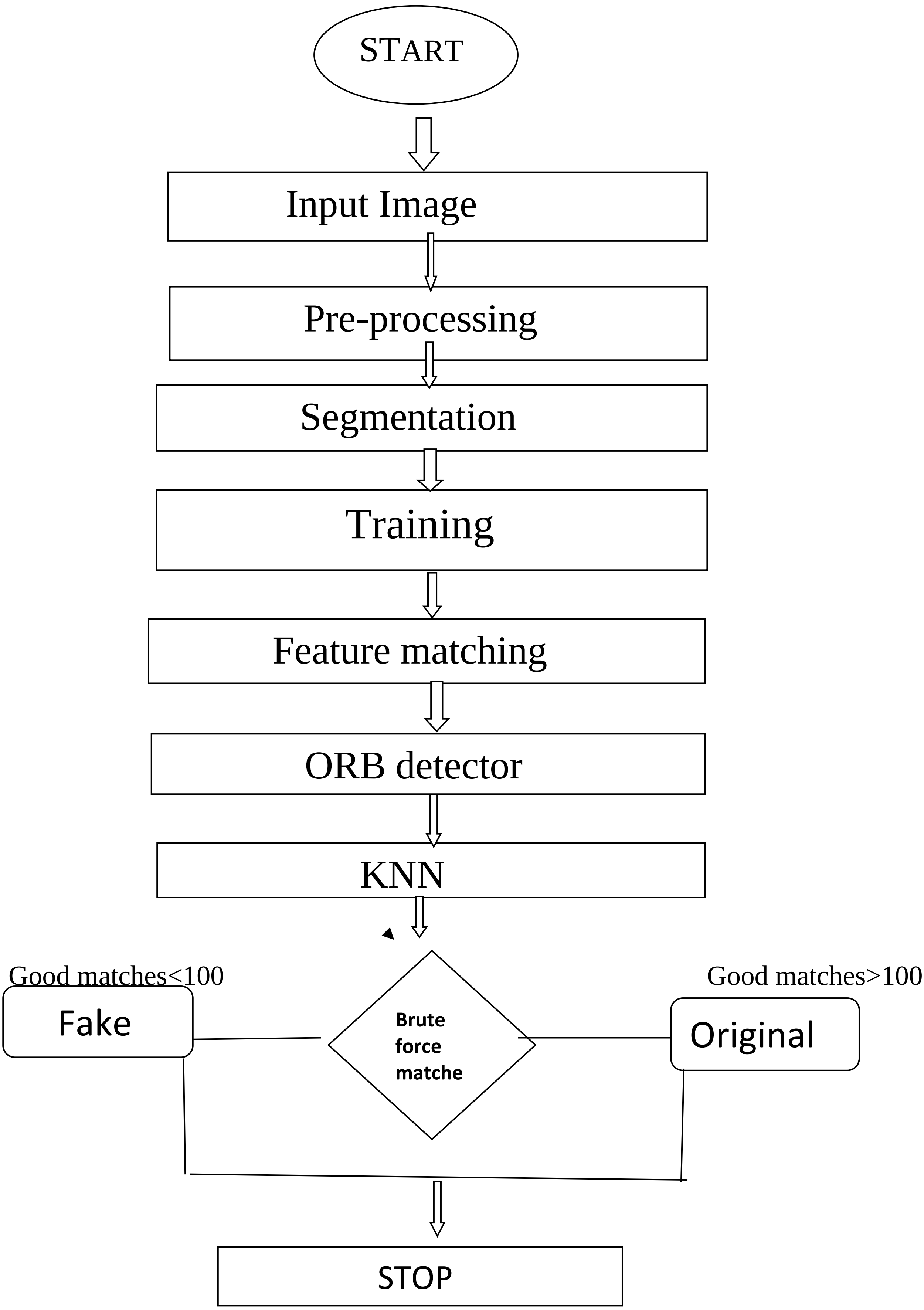
The main objective of the project is now a days counterfeit currency notes are increasing day to day it causes very vast and serious problem in country especially in India it is the most Hiten country in the generation of fake currency notes. The main aim Is to discriminate original and counterfeit currency notes with the help of the software using the image processing techniques and KNN algorithm for image differentiation between fake and original respectively. This process has the capacity to detect the fake notes using matching points.

1.8 Motivation:

Today in the modern digitalization world, we are surrounded by technology and such technology is growing day by day in rapid manner. Of course, such technologies make life very easy. Today people can do their work with minimum effort and such thing are only possible because of the technology. But some people utilizing the advantages of such technology to fulfil their bad purposes. There are a lot of such examples that are surrounded around us. Counterfeit note is the one of the most important examples of such things. Production of currency without the legal sanction of Government is termed as Counterfeit currency. The demand for reducing the fake currency is increasing day by day so we proposed a system which will detect a fake currency mostly

1.9 Methodology used in work:

The image processing-based approach is discussed with python to extract the features, detect the defects of the currency. Image processing includes any form of information processing in which the input is an image. The name image processing is most appropriate when both the inputs and the outputs are image. The first step toward any kind of image processing is the acquisition of the actual images to be processed. The images can be obtained from a camera (of which USB and DV are but two possible varieties) or from a file stored on a local hard disk. Once the images are obtained, they can be further processed by programs to extract whatever19 information is both desired and discernible from them. After image acquisition, in the pre-processing steps, first the image is resized and it is converted to a grayscale image to remove the RGB content of the currency image. It is followed by filtering the image. Then, the image is segmented and by using threshold-based segmentation and by using brute force matcher we match the input with training data base images then based upon the good matching points nature of the currency is classified


START
Input Image
Pre-processing
Segmentation
Training
Feature matching
ORB detector
KNN
Good matches<100
Fake
Brute force matche
Good matches>100
Original
STOP

CHAPTER-2

IMAGE PROCESSING

2.1 Introduction to Image Processing:

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. Image processing is one form of signal processing in which the input is a photograph or video frame; the output may be either an image or a set of characteristics or parameters related to the image. An image contains sub-images sometimes referred as regions- of-interest, or simply regions which implies that images contain collections of objects each of which can be the basis for a region.

In image science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Image processing usually refers to digital image processing, but optical and analog image processing also are possible. The acquisition of images (producing the input image in the first place) is referred to as imaging.

Most of the image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. An image may be considered to contain sub-images sometimes referred to as regions-of-interest, ROIs, or simply regions. This concept reflects the fact that images frequently contain collections of objects each of which can be the basis for a region. Thus, we have chosen image processing for identifying the defects on the surface, where the defective part will be the area of interest. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too.

Image processing basically includes the following three steps:

- Importing the image with optical scanner or by digital photography.
- Analysing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs.
- Output is the last stage in which result can be altered image or report that is based on image analysis.

2.2 Purpose of Image Processing: The purpose of image processing is divided into 5 groups. They are:

1. Visualization - Observe the objects that are not visible.

2.Image sharpening and restoration - To create a better image.

3.Image retrieval - Seek for the image of interest.

4.Measurement of pattern – Measures various objects in an image.

5. Image recognition – Distinguish the objects in an image.

2.3 Basic Terms in Image Processing:

2.3.1Digital Image Processing: Digital Image Processing deals with manipulation of digital images through a digital computer. Digital Image Processing focuses on developing a computer system which is able to perform processing on an image. The input of that system is a digital image and the system process that image using efficient algorithms, and gives an image as an output.

2.3.2 Processing Images: Image processing has been developed in response to three major problems concerned with pictures:

- Picture digitization and coding to facilitate transmission, printing and storage of pictures.
- Picture enhancement and restoration in order to interpret easily.
- Picture segmentation and description as early-stage machine vision.
- The most requirements for image processing of images are that the images should be available in digitized form, i.e., arrays of finite length binary words. For digitization, the given image is sampled on a discrete grid and each sample or pixel is quantized using a finite number of bits and the digitized image is processed by a computer. To display a digital image, it is first converted into analog signal, which is scanned onto a display.

2.3.3 Pixel: Pixel is the smallest element of an image. The value of a pixel at any point corresponds to the intensity of the light photons striking at that point. Each pixel stores a value proportional to the light intensity at that particular location.

Calculation of Total Number of Pixels: We have defined an image as a two-dimensional signal or matrix. Then in that case, the number of pixels would be equal to the number of rows multiplied with number of columns. This can be mathematically represented as below (or) we can say that the number of (x,y) coordinate pairs is equal to the total number of pixels.

Total number of pixels = (number of rows) x (number of columns).

2.3.4 Resolution: The term resolution refers to the total number of count of pixels in a digital image. For example, if an image has M rows and N columns, then its resolution can be defined as M x N.

If we define resolution as the total number of pixels, then pixel resolution can be defined with set of two numbers. The 1st number is the pixels across columns, and the 2nd number is the pixels across its rows. We can say that, the higher is the pixel resolution, the higher the quality of the image.

Size of an image = (pixel resolution) x (bits per pixel).

2.4Types of Images: An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude off at any pair of coordinates (x, y) is called the intensity or Gray level of the image at that point. When x, y, and the amplitude values of f are all finite and discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. Image digital processing encompasses processes whose inputs and outputs are images and, in addition, encompasses processes that extract attributes from images, up to and including the recognition of individual objects. As a simple illustration to clarify these concepts, consider the area of automated analysis of text. The processes of acquiring an image of the area containing the text, pre-processing that image, extracting the individual characters, describing the characters in a form suitable for computer processing, and recognizing those individual characters are in the scope of what we call digital image processing.

Each pixel of an image is typically associated to a specific 'position' in some 2-D region and has a value consisting of one or more quantities (samples) related to the position. There are two basic types of images supported by python

- Binary images
- Grey scale images

2.4.1Binary Image: binary image is stored as a logical array. Binary images are also called bi-level or two level (the name black and white, B&W used for this concept). Some input/output devices such as laser printers, fax machines and bi- level computer displays can only handle bi- level images.

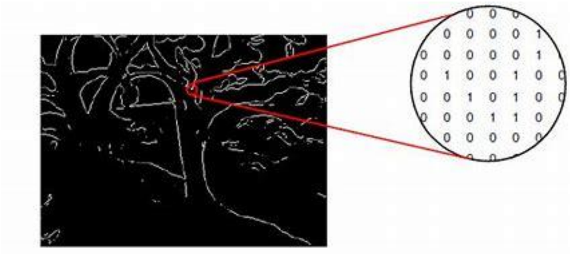


Fig 2.1 Binary image

A binary image will be shown in the figure 2.1. In a binary image, each pixel assumes one of only two discrete values: 1 or 0.

2.4.2 Gray Scale Images: A Gray scale or a Gray level image in which the value of each pixel is a single sample, displayed images of this sort are typically composed of Gray shades varying from black at the weakest intensity to the white at the strongest. Grayscale images are often the result of measuring the intensity of light at each pixel in a single band of the electromagnetic spectrum (e.g., infrared, visible light, ultraviolet, etc.). Gray scale images are often the result of measuring the intensity of images at each pixel. Gray scale images are intended for visual displays are typically stored with 8 bit per sample pixel, which allow 256 intensities i.e., shades of gray to be recorded. A gray scale image is shown in the fig

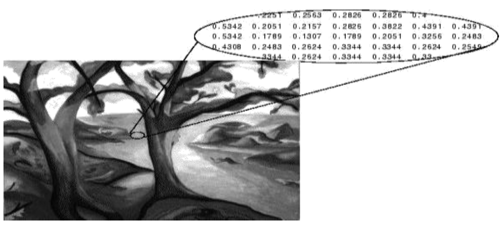


Fig 2.2 Grey scale image

2.5 Types of Image Processing:

The two types of image processing used are:

- Analog image processing
- Digital image processing

2.2.1Analog Image Processing:

In electrical engineering and computer science, analog image processing is any image processing task conducted on two-dimensional analog signals by analog means (as opposed to digital image processing).Analog or visual techniques of image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. The image processing is not just confined to area that has to be studied but on knowledge of analyst. Association is another important tool in image processing through visual techniques. So, analysts apply a combination of personal knowledge and collateral data to image processing.

2.5.2 Digital Image Processing:

Digital Processing techniques help in manipulation of the digital images by using computers. Raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are pre- processing, enhancement and display, information extraction. In this case, digital computers are used to process the image. The image will be converted into the digital form using a scanner –digitizer and then process it. It is defined as the subjecting numerical representation of objects to a series of operations in order to obtain the desired result. It starts with one image and produces a modified version of the image. It is therefore an image that takes one image into another.

The term image processing generally refers to processing of a two-dimensional picture by a digital computer, in the broader context, it implies digital processing of a two-dimensional data. A digital image is an array of real numbers represented by a finite number of bits. The principal disadvantage of digital image processing is its versatility, repeatability and the preservation of original data precision

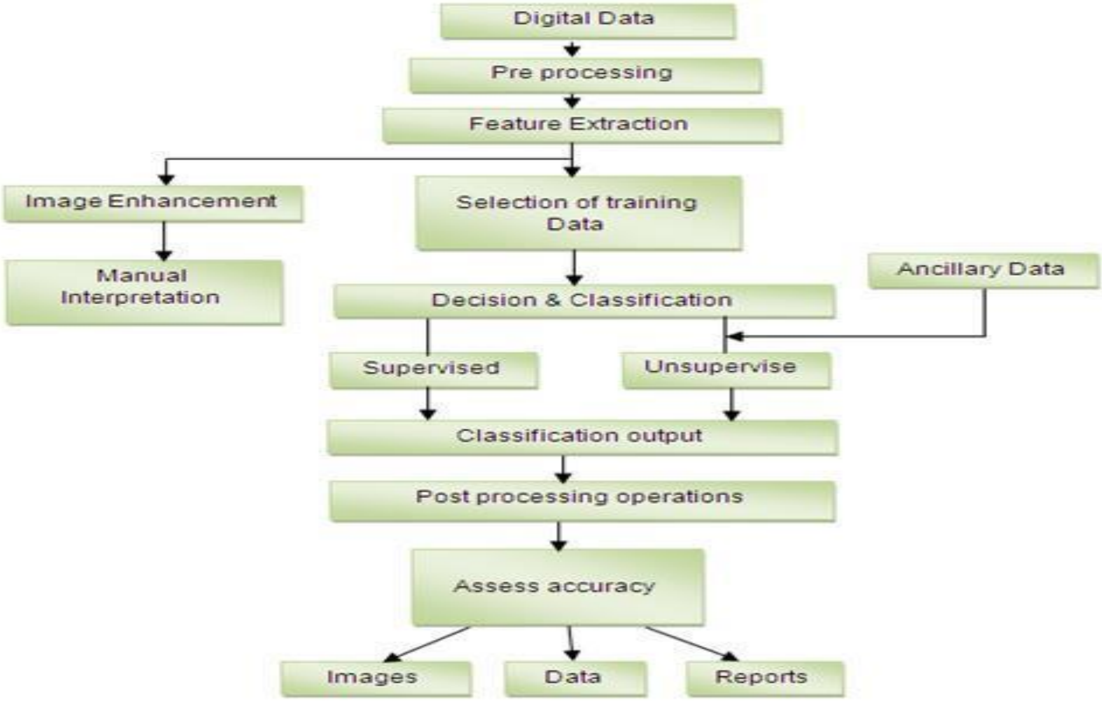


Fig 2.3 Hierarchy of digital image processing

2.6 Image Processing Techniques:

Digital Image Processing deals with manipulation and analysis of images by using computer algorithm, so as to improve pictorial information for better understanding and clarity. This area is characterized by the need for extensive experimental work to establish the viability of proposed solutions to a given problem. Image processing involves the manipulation of images to extract information to emphasize or de-emphasize certain aspects of the information, contained in the image or perform image analysis to extract hidden information.

2.6.1 Image re-sizing:

Re-sizing of an image is performed by the process of the interpolation. It is a process which re-samples the image to determine values between defined pixels. Thus, resized image contains more or less pixels than that of original image. The intensity values of additional pixels are obtained through interpolation if the resolution of the image is increased.

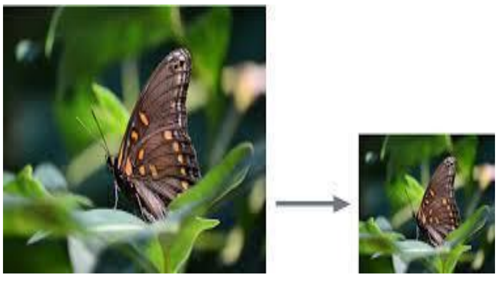


Fig 2.4: Image resizing

2.6.2 Image filtering:

Uncertainties are introduced into the image such as random image noise, partial volume effects and Intensity Non-uniformity artifact (INU), due to the movement of the camera. This results in smooth and slowly varying change in image pixel values and lead to information loss, SNR gain and degradation of edge and finer details of image. Spatial filters are used for noise reduction. These27 filters may be linear or non-linear filters

Fig 2.5 Image filters

2.6.3 Image segmentation:

Depending on type of input image samples, segmentation can be classified as Gray scale single image segmentation and Histogram based segmentation. Here the image is converted to digital form. Digitization includes sampling of image and quantization of sampled values. After converting the image into bit information, processing is performed. This processing technique may be, image enhancement, image restoration, image compression, and image segmentation. As far as project is concerned, we used the image segmentation techniques.

Image segmentation is the process of dividing or partitioning an image into multiple parts.

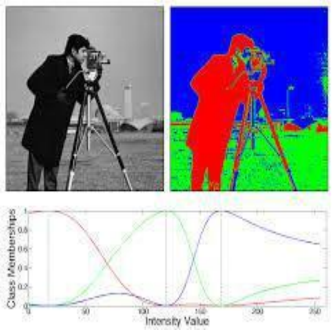


Fig 2.6: Image segmentation

Gray Scale Single Image Segmentation:

In gray scale segmentation, a single image is used for feature extraction and segmentation. The gray scale single image segmentation methods can be subdivided as:

- Edge based segmentation method: Edge detection schemes suffer from incorrect detection of edges due to noise, over and under segmentation and variability in threshold selection in the edge image.

Fig 2.7: Edge based segmentation method

Region growing segmentation method: This segmentation requires an operator to select seeds and thresholds. Pixels around the seeds are examined and included in the region if they are within the thresholds. Results obtained with seed growing are generally dependent on the operator settings.

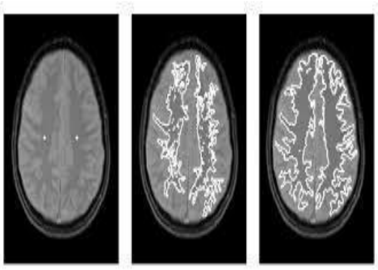


Fig 2.8: Region growing segmentation method

Threshold based segmentation method: The most intuitive approach to segmentation is global threshold, which has been performed on various types of images. One common difficulty with this approach is to determine the value of the thresholds. Gray scale segmentation methods are generally limited to relatively simple structures.

Thresholding is probably the most frequently used technique to segment an image. Thresholding maps a Gray valued image to a binary image. After the thresholding operation, the image has been segmented into two, identified by the pixel values 0 and 1 respectively. If we have an image which contains bright objects on a dark background, thresholding can be used to segment the image. Since in many types of images the Gray values of objects are very different from the back ground value, thresholding is often a well-suited method to segment an

Image objects into background

2.6.4 Global thresholding:

Suppose let the histogram of an image f (x, y) is composed of light objects on a dark background. The pixel intensity levels of the object and the background are grouped into two dominant modes. In global thresholding,30 a threshold value T is selected in such a way that it separates the object and the background.

The condition for selecting T is given as follows:

$$g(x,y) = \begin{cases} 1, & \text{if } f(x,y) > T \\ 0, & \text{if } f(x,y) <= T \end{cases}$$

This Equation has no indication on selecting the threshold value T. The threshold T separates the object from the dark background. Any point (x,y) for which $f(x, y) \geq T$ is called an object point. After thresholding operation, the image is segmented as follows: Pixels labelled 1 corresponds to object whereas pixels labelled 0 corresponds to the background. In global thresholding, the threshold value T depends only on Gray levels of f(x, y).

2.7 Feature matching:

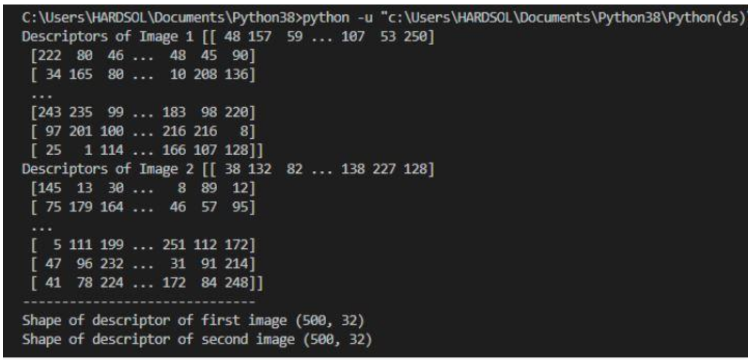
2.7.1 ORB detector:

- It takes one descriptor of first image and matches to all the descriptors of the second image and then it goes to the second descriptor of first image and matches to all the descriptor of the second image and so on.
- ORB detector stands for Oriented Fast and Rotated Brief, this is free of cost algorithm, the benefit of this algorithm is that it does not require GPU it can compute on normal CPU.
- ORB is basically the combination of two algorithms involved FAST and BRIEF where FAST stands for Features from Accelerated Segments Test whereas BRIEF stands for Binary Robust Independent Elementary Features.
- ORB detector first uses FAST algorithm, this FAST algorithm finds the key points then applies Harries corner measure to find top N numbers of key points among them, this algorithm quickly selects the key points by comparing the distinctive regions like the intensity variations.
- This algorithm works on Key point matching, Key point is distinctive regions in an image like the intensity variations.

Now the role of BRIEF algorithm comes, this algorithm takes the key points and turn into the binary descriptor/binary feature vector that contains the combination of 0s and1s only.

- The key points founded by FAST algorithm and Descriptors created by BRIEF algorithm both together represent the object. BRIEF is the faster method for feature descriptor calculation and it also provides a high recognition rate until and unless there is large in-plane rotation

Example:



```
C:\Users\HARDSOL\Documents\Python38>python -u "c:\Users\HARDSOL\Documents\Python38\Python(ds)
Descriptors of Image 1 [[ 48 157  59 ... 107  53 250]
 [222  80  46 ...  48  45  90]
 [ 34 165  80 ...  10 208 136]
 ...
 [243 235  99 ... 183  98 220]
 [ 97 201 100 ... 216 216   8]
 [ 25   1 114 ... 166 107 128]]
Descriptors of Image 2 [[ 38 132  82 ... 138 227 128]
 [145  13  30 ...   8  89  12]
 [ 75 179 164 ...  46  57  95]
 ...
 [  5 111 199 ... 251 112 172]
 [ 47  96 232 ...  31  91 214]
 [ 41  78 224 ... 172  84 248]]
-----------------------------
Shape of descriptor of first image (500, 32)
Shape of descriptor of second image (500, 32)
```

Fig 2.10 Keys and descriptors

Key Points are the point of interest, in simple words means that when the human will see the image at that time the features he notices in that image, in the similar way when the machine read the image it sees some points of interest known as Key points.

The second output image shows the descriptors and the shape of the descriptors.

These Descriptors are basically array or bin of numbers. These are used to describe the features, using these descriptors we can match the two different images.

In the second output image, we can see first image descriptor shape and second image descriptor shape is (467, 32) and (500,32) respectively. So, Oriented Fast and Rotated Brief (ORB) detector try to find 500 features in the image by default, and for each descriptor, it will describe 32 values

Brute force matcher:

- Brute Force Matcher is used for matching the features of the first image with another image.
- The orb detector detects the key points and descriptors in the input images and trained data base images after the detecting of key points and descriptors we use brute force matcher to match the key points and descriptors

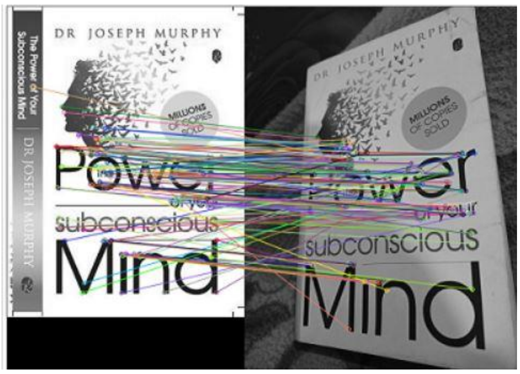


Fig 2.11 Brute force matching points

Currency classification:

The classification is divided into:

- Training phase
- Testing phase

In training phase known data are given and in testing phase unknown data are given. Classification is performed using the classifiers like K-nearest neighbour algorithm after training. The accuracy of classification depends on efficiency of training.

2.8.1 K-nearest algorithm:

- K-Nearest Neighbour is one of the simplest Machine Learning algorithms based on Supervised Learning technique.
- K-NN algorithm assumes the similarity between the new case/data and available cases and put the new case into the category that is most similar to the available categories.
- K-NN algorithm stores all the available data and classifies a new data point based on the similarity. This means when new data appears then it can be easily classified into a well suite category by using K- NN algorithm.
- K-NN algorithm can be used for Regression as well as for Classification but mostly it is used for the Classification problems.
- KNN algorithm at the training phase just stores the dataset and when it gets new data, then it classifies that data into a category that is much similar to the new data.
- **Example:** Suppose, we have an image of a creature that looks similar to fake and original, but we want to know either it is a fake or original. So, for this identification, we can use the KNN algorithm, as it works on a similarity measure. Our KNN model will find the similar features of the new data set to the fake and original images and based on the most similar features it will put it in either fake or original category

Suppose there are two categories, i.e., Category A and Category B, and we have a new data point x1, so this data point will lie in which of these categories. To solve this type of problem, we need a K-NN algorithm. With the help of K-NN, we can easily identify the category or class of a particular dataset. Consider the below diagram:

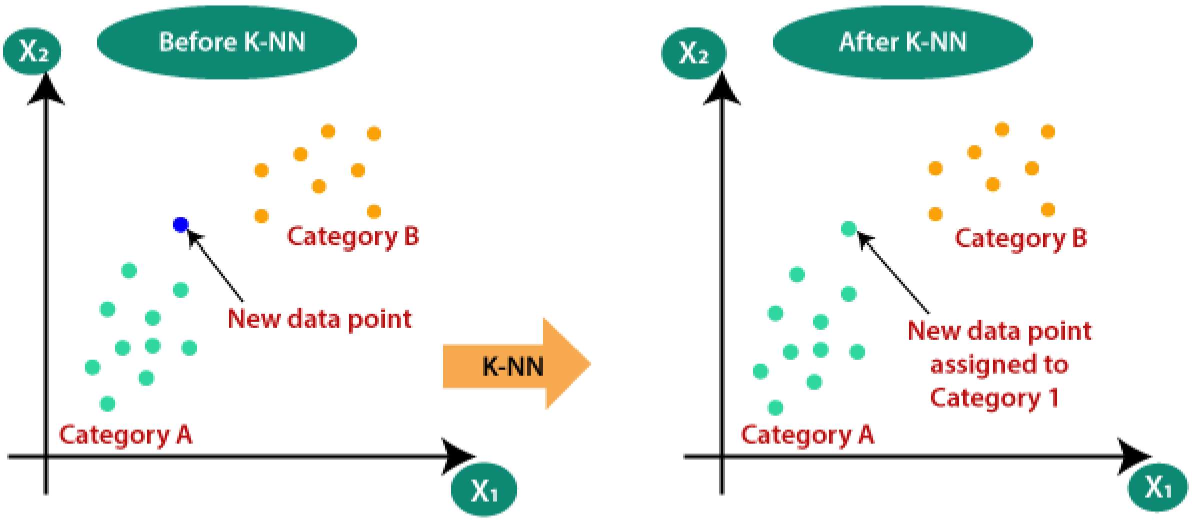


Fig 2.12 Comparison of K-NN algorithm

K-NN working:

The K-NN working can be explained on the basis of the below algorithm:

- **Step-1:** Select the number K of the neighbours
- **Step-2:** Calculate the Euclidean distance of **K number of neighbours**
- **Step-3:** Take the K nearest neighbours as per the calculated Euclidean distance.
- **Step-4:** Among these k neighbours, count the number of the data points in each category.
- **Step-5:** Assign the new data points to that category for which the number of the neighbour is maximum.
- **Step-6:** Our model is ready.

Suppose we have a new data point and we need to put it in the required category. Consider the below image:

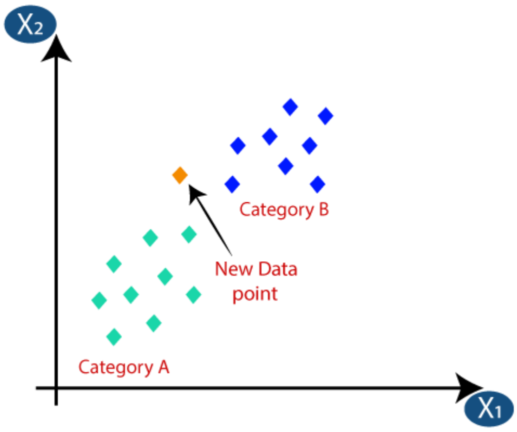


Fig 2.13 Giving Input as new data point

Firstly, we will choose the number of neighbours, so we will choose the k=5.

- Next, we will calculate the **Euclidean distance** between the data points. The Euclidean distance is the distance between two points, which we have already studied in geometry. It can be calculated as:

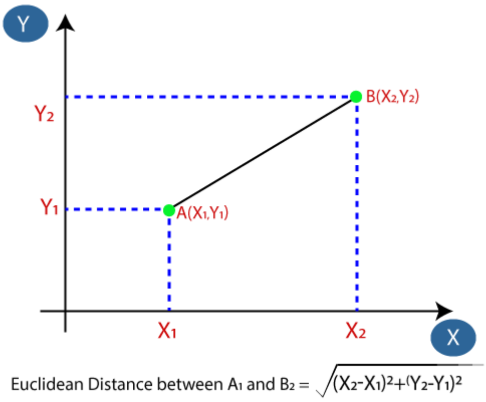


Fig 2.14 Finding Euclidean distance

- By calculating the Euclidean distance, we got the nearest neighbours, as three nearest neighbours in category A and two nearest neighbours in category B. Consider the below image:

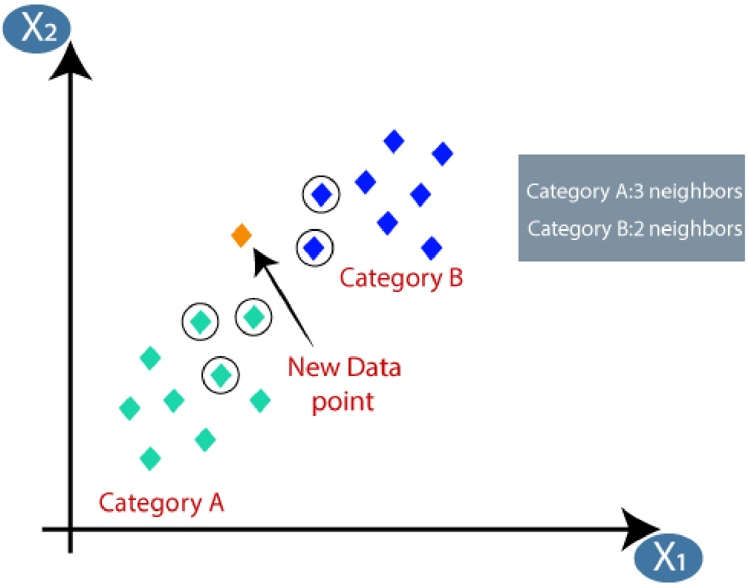


Fig 2.15 Allocation of data point

- As we can see the 3 nearest neighbours are from category A, hence this new data point must belong to category A.

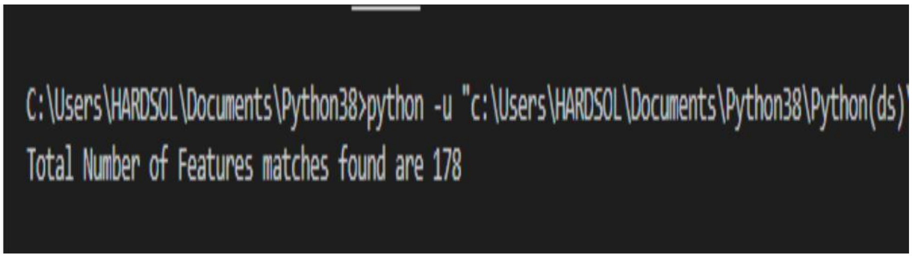


Fig 2.16 Best Matches

2.9 Applications of Image Processing:

Signature Verification: A digital signature is a mathematical scheme for representing the legitimacy of a digital communication. A legal digital signature affords a receiver reason to consider that the message was created by a recognized sender, such that the sender cannot reject having sent the message with non-repudiation and authentication and the message was not changed in transfer. Digital signatures are commonly used for software allocation, financial communication, and in further cases where it is vital to detect imitation or tampering

Bio-metrics: Biometrics (or biometric verification) refers to the automatic identification of humans by their behaviours or characteristics. Biometrics is recycled in computer science as a type of identification and access control. It is also used to recognize individuals in groups that are under surveillance. Biometric identifiers are the exceptional, accessible characteristics used to label and describe individuals, examples include fingerprint, face recognition, Palm print, DNA, hand geometry, iris recognition, retina and odour/smell. Behavioural characteristics are related to the pattern of performance of a person, including but not limited to typing rhythm, voice and gait. Some researchers have coined the term behaviour metrics to describe the latter class of biometric

Agriculture: Applications towards agriculture providing the earth observation data which supports increased area under agriculture, increased crop intensity and productivity, etc. RS data can provide the data related to groundwater helping in irrigation, flood management. Applications like environment assessment and monitoring, disaster monitoring and mitigation, weather climate, village resource centre, etc

Automatic Target Recognition: Automatic Target Recognition (ATR) is the skill for an algorithm or device to distinguish objects or targets stand on data gained from sensors. The function of regular target recognition technology is a serious element of robotic warfare. ATR machines are used in unmanned aerial vehicles and cruise missiles. Electric affords an ATRU (Automatic Target Recognition Unit) to the Land Attack Missile of Standoff, which processes post-launch and pre-launch aiming data, allows high quickness in video comparison, and permits the SLAM-ER i.e., Standoff Land Attack Missile - Expanded Response, "Fire- and-forget" missile. The fundamental version of an ATR system is the IFF transponder. Other applications of ATR include a proposed security system that uses active UWB radar signals to recognize37 objects or humans that have dropped onto channel tracks of rail. It is also possible to detect the damaged infrastructures caused by the earthquakes using satellite

Traffic Monitoring: The current disclosure relates to a number of inventions heading for, normally to the application of image processing techniques to traffic data acquisition using images/videos. The inventions exist in a system of traffic monitoring, the fundamental job of which is for acquisition of traffic data and detection of incident. Further distinctively, the application of image processing methods for the vehicle detection, from the series of video images, as well as the acquisition of traffic data and detection of traffic incident. In an individual facet, the present development provides a technique of processing images recognized from a system of traffic monitoring which is video based. In one more feature, the current development is headed to a Region of Interest i.e., ROI for judgment of a vehicle which is moving and an added feature is directed to a technique of detecting day or night position in monitoring a traffic system. It is the application of a variety of algorithms to a traffic monitoring system based on video is also measured imaginative. Other creative characteristic of the present monitoring of traffic system is sketched in the assert

Biomedical Application: Biomedical image processing is similar in concept to biomedical signal processing in multiple dimensions. It includes the analysis, enhancement and display of images captured via x-ray, ultrasound, MRI, nuclear medicine and optical imaging technologies. Image reconstruction and modelling techniques allow instant processing of 2D signals to create 3D images. When the original CT scanner was invented in 1972, it literally took hours to acquire one slice of image data and more than 24 hours to reconstruct that data into a single image. Today, this acquisition and reconstruction occurs in less than a second. Rather than simply eyeball an x-ray on a light box, image processing software helps to automatically identify and analyse what might not be apparent to the human eye

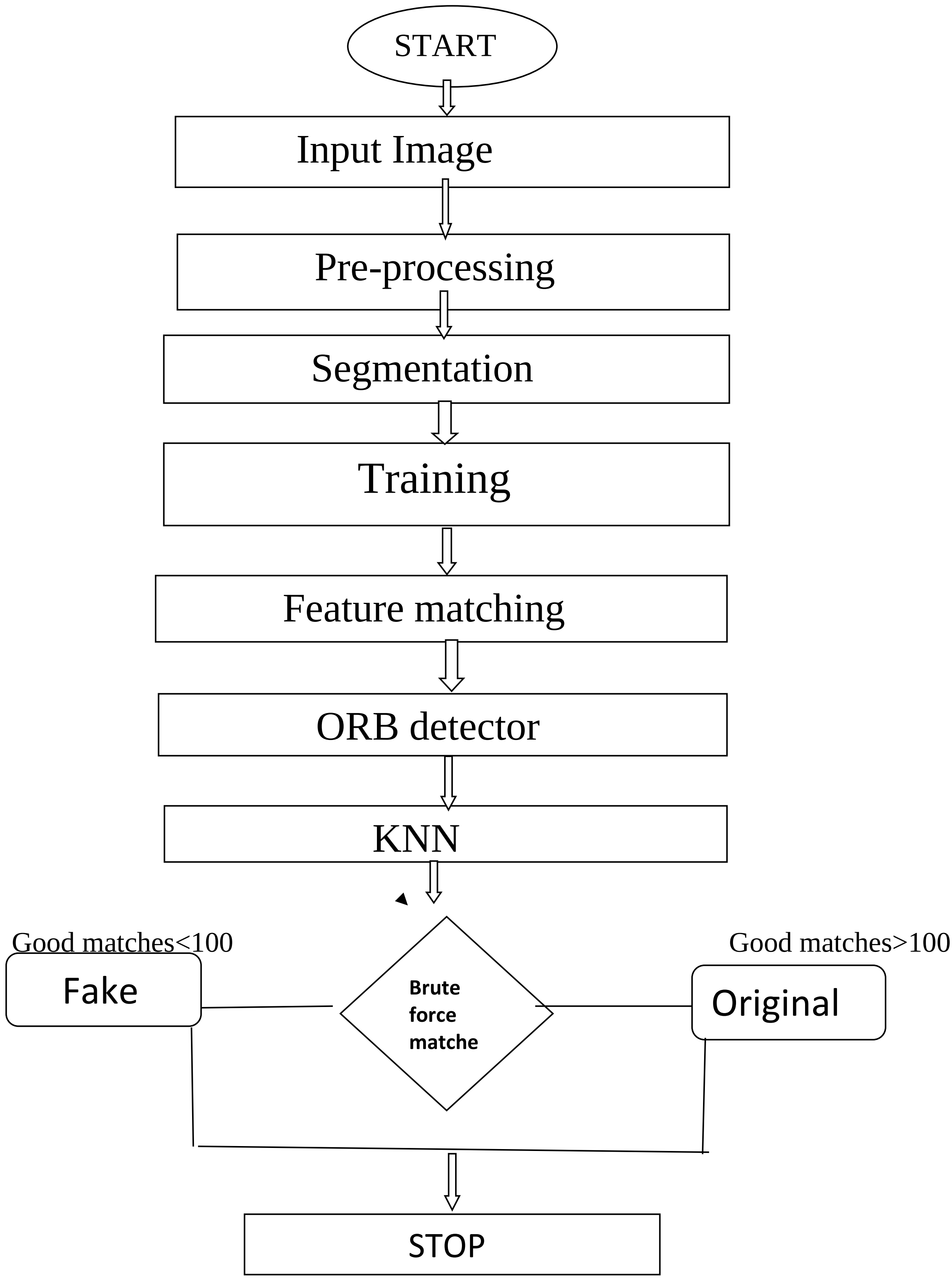
CHAPTER-3

METHOD OF ANALAYSIS

3.1 System design:

The first step toward any kind of image processing is the acquisition of the actual images to be processed. The images can be obtained from a camera (of which USB and DV are but two possible varieties) or from a file stored on a local hard disk. Once the images are obtained, they can be further processed by programs to extract whatever information is both desired and discernible from them. After image acquisition, in the pre-processing steps, first the image is resized and it is converted to a grayscale image to remove the RGB content of the currency image. It is followed by filtering the image. Then, the image is segmented and by using threshold-based segmentation and by using brute force matcher we match the input with training data base images then based upon the good matching points nature of the currency is classified

The main objective of the project is now a days counterfeit currency notes are increasing day to day it causes very vast and serious problem in country especially in India it is the most Hiten country in the generation of fake currency notes. Our aim Is to discriminate original and counterfeit currency notes with the help of the software using the image processing techniques and KNN algorithm for image differentiation between fake and original respectively. This process has the capacity to detect the fake notes using matching points


START
Input Image
Pre-processing
Segmentation
Training
Feature matching
ORB detector
KNN
Good matches<100
Fake
Brute force matche
Good matches>100
Original
STOP

3.2 algorithm of proposed work:

- STEP-1: Start
- STEP-2: Image acquisition
- STEP-3: Pre-processing
- STEP-4: Segmentation
- STEP-5: Feature matching
- STEP-6: Implementation of K-NN
- STEP-7: Result

3.3 Image acquisition:

Image acquisition in image processing can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. Performing image acquisition in image processing is always the first step in the work-flow sequence because, without an image, no processing is possible. The image that is acquired is completely unprocessed and is the result of whatever hardware was used to generate it, which can be very important in some fields to have a consistent baseline from which to work. One of the ultimate goals of this process is to have a source of input that operates within such controlled and measured guidelines that the same image can, if necessary, be nearly perfectly reproduced under the same conditions so anomalous factors are easier to locate and eliminate.

The first step toward any kind of image processing is the acquisition of the actual images to be processed. The images can be obtained from a camera (of which USB and DV are but two possible varieties) or from a file stored on a local hard disk. Once the images are obtained, they can be further processed by programs to extract whatever information is both desired and discernible from them. Of course, such extraction programs will rarely be perfect on their first execution and, in the course of debugging them; it is often helpful to have a perfectly replicable input

Fig 3.1 Input image

3.4 Pre-processing:

- Resize
- Negative transformation
- Gray scale conversion
- Edge detection
- Morphological operations
- Filtering
- FFT of the image

3.4.1 Resize:

Image interpolation occurs when you resize or distort your image from one pixel grid to another. Image resizing is necessary when you need to increase or decrease the total number of pixels, whereas remapping can occur when you are correcting for lens distortion or rotating an image.

Fig 3.2 Resized image

3.4.2 Negative Transformation:

Negative transformation the second linear transformation is negative transformation, which is invert of identity transformation. In negative transformation, each value of the input image is subtracted from the L-1 and mapped onto the output image.

The result is somewhat like this.

Fig 3.3 Negative transformation

3.4.3 Grey scale conversion:

Gray Level Transformation All Image Processing Techniques focused on Gray level transformation as it operates directly on pixels. The gray level image involves 256 levels of gray and in a histogram, horizontal axis spans from 0 to 255, and the vertical axis depends on the number of pixels in the image.

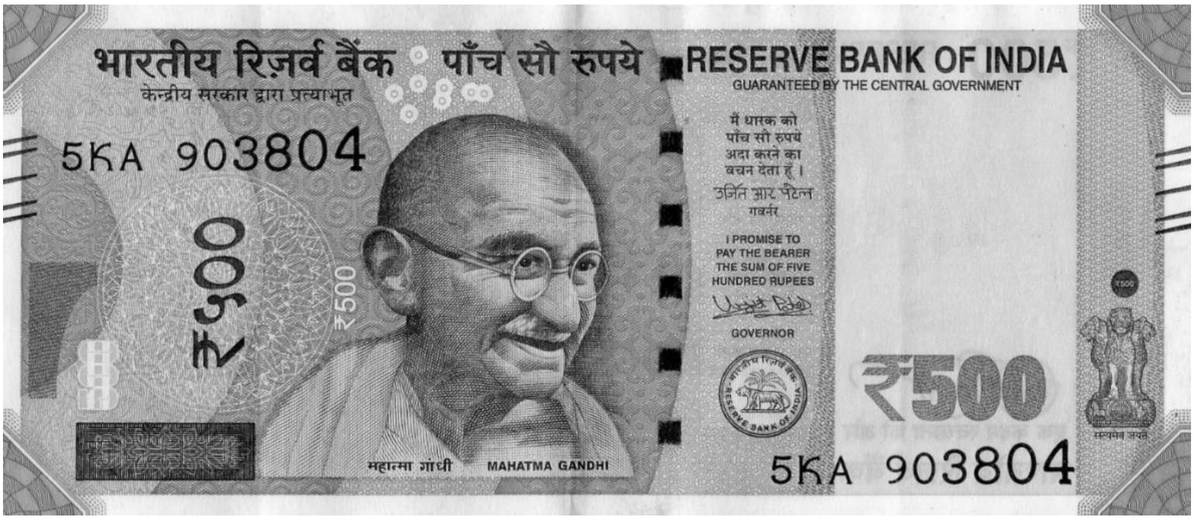


Fig 3.4 Grey scale transformation

3.4.4 Edge detection:

Edge detection can be used to extract the structure of objects in an image. If we are interested in the number, size, shape, or relative location of objects in an image, edge detection allows us to focus on the parts of the image most helpful

1. Detection: The probability of detecting real edge points should be maximized while the probability of falsely detecting non-edge points should be minimized. This corresponds to maximizing the signal-to-noise ratio.
2. Localization: The detected edges should be as close as possible to the real edges.
3. Number of responses: One real edge should not result in more than one detected edge (one can argue that this is implicitly included in the first requirement).

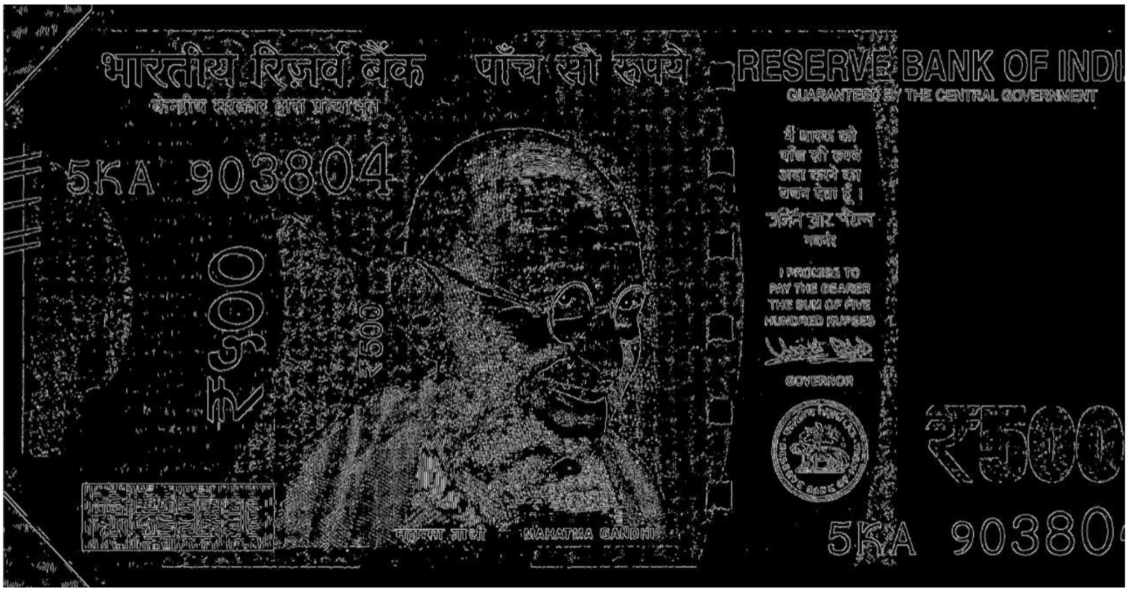


Fig 3.5 Canny edge detection

3.4.5 Morphological operations:

Morphological image processing tries to remove the imperfections from the binary images because binary regions produced by simple thresholding can be distorted by noise. It also helps in smoothing the image using opening and closing operations.

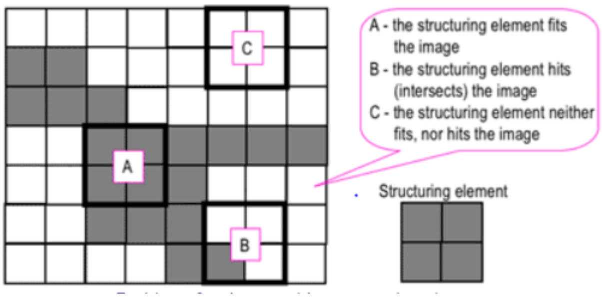
Morphological operations can be extended to grayscale images. It consists of non-linear operations related to the structure of features of an image. It depends on the related ordering of pixels but on their numerical values. This technique analyses an image using a small template known as **structuring element** which is placed on different possible locations in the image and is compared with the corresponding neighbourhood pixels. A structuring element is a small matrix with 0 and 1 values.

Let’s see the two fundamental operations of morphological image processing, **Dilation and Erosion:**

- **dilation** operation adds pixels to the boundaries of the object in an image
- **erosion** operation removes the pixels from the object boundaries.

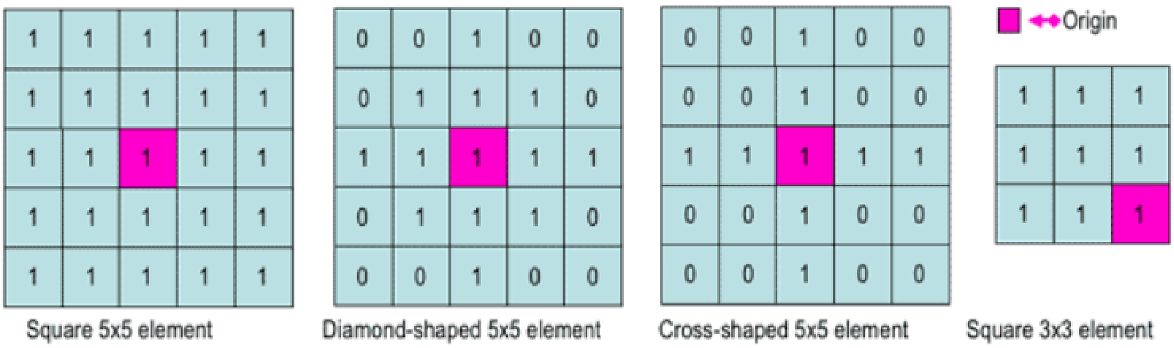
The number of pixels removed or added to the original image depends on the size of the structuring element.

Structuring element: Structuring element is a matrix consisting of only 0’s and 1’s that can have any arbitrary shape and size. It is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels.



3.6 Structuring element

- The square structuring element ‘A’ fits in the object we want to select, the ‘B’ intersects the object and ‘C’ is out of the object.
- The zero-one pattern defines the configuration of the structuring element. It’s according to the shape of the object we want to select. The centre of the structuring element identifies the pixel being processed.



3.7 Different sizes of structing element

Dilation:

Fig 3.8 Dilation

Closing:

Fig 3.9 Closing

3.4.6 Filtering:

Median filter:

The median filter is a non-linear digital filtering technique, often used to remove noise from an image or signal. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise (but see the discussion below), also having applications in signal processing

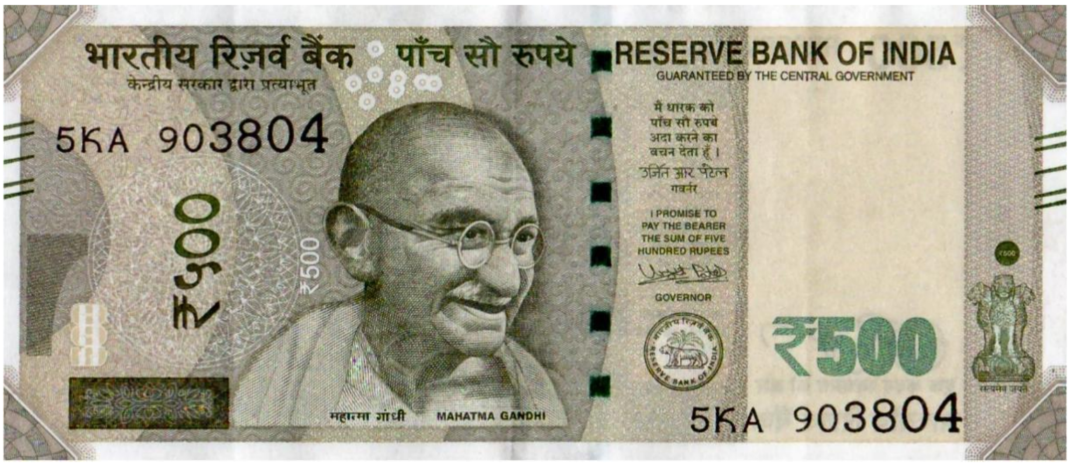


Fig 3.10 Median filter

Gaussian image filter:

Gaussian blur which is also known as gaussian smoothing, is the result of blurring an **image** by a **Gaussian** function.

It is **used to reduce image noise and reduce details**. The visual effect of this blurring technique is similar to looking at an image through the translucent screen. It is sometimes used in computer vision for image enhancement at different scales or as a data augmentation technique in deep learning.

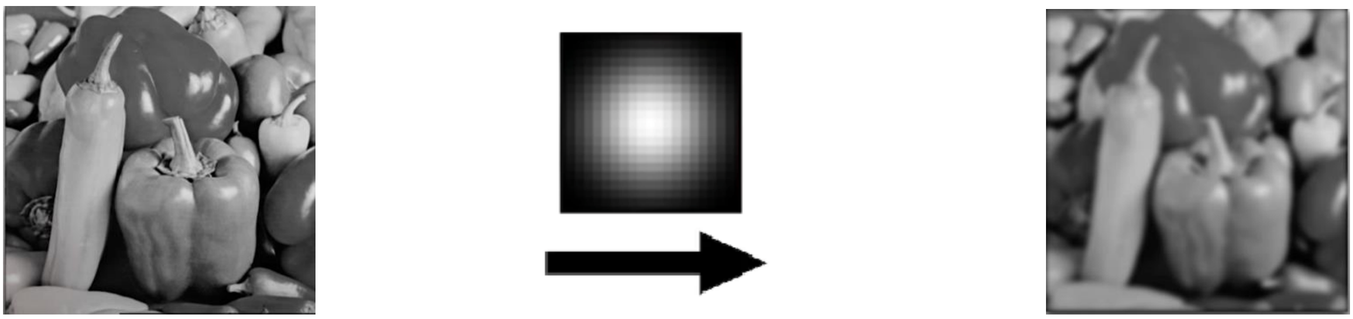
The basic gaussian function looks like:

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

where x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, and σ is the standard derivation of the Gaussian distribution

In practice, it is best to take advantage of the Gaussian blur's separable property by dividing the process into two passes. In the first pass, a one-dimensional kernel is used to blur the image in only the horizontal or vertical direction. In the second pass, the same one-dimensional kernel is used to blur in the remaining direction. The resulting effect is the same as convolving with a two-dimensional kernel in a single pass. Let's see an example to understand what gaussian filters do to an image.

If we have a filter which is normally distributed, and when it's applied to an image, the results look like this:



Original Fake Result

Fig 3.11 Gaussian filter

3.4.7 **Fourier Transform in image processing**

Fourier transform breaks down an image into sine and cosine components. It has multiple applications like image reconstruction, image compression, or image filtering. Since we are talking about images, we will take discrete Fourier transform into consideration.

Let's consider a sinusoid, it comprises of three things:

- Magnitude – related to contrast
- Spatial frequency – related to brightness
- Phase – related to colour information

The image in the frequency domain looks like this:

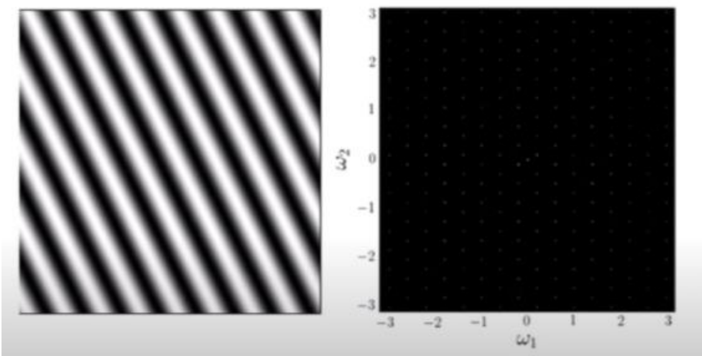


Fig 3.12 FFT of an image

The formula for 2D discrete Fourier transform is:

$$F(u, v) = \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y)\, e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$$

In the above formula, f(x,y) denotes the image. (u,v) denotes the co-ordinates are the amplitude.

The inverse Fourier transform converts the transform back to image. The formula for 2D inverse discrete Fourier transform is:

$$f(x, y) = \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u, v)\, e^{j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$$

3.5 Segmentation:

3.5.1Threshold based segmentation method: The most intuitive approach to segmentation is global threshold, which has been performed on various types of images. One common difficulty with this approach is to determine the value of the thresholds. Gray scale segmentation methods are generally limited to relatively simple structures.

- Thresholding is probably the most frequently used technique to segment an image. Thresholding maps a gray valued image to a binary image. After the thresholding operation, the image has been segmented into two, identified by the pixel values 0 and 1 respectively. If we have an image which contains bright objects on a dark background, thresholding can be used to segment the image. Since in many types of images the gray values of objects are very different from the back ground value, thresholding is often a well-suited method to segment an image into objects and background

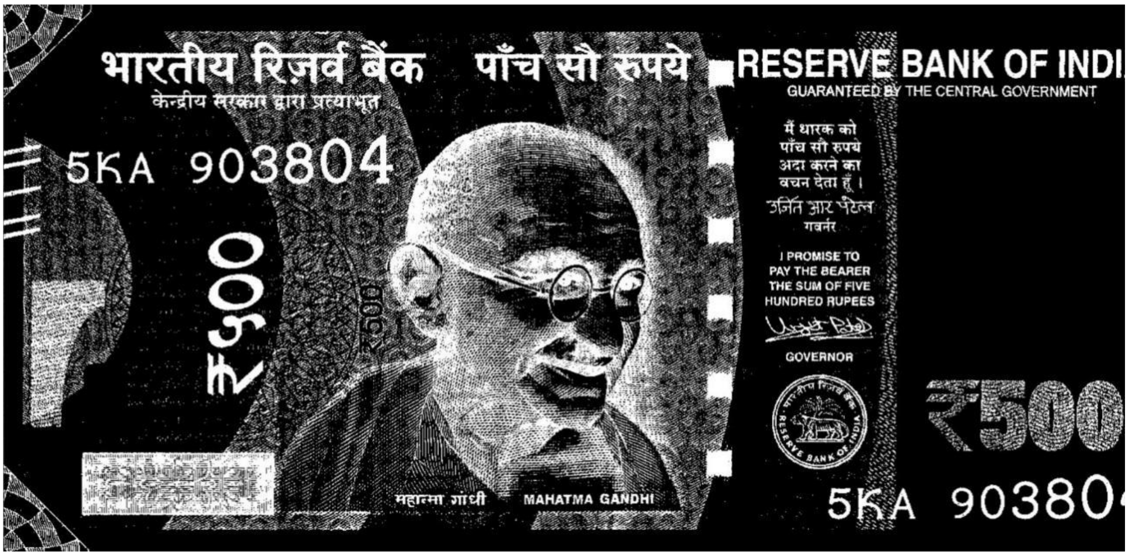


Fig 3.13 segmentation of an image

3.5.2 Global Thresholding: Suppose the histogram of an image f (x, y) is composed of light objects on a dark background. The pixel intensity levels of the object and the background are grouped into two dominant modes. In global thresholding, a threshold value T is selected in such a way that it separates the object and the background.

The condition for selecting T is given as follows:

$$g(x,y) = 1, \text{ if } f(x,y)>T$$
$$0, \text{ if } f(x,y)\geq T$$

This Equation has no indication on selecting the threshold value T. The threshold T separates the object from the dark background. Any point (x,y) for which f(x, y) ≥ T is called an object point. After thresholding operation, the image is segmented as follows: Pixels labelled 1 correspond to objects whereas pixels labelled 0 correspond to the background. In global thresholding, the threshold value T depends only on

3.6 Feature matching: It consists of two algorithms

- ORB detector
- Brute force matcher

  - Approach of feature matching: Import the OpenCV library.
  - Load the images using i*mread()* function and pass the path or name of the image as a parameter.
  - Create the ORB detector for detecting the features of the images.
  - Using the ORB detector find the keypoints and descriptors for both of the images.
  - Now after detecting the features of the images. Now write the Brute Force Matcher for matching the features of the images and stored it in the variable named as “*brute_force*“.
  - For matching we are using the brute_force.match() and pass the descriptors of first image and descriptors of the second image as a parameter.
  - After finding the matches we have to sort that matches according to the humming distance between the matches, less will be the humming distance better will be the accuracy of the matches.
  - Now after sorting according to humming distance we have to draw the feature matches for that we use *drawMatches()* function in which pass first image and keypoints of first image, second image and keypoints of second image and the *best_matches* as a parameter and stored it in the variable named as “*output_image*“.
  - Now after drawing the feature matches we have to see the matches for that we use *imshow()* function which comes in cv2 library and pass the window name and *output_image*.
  - Now write the *waitkey()* function and write the *destroyAllWindows()* for destroying all the windows.

3.6.1 ORB DETECTOR: ORB detector stands for Oriented Fast and Rotated Brief, this is free of cost algorithm, the benefit of this algorithm is that it does not require GPU it can compute on normal CPU.

ORB is basically the combination of two algorithms involved FAST and BRIEF where FAST stands for Features from Accelerated Segments Test whereas BRIEF stands for Binary Robust Independent Elementary Features.

ORB detector first uses FAST algorithm, this FAST algorithm finds the key points then applies Harries corner measure to find top N numbers of key points among them, this algorithm quickly selects the key points by comparing the distinctive regions like the intensity variations.

This algorithm works on Key point matching, Key point is distinctive regions in an image like the intensity variations.

Now the role of BRIEF algorithm comes, this algorithm takes the key points and turn into the binary descriptor/binary feature vector that contains the combination of 0s and1s only.

The key points founded by FAST algorithm and Descriptors created by BRIEF algorithm both together represent the object. BRIEF is the faster method for feature descriptor calculation and it also provides a high recognition rate until and unless there is large in-plane rotation.

3.14 Input image

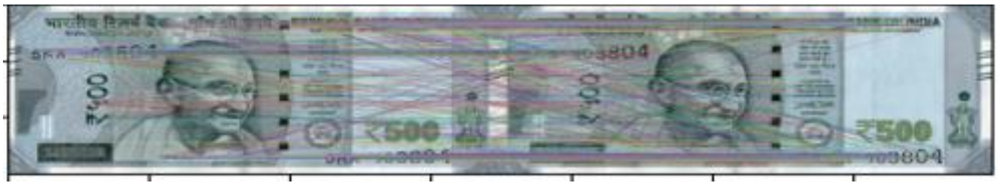
The keys and descriptors for the given input image:

```
Squeezed text (182 lines).
[[ 17 221  75 ... 154 240 153]
 [ 42 133   2 ...  14 236 142]
 [ 33 136 195 ... 170 114 128]
 ...
 [ 46 251 113 ...  30 143 223]
 [ 49  57 106 ...  47 125 218]
 [ 34 144  58 ...   8  61 219]]
```

3.15 Keys and descriptors

3.6.2 Brute force matcher:

Brute Force Matcher is used for matching the features of the first image with another image. It takes one descriptor of first image and matches to all the descriptors of the second image and then it goes to the second descriptor of first image and matches to all the descriptor of the second image and so on.



3.16 Brute force matcher

3.7 Implementation of k-NN:

- K-Nearest Neighbour is one of the simplest Machine Learning algorithms based on Supervised Learning technique.
- K-NN algorithm assumes the similarity between the new case/data and available cases and put the new case into the category that is most similar to the available categories.
- K-NN algorithm stores all the available data and classifies a new data point based on the similarity. This means when new data appears then it can be easily classified into a well suite category by using K- NN algorithm.
- K-NN algorithm can be used for Regression as well as for Classification but mostly it is used for the Classification problems.
- KNN algorithm at the training phase just stores the dataset and when it gets new data, then it classifies that data into a category that is much similar to the new data.
- **Example:** Suppose, we have an image of a creature that looks similar to fake and original, but we want to know either it is a fake or original. So, for this identification, we can use the KNN algorithm, as it works on a similarity measure. Our KNN model will find the similar features of the new data set to the fake and original images and based on the most similar features it will put it in either fake or original category

Suppose there are two categories, i.e., Category A and Category B, and we have a new data point x1, so this data point will lie in which of these categories. To solve this type of problem, we need a K-NN algorithm. With the help of K-NN, we can easily identify the category or class of a particular dataset. Considers the below diagram

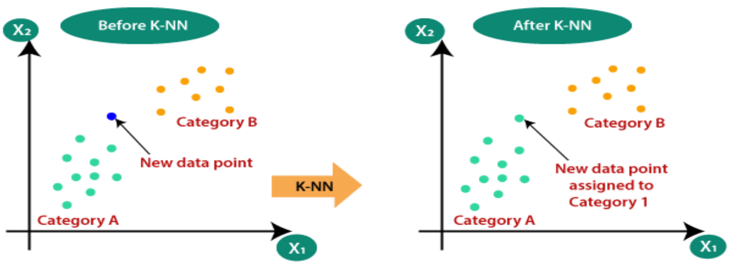


Fig 3.17 Comparison of K-N

K-NN working:

The K-NN working can be explained on the basis of the below algorithm:

- **Step-1:** Select the number K of the neighbours
- **Step-2:** Calculate the Euclidean distance of **K number of neighbours**
- **Step-3:** Take the K nearest neighbours as per the calculated Euclidean distance.
- **Step-4:** Among these k neighbours, count the number of the data points in each category.
- **Step-5:** Assign the new data points to that category for which the number of the neighbour is maximum.
- **Step-6:** Our model is ready.

Suppose we have a new data point and we need to put it in the required category. Consider the below image:

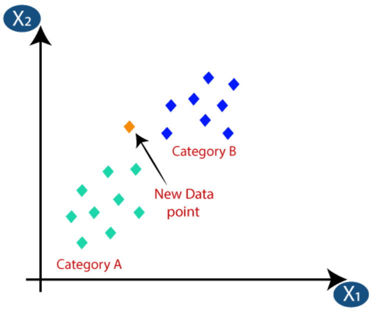


Fig 3.18 Giving input data point

- Firstly, we will choose the number of neighbours, so we will choose the k=5.
- Next, we will calculate the **Euclidean distance** between the data points. The Euclidean distance is the distance between two points, which we have already studied in geometry. It can be calculated as:

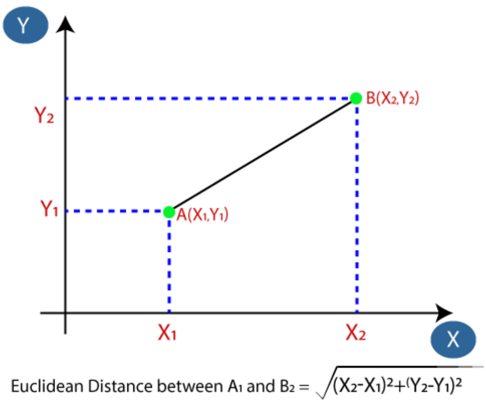


Fig 3.19 Finding Euclidean distance

- By calculating the Euclidean distance, we got the nearest neighbours, as three nearest neighbours in category A and two nearest neighbours in category B. Consider the below image:

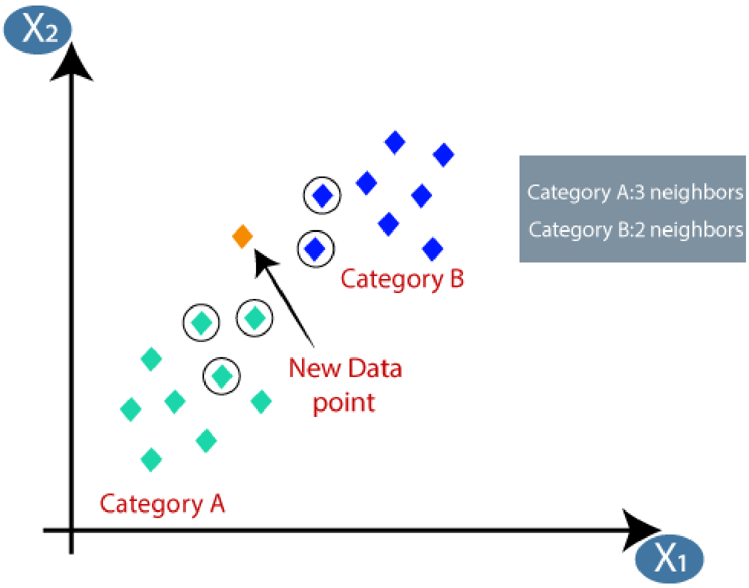


Fig 3.20 Allocation of data point

- As we can see the 3 nearest neighbours are from category A, hence this new data point must belong to category A.

Result of Best matches of given input image:

```
0   training-data/100_3.jpg    9
1   training-data/100_new_back.jpg    14
2   training-data/100_new_front.jpg    45
3   training-data/100_old_back.jpg    52
4   training-data/100_old_front.jpg    56
5   training-data/10_new_front.jpg    68
6   training-data/10_old_back.jpg    72
7   training-data/10_old_front.jpg    74
8   training-data/2000_new_back.jpg    85
9   training-data/2000_new_front.jpg    111
10   training-data/200_new_back.jpg    117
11   training-data/200_new_front.jpg    138
12   training-data/20_old_back.jpg    146
13   training-data/20_old_front.jpg    149
14   training-data/500_new_back.jpg    152
15   training-data/500_new_front.jpg    192
16   training-data/500_old_back.jpg    195
17   training-data/500_old_front.jpg    201
18   training-data/50_new_back.jpg    210
19   training-data/50_new_front.jpg    242
20   training-data/50_old_back.jpg    246
21   training-data/50_old_front.jpg    251
22   training-data/image_2000_25.jpg    256
23   training-data/image_2000_54.jpg    277
24   training-data/real_money.jpg    777
training-data/real_money.jpg
good matches   777
```

Fig 3.21 Best matches using K-NN

CHAPTER-4
SOFTWARE DESCRIPTION

4.1 Introduction:

Python is an open source, general purpose programming language that is easy to read and powerful. It is an interpreted language, which do not need to be compiled to run. Python is a high-level language that will make a programmer focus on what to do instead of how to do. Python has been designed to emphasize on code readability with its significant use of whitespace. Writing programs in Python is less time consuming compared to any other languages.

It is used for:

- web development (server-side),
- software development,
- mathematics,
- system scripting.

4.2 Components in Python:

- **Development Environment:** Introduces the Python development environment, including information about tools and all the libraries in python.
- **Mathematics**-introduces how to use python to generate Matrices and perform mathematical operations on matrices.
- **Graphics** - introduces Python graphic capabilities, including information about plotting data, annotating graphs, and working with images.
- **Programming with python** - describes how to use the python language to create scripts and functions, and manipulate data structures, such as cell arrays and multidimensional arrays.

python can be used on a server to create web applications, used alongside software to create workflows. Used to connect to database systems. It can also read and modify files. Used to handle big data and perform complex mathematics. can be used for rapid prototyping, or for production-ready software development.

5.3 Typical uses include

i. Math and computation
ii. Algorithm development
iii. Modelling, simulation, and prototyping
iv. Data analysis, exploration, and visualization
v. Scientific and engineering graphics
vi. Application development, including graphical user interface building

python is an interactive system whose basic data elements are array, strings, tress and many mathematical computations that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time python has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science.

Python consists of many libraries like keras, TensorFlow, subprocess, there used specially for the machine learning concepts like CNN, and basic Libraries like matplotlib, NumPy, computer vision etc

5.4 Different Modules used:

5.4.1 OpenCV: OpenCV is an open-source library for the computer vision. It provides the facility to the machine to recognize the faces or object. OpenCV is a Python open-source library, which is used for computer vision in Artificial intelligence, Machine Learning, face recognition, etc.

In OpenCV, the CV is an abbreviation form of a computer vision, which is defined as a field of study that helps computers to understand the content of the digital images such as photographs and videos.

The purpose of computer vision is to understand the content of the images. It extracts the description from the pictures, which may be an object, a text description, and three-dimension model, and so on. For example, cars can be facilitated with computer vision, which will be able to identify and different objects around the road, such as traffic lights, pedestrians, traffic signs, and so on, and acts accordingly.

Computer vision allows the computer to perform the same kind of tasks as humans with the same efficiency. There are a two main task which are defined below:

i. **Object Classification -** In the object classification, we train a model on a dataset of particular objects, and the model classifies new objects as belonging to one or more of your training categories.
ii. **Object Identification -** In the object identification, our model will identify a particular instance of an object - for example, identification of persons road, buildings, cars etc.

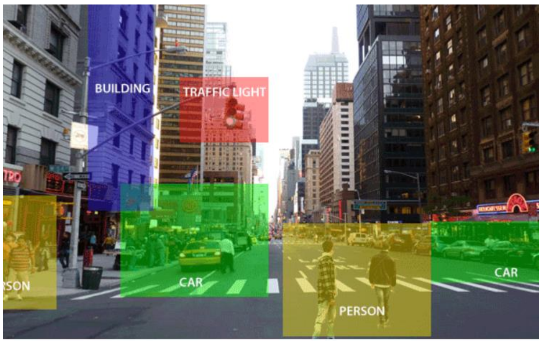


Fig 4.1 Identification of objects

5.4.2 Mathematical Module: The **math** module is used to access mathematical functions in the Python. All methods of this functions are used for integer or real type objects, not for complex numbers.

Some Constants

These constants are used to put them into our calculations.

Sr. No.	Constants & Description
1	**pi** Return the value of pi: 3.141592
2	**E** Return the value of natural base e. e is 0.718282
3	**tau** Returns the value of tau. tau = 6.283185
4	**inf** Returns the infinite
5	**nan** Not a number type.

Table 4.1 Constants in math module

Numbers and Numeric Representation

These functions are used to represent numbers in different forms. The methods are like below −

Sr. No.	Function & Description
1	**ceil(x)** Return the Ceiling value. It is the smallest integer, greater or equal to the number x.
2	**copysign(x, y)** It returns the number x and copy the sign of y to x.
3	**fabs(x)** Returns the absolute value of x.

4	**factorial(x)** Returns factorial of x. where $x \geq 0$
5	**floor(x)** Return the Floor value. It is the largest integer, less or equal to the number x.

Table 4.2 Numeric constants in math module

Power and Logarithmic Functions

These functions are used to calculate different power related and logarithmic related tasks.

Sr. No.	Function & Description
1	**pow (x, y)** Return the x to the power y value.
2	**sqrt(x)** Finds the square root of x
3	**exp(x)** Finds xe, where e = 2.718281
4	**log (x [, base])** Returns the Log of x, where base is given. The default base is e
5	**log2(x)** Returns the Log of x, where base is 2
6	**log10(x)** Returns the Log of x, where base is 10

Table 4.3 Power and log functions in math module

5.4.3 NumPy:

NumPy is a Python library used for working with arrays. It also has functions for working in domain of linear algebra, Fourier transform, and matrices. NumPy was created in 2005 by Travis Oliphant. It is an open-source project and you can use it freely. NumPy stands for Numerical Python.

Why Use NumPy?

In Python we have lists that serve the purpose of arrays, but they are slow to process.

NumPy aims to provide an array object that is up to 50x faster than traditional Python lists.

The array object in NumPy is called ndarray, it provides a lot of supporting functions that make working with ndarray very easy.

Arrays are very frequently used in data science, where speed and resources are very important.

4.4.4 Matplotlib:

Matplotlib is an amazing visualization library in Python for 2D plots of arrays. Matplotlib is a multi-platform data visualization library built on NumPy arrays and designed to work with the broader SciPy stack. It was introduced by John Hunter in the year 2002.

One of the greatest benefits of visualization is that it allows us visual access to huge amounts of data in easily digestible visuals. Matplotlib consists of several plots like line, bar, scatter, histogram etc.

Installation:

Windows, Linux and macOS distributions have matplotlib and most of its dependencies as wheel packages. Run the following command to install matplotlib package: python -mpip install -U matplotlib

Importing matplotlib:

from matplotlib import pyplot as plt

or

import matplotlib.pyplot as plt

5.5 Python system:

- Development Environment: This is the set of tools and facilities that help you use PYTHON functions and files. Many of these tools are graphical user interfaces. It includes the PYTHON desktop and Command Window, a command history, and browsers for viewing help, the workspace, files, and the search path.
- The Python Mathematical Function Library: This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

- The Python Language This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.
- Handle Graphics This is the PYTHON graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete graphical user interfaces on your PYTHON applications.

5.6 Some Basic Commands:

1. For downloading packages and installation: There are many packages in python to work on it for e.g., computer vision and basic command (pip install CV2), TensorFlow (pip install TensorFlow)
2. For loading a package: The basic command used for loading a package is import name as other name
3. To check for working directory: The basic command used to check working directory is import OS (OS.getcwd())
4. For setting path to directory: The command used for setting path to directory is os.chdir('path')
5. Listing Files in directory:os.listdir('path')
6. List all objects: globals()
7. Remove an Object:del('object')
8. Append an object: append.[]
9. See manual for a function: help(help)
10. See type of object: type(object)
11. For mathematical operations: In python the main libraries used id NumPy and basic function used for mathematical operations e.g.: math.sqrt()

5.7 Familiarizing with python:

we will run a simple program to print **Hello World** on the console.

Python provides us the two ways to run a program:

- Using Interactive interpreter prompt
- Using a script file

Interactive interpreter prompt:

Python provides us the feature to execute the Python statement one by one at the interactive prompt. It is preferable in the case where we are concerned about the output of each line of our Python program

To open the interactive mode, open the terminal (or command prompt) and type python (python3 in case if you have Python2 and Python3 both installed on your system).

It will open the following prompt where we can execute the Python statement and check their impact on the console.

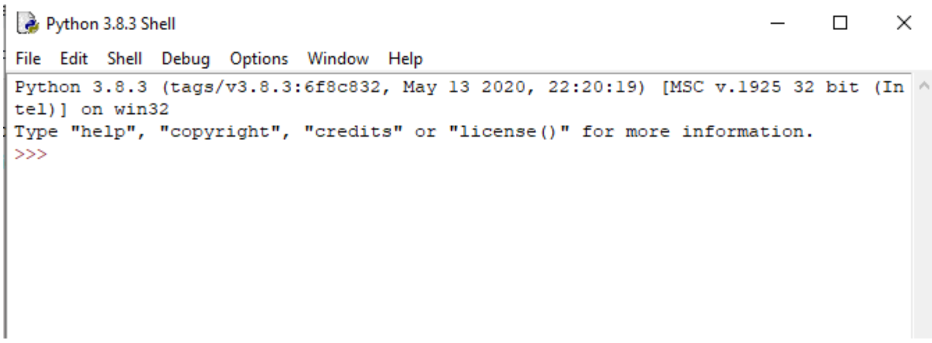


Fig 4.2 Python shell

After writing the print statement, press the **Enter** key.

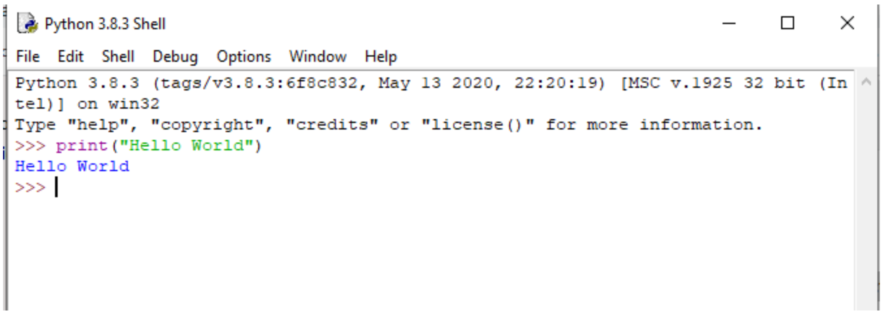


Fig 4.3 Output in Python shell

Here, we get the message **"Hello World!"** printed on the console.

Using a script file (Script Mode Programming):

The interpreter prompt is best to run the single-line statements of the code. However, we cannot write the code every-time on the terminal. It is not suitable to write multiple lines of code. Using the script mode, we can write multiple lines code into a file which can be executed later. For this purpose, we need to open an editor like notepad, create a file named and save it with **.py** extension, which stands for **"Python".** Now, we will implement the above example using the script mode.

To run this file named as first.py, we need to run the following command on the terminal.

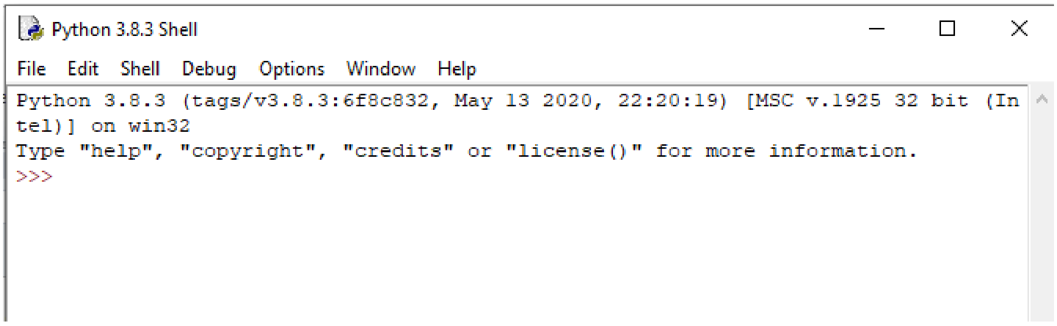


Fig 4.4 Python shell in script mode

Step - 1: Open the Python interactive shell, and click **"File"** then choose **"New",** it will open a new blank script in which we can write our code.

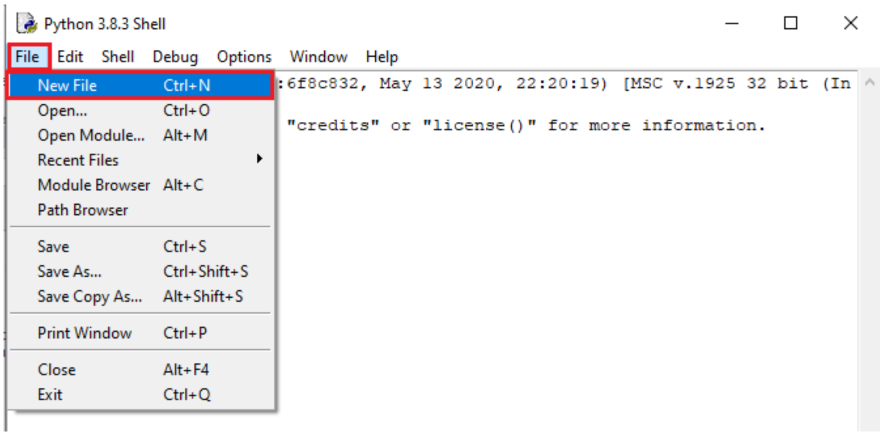


Fig 4.5 Creating file in python shell

Step -2: Now, write the code and press **"Ctrl+S"** to save the file.

Fig 4.6 working in python file

Step - 3: After saving the code, we can run it by clicking "Run" or "Run Module". It will display the output to the shell.

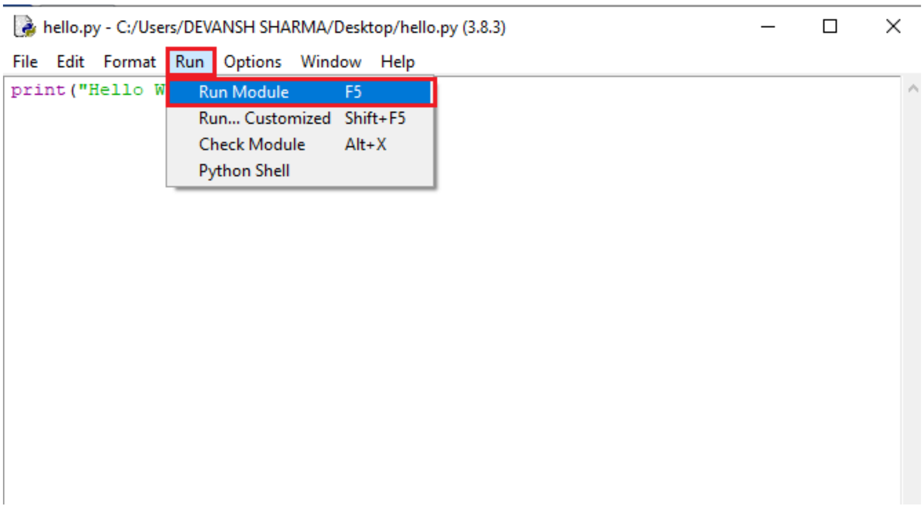


Fig 4.7 Running the python file

The output will be shown as follows.

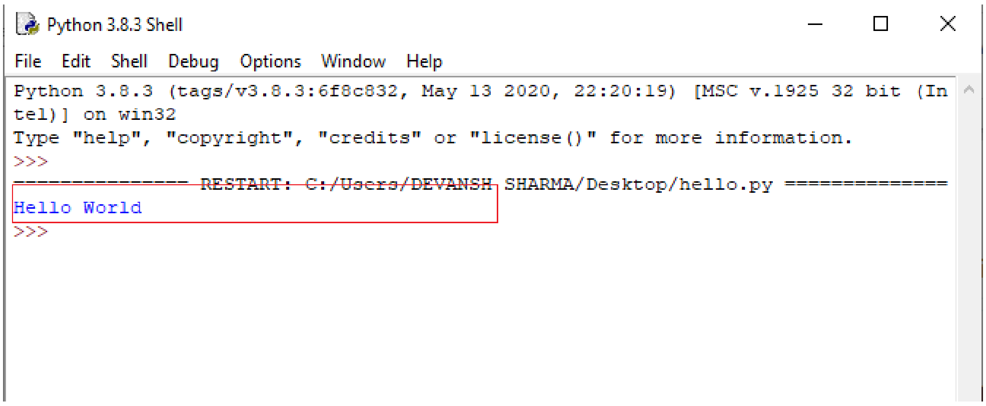


Fig 4.8 Output in python shell

CHAPTER-5

SIMULTATION RESULTS

5.1 sample simulation results:

5.1.1 Original currency:

Input image:

Fig 5.1 Input image

Pre-processing of Input image:

1.Resize:

.

Fig 5.2 Resized image

2.Negative:

Fig 5.3 Negative Transformation

3.gray scale conversion:

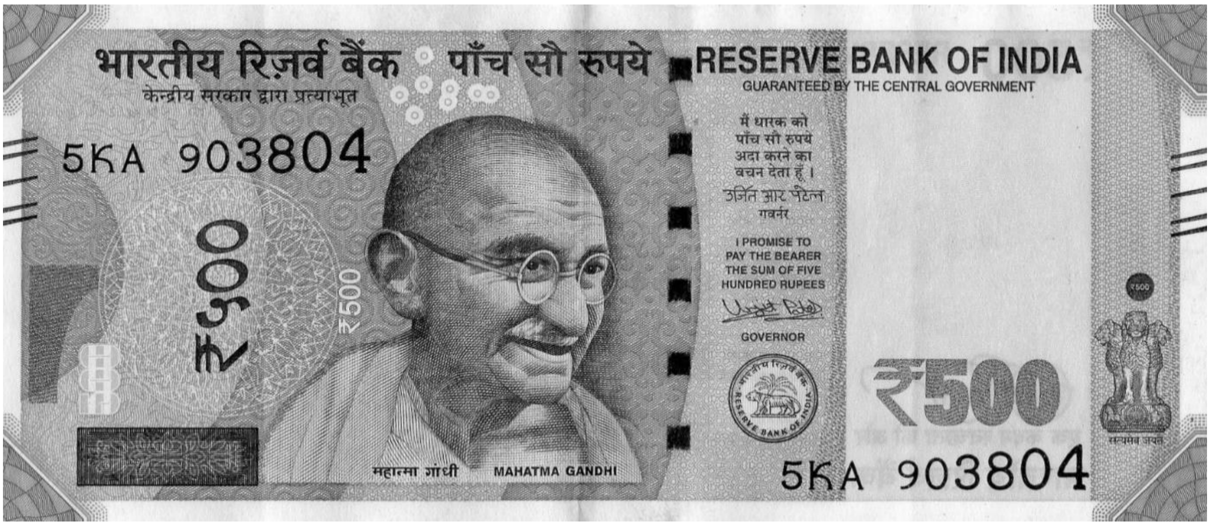


Fig 5.4 Grey scale conversion

4.Edge detection:

5.Morphogical processing:

- **Dilation**:

Fig 5.5 Dilation

Closing:

Fig 5.6 Closing

6.Filtering:

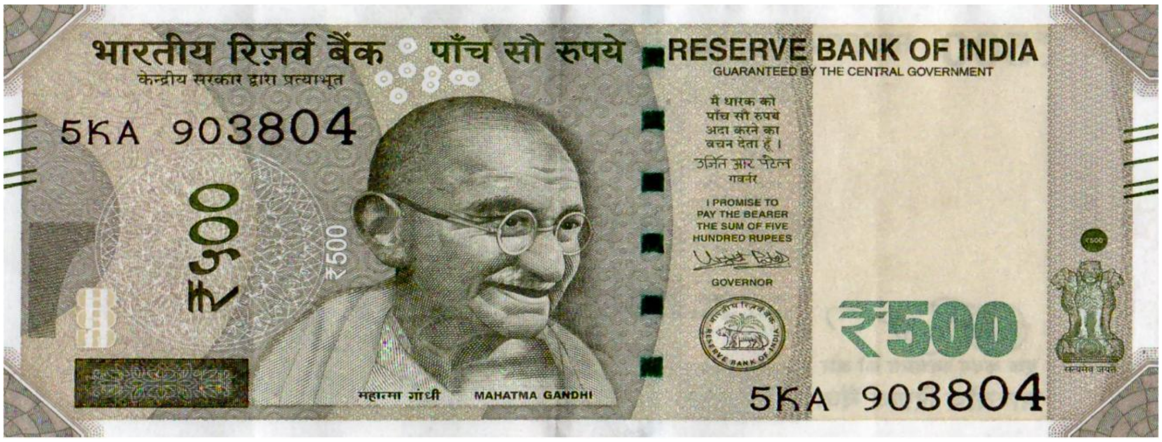


Fig 5.7 Median filter

SEGEMENTED IMAGE:

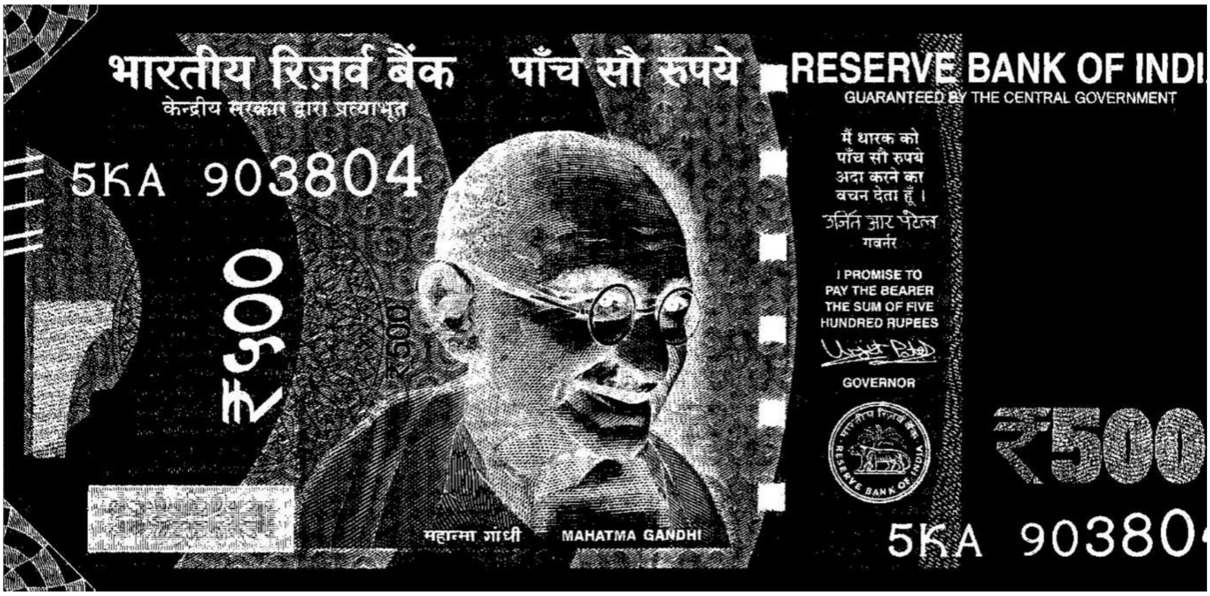
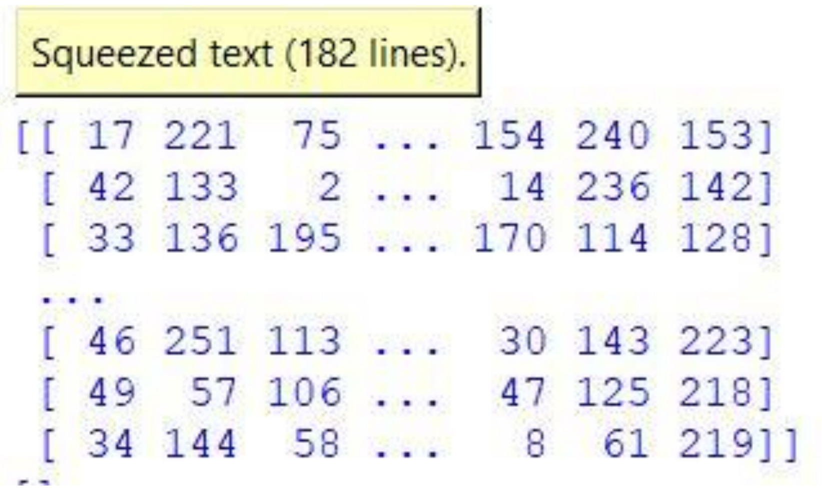


Fig 5.8 Segmentation

Oriented Fast and Rotated Brief Detector (ORBD):

- Finds the keys in given input image and descriptors in trained images (for best match image)



```
Squeezed text (182 lines).
[[ 17 221  75 ... 154 240 153]
 [ 42 133   2 ...  14 236 142]
 [ 33 136 195 ... 170 114 128]
 ...
 [ 46 251 113 ...  30 143 223]
 [ 49  57 106 ...  47 125 218]
 [ 34 144  58 ...   8  61 219]]
```

Fig 5.9 Keys and descriptors

Brute force matcher:

Brute Force Matcher is used for matching the features of the first image with another image. It takes one descriptor of first image and matches to all the descriptors of the second image and then it goes to the second descriptor of first image and matches to all the descriptor of the second image and so on.

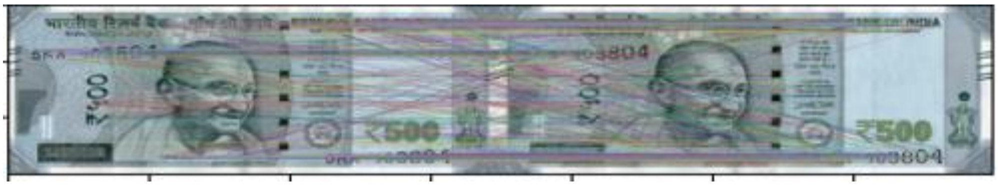


Fig 5.10 Brute force Matcher

K-NN for best matches:

```
0   training-data/100_3.jpg   9
1   training-data/100_new_back.jpg   14
2   training-data/100_new_front.jpg   45
3   training-data/100_old_back.jpg   52
4   training-data/100_old_front.jpg   56
5   training-data/10_new_front.jpg   68
6   training-data/10_old_back.jpg   72
7   training-data/10_old_front.jpg   74
8   training-data/2000_new_back.jpg   85
9   training-data/2000_new_front.jpg   111
10   training-data/200_new_back.jpg   117
11   training-data/200_new_front.jpg   138
12   training-data/20_old_back.jpg   146
13   training-data/20_old_front.jpg   149
14   training-data/500_new_back.jpg   152
15   training-data/500_new_front.jpg   192
16   training-data/500_old_back.jpg   195
17   training-data/500_old_front.jpg   201
18   training-data/50_new_back.jpg   210
19   training-data/50_new_front.jpg   242
20   training-data/50_old_back.jpg   246
21   training-data/50_old_front.jpg   251
22   training-data/image_2000_25.jpg   256
23   training-data/image_2000_54.jpg   277
24   training-data/real_money.jpg   777
training-data/real_money.jpg
good matches  777
```

4.2 Fake currency:

Fig 5.11 Input image

- **Resize**

Fig 5.12 Resized image

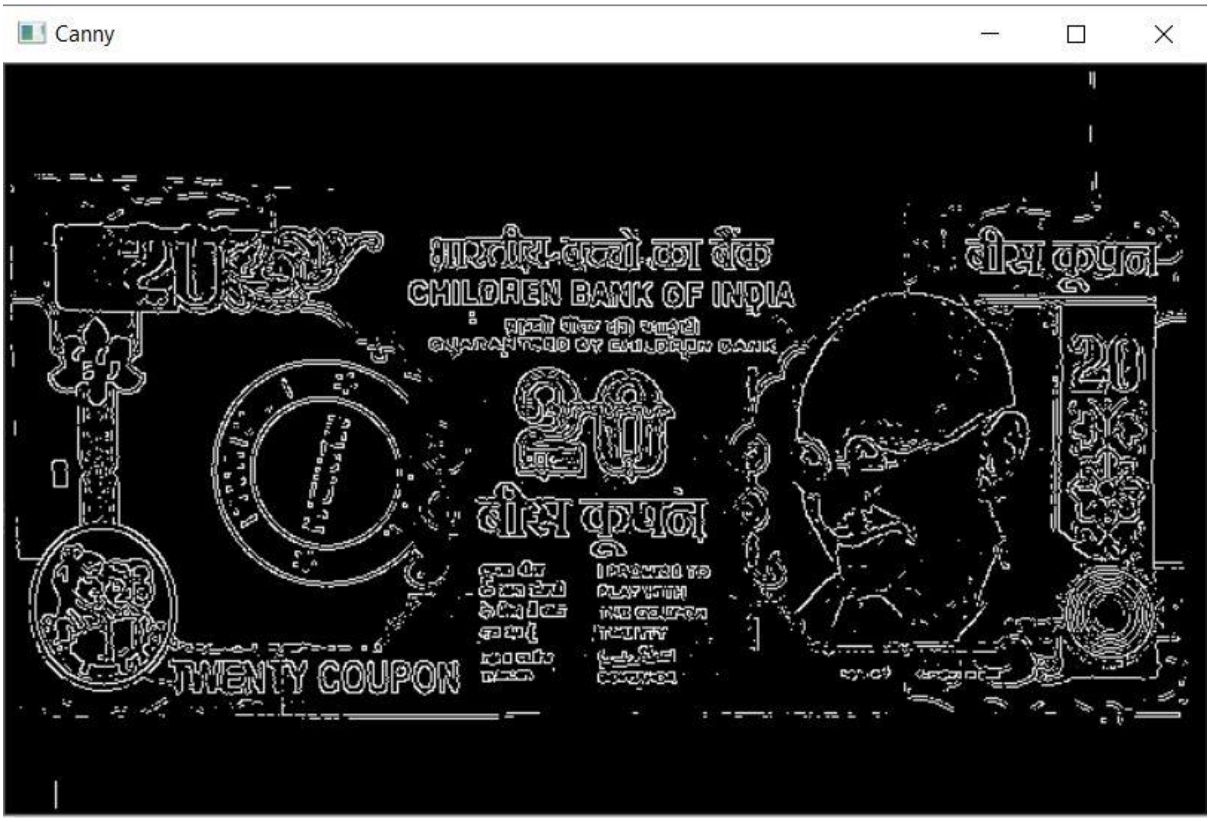
- **Negative**

Fig 5.13 Negative Transformation

- **Greyscale**

Fig 5.14 Grey scale conversion

- **Edge detection:**



Morphological processing:

- **Dilation**

Fig 5.15 Dilation

- **Closing**:

Fig 5.16 Closing

- **Median filter:**

Fig 5.17 Median filter

Segmented image:

Fig 5.18 Segmentation

Oriented Fast and Rotated Brief Detector (ORBD):

```
Squeezed text (182 lines).
[[ 74 208  80 ...  12  13 214]
 [244  76  22 ... 121  60   2]
 [  0 249 145 ... 216 133 169]
 ...
 [ 78 180 176 ...  76 135 242]
 [ 57 168 146 ...  21  34 168]
 [ 43  19  97 ... 142  16 245]]
```

Fig 5.19 Keys and   descriptors

Brute force matcher:

Fig 5.20 Brute force Matcher

K-NN implementation for best matches:

```
0   training-data/100_3.jpg   3
1   training-data/100_new_back.jpg   5
2   training-data/100_new_front.jpg   6
3   training-data/100_old_back.jpg   7
4   training-data/100_old_front.jpg   9
5   training-data/10_new_front.jpg   9
6   training-data/10_old_back.jpg   9
7   training-data/10_old_front.jpg   10
8   training-data/2000_new_back.jpg   10
9   training-data/2000_new_front.jpg   13
10   training-data/200_new_back.jpg   13
11   training-data/200_new_front.jpg   13
12   training-data/20_old_back.jpg   15
13   training-data/20_old_front.jpg   16
14   training-data/500_new_back.jpg   17
15   training-data/500_new_front.jpg   17
16   training-data/500_old_back.jpg   17
17   training-data/500_old_front.jpg   19
18   training-data/50_new_back.jpg   20
19   training-data/50_new_front.jpg   22
20   training-data/50_old_back.jpg   22
21   training-data/50_old_front.jpg   22
22   training-data/image_2000_25.jpg   24
23   training-data/image_2000_54.jpg   24
24   training-data/real_money.jpg   25
training-data/real_money.jpg
good matches  25
```

- **Fig.5.21 Results of Other denomination:**
- 20RS

Squeezed text (170 lines).

```
[[ 50 157 106 ...  26 112 174]
 [ 36  31 125 ... 235  84 251]
 [ 23 203  70 ...  23 185   5]
 ...
 [128 128 157 ...  89   5 170]
 [117  77  74 ... 251 210 112]
 [ 41 145 124 ... 138 248 169]]
```


```
training-data/real_money.jpg
good matches  150
```

- 200 RS

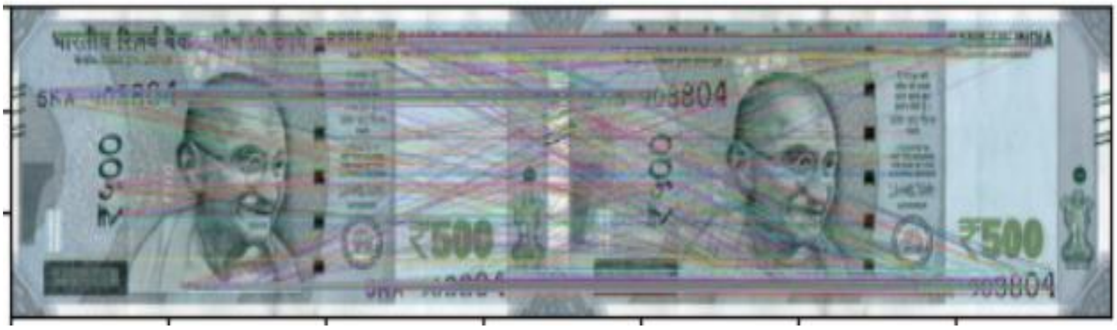
Squeezed text (182 lines).

```
[[ 52  29 254 ... 121 236 115]
 [ 46 121 172 ... 127 151  70]
 [ 14 181  50 ...  15 189 134]
 ...
 [130 177 119 ...  12 165 179]
 [230 120  59 ... 184 181 161]
 [ 67 148 186 ... 116 175  86]]
```


```
training-data/real_money.jpg
good matches  329
```

- 500 RS

```
Squeezed text (182 lines).
[[ 17 221  75 ... 154 240 153]
 [ 42 133   2 ...  14 236 142]
 [ 33 136 195 ... 170 114 128]
 ...
 [ 46 251 113 ...  30 143 223]
 [ 49  57 106 ...  47 125 218]
 [ 34 144  58 ...   8  61 219]]
```



```
training-data/real_money.jpg
good matches  777
```

- 100 RS:

```
Squeezed text (182 lines).
[[134  86 111 ... 123  49  56]
 [225 222 245 ... 130 194 189]
 [186 217  36 ...  28 248 154]
 ...
 [ 92 122 255 ... 241  38 243]
 [197  41 154 ... 224  33 161]
 [126 192  58 ...  11 116  98]]
[]
```

```
training-data/real_money.jpg
good matches  694
```

- 10 RS:

Squeezed text (182 lines).

```
[[127  29  99 ... 247  84 119]
 [ 61  61 123 ... 231  78 229]
 [111   1 163 ... 102 126 118]
 ...
 [ 35 158 235 ...  14 247 247]
 [154 147 254 ... 168  69 243]
 [  1 157 137 ... 249 177 241]]
```

```
training-data/real_money.jpg
good matches  241
```

- 2000 RS:


```
[[ 10  56 126 ...  12   7 255]
 [ 98 216 237 ...  10  84 122]
 [ 46 113 124 ...  59  91 147]
 ...
 [187  53  82 ...  12  89 156]
 [126  64 110 ... 252 126 198]
 [  3  82 109 ... 240 227 253]]
```

```
training-data/image_2000_54.jpg
good matches  441
```

20 RS:


```
[[182 125 107 ... 187 118 254]
 [114 211  99 ... 174 118 245]
 [  3 118 238 ... 202 248 223]
 ...
 [ 90  21  51 ...  68  37  94]
 [123  25 227 ... 174 124 250]
 [232 253 188 ...  89 214 154]]
[]
```


```
training-data/image_2000_54.jpg
good matches  121
```

- 50 RS:


```
[[195  32 238 ... 132  41  64]
 [ 65 192 145 ... 170 129  32]
 [  9  18 111 ... 128 111 249]
 ...
 [153  17 235 ... 200 244 248]
 [194 144 147 ...   0 165 179]
 [  2 170 178 ...   8 129 169]]
```


```
training-data/50_old_front.jpg
good matches  300
```

Fig.5.22 Original currency with ink mark:


```
[[ 99  80 186 ...   4 171  95]
 [ 66 248 181 ...   9 135 242]
 [161 205  73 ... 154  80 168]
 ...
 [253  79  97 ... 251 210 120]
 [ 55 255 233 ... 255  80  85]
 [126  54 172 ... 127  60  87]]
```


```
training-data/image_2000_54.jpg
good matches  132
```

Fig. 5.23 Original currency colour xerox:

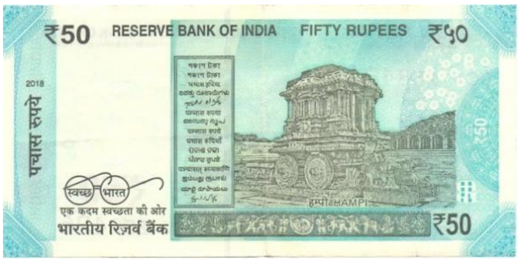

```
[[  7 173 168 ... 116 219 218]
 [ 59 181 121 ... 136 176 251]
 [ 98 152 236 ...  41  84  90]
 ...
 [159  85  98 ... 247 177  87]
 [159  80 234 ... 246  57 211]
 [147 123 251 ... 245  39 249]]
```


```
training-data/real_money.jpg
good matches  98
```

- 50 RS Colour xerox:


```
[[ 46  59 196 ... 191  88 176]
 [113 147 249 ...  10 196 161]
 [ 47 184 198 ... 252 218 148]
 ...
 [ 62 111 243 ... 247 102 173]
 [128 130 154 ...  72 169 138]
 [194 146 216 ...   8 169 143]]
```

- 50 RS new note:




```
Squeezed text (126 lines).
[[ 46  59 196 ... 191  88 176]
 [113 147 249 ...  10 196 161]
 [ 47 184 198 ... 252 218 148]
 ...
 [ 62 111 243 ... 247 102 173]
 [128 130 154 ...  72 169 138]
 [194 146 216 ...   8 169 143]]
```


```
training-data/image_2000_54.jpg
good matches  46
```

- **2000Rs Colour xerox:**


```
[[ 46  59 196 ... 191  88 176]
 [113 147 249 ...  10 196 161]
 [ 47 184 198 ... 252 218 148]
 ...
 [ 62 111 243 ... 247 102 173]
 [128 130 154 ...  72 169 138]
 [194 146 216 ...   8 169 143]]
```


```
training-data/image_2000_54.jpg
good matches  78
```

CHAPTER-6
CONCLUSION AND FUTURE SCOPE

6.1 Conclusion:

Inclusion of currency without legal sanction of government is illegal and it causes various threats for any country. Due to the advancement in technology counterfeiting the currency is very easy now a days, it is very difficult to differentiate between original currency and counterfeit currency. Therefore we have proposed a system to detect such types of notes, This proposed system is implemented on python software .In this technique we have used all types of Indian currencies and performed the Image processing steps like resize, greyscale conversion, filtering, Morphological processing and segmentation and this so called steps are called pre-processing, and the main step in feature matching we used ORBD detectors for the matching the keys and descriptors for the specified image and further we have using the K-NN supervised learning algorithm with brute force matcher for the best matching of features .In this system we have used about 30 currencies of all denomination out of that 23 are original 7 are fake ,the proposed system classified between original and fake currencies The system can be made more reliable by using a larger number of data and more relevant features for accurate classification can be found out.

6.2 Future scope:

In this project Image processing techniques like Resizing, edge detection, filtering, and morphological processing in addition to that, concepts from computer vision and Machine learning are included like ORB detector and brute force matcher and flan-based matcher and K-NN supervised algorithm for accurate detection of fake and original notes. Future work should focus on the more accurate detection if we use Decision tree and with deep learning and creating like user interface like GUI it is more effective and easier to given input to the system. And it must also focus on the detection of coins also and it requires artificial intelligence and as well as texture and colour detection of original as well as fake notes

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