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A Survey on Image Feature Extraction Techniques

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Abstract-Images play a vital role in various real-life areas like Object Detection, Image Classification, Image Detection, etc. While studying about images we come across various types of image features such as colour, shape, texture, etc. These image features are mainly used to illustrate the important features or properties of an image that can be used to classify and identify it. This paper provides a detailed study of various image features and its extraction techniques methods along with their mathematical function, real-life application and advantages of these features.

Index Terms-Image Features, Feature extraction techniques, Image processing.

I. INTRODUCTION

Image Features contributes a very significant part in image processing and image analysis tasks. Image Features are characteristics or properties of an image that are mostly used in tasks such as object detection, image classification, picture recognition, etc.

Features help us to know important information from an image and with the help of these features we can distinguish more than one object from each other. Before studying about features we need to perform image pre-processing on an image. Once the image pre-processing is done, we need to do feature extraction from an image to extract useful features. We will be studying about various image features such as colour, shape, corners, edges. [1]

The technique for extracting the feature from an image is of great use when we have tremendous amount of data and we need to decrease the size of data without losing any suitable information [2]. At the end, we can set up the model with less machine effort as the input data is of less size which helps in increasing the performance and speed of learning a model. [3] Feature extraction have an efficient role in determining the overall performance of the model. CNN Based feature extraction were used before but due to lack of responsibility and computationally being expensive it was less preferred. On the other hand, traditional methods are preferred recently, because they are intensive and have domain knowledge that make them a better alternative than CNN. [1]

The survey paper is broadly classified into 3 main parts:-

- In first part, we studied about what is image processing and various steps involved while performing image processing on any image data.
- Next, we provided a detailed information about various types of image features available along with their mathematical equations, advantages and application.
- To extract these features from an image, various image feature extraction method are applied.Their aim is to extract relevant information from the image data such as edge, color, corner, key point, shape and many more.

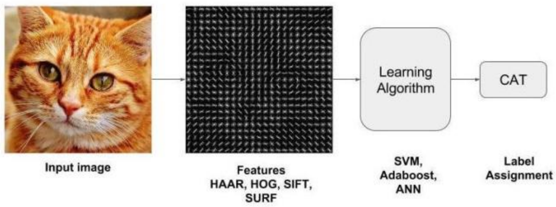

Fig. 1: Basic working of the system

II. BACKGROUND AND LITERATURE SURVEY

1. Image Processing

It is an important part of machine learning, which is used for modifying an image into its another useful form and performing some changes on an image to get useful information from it. Image processing is prominently used application in areas such as computer vision, machine and deep learning. Image processing can improve the performance of many models. [4]
Steps in Image Processing-

- **Image Acquisition-** It is primary step in image processing. We can retrieve the image from any useful area. [5]
- **Image Enhancement-** It process of highlighting important features of an image that can bring some changes in brightness, contrast, etc. [6] [7]
- **Image Restoration-**It is a process done using mathematical model and with the help of that we can improve the appearance of an image. [8] [7]
- **Compression-** It is a process of reducing the storage value to save an image. [9] [10]
- **Segmentation-** It is a very difficult stage in image processing. In this step, we divide or partition a particular image into its smaller parts. [11] [12]

2. Image Features

In this part, we will discuss various types of image features used during the study. We will explain them one by one. [1]

Color Features

Color is most important com- ponent of image features.Color provides better and more information about any image.While comparing with other features, color features shows more stability and is more robust to changes in rotation, zoom, etc. Types of color features are:

Color Moments:

It is a type of color features used in an image data.Theyare represented as scales that differ- entiate images based on their own colors. It can represent the distribution of colors in an image very effectively. They are computationally simple and have good storage. Color Moments are further divided into 3 parts: [13]

Mean:

It is defined as the mean or average color value present in an image.

$$Mj = \sum_{m}^{i=1} \frac{1}{M} Pji$$

where M is mean value,P is pixel at point (i,j)

Standard Deviation

It is defined as the square root of the distribution of colors in an image.

$$\sigma j = \sqrt{\frac{1}{M} \sum_{m}^{i=1} (Pji - Mj)^2}$$

Skewness

It is defined as the measure of the degree or level of asymmetry in the color distribution of image.

$$Sk = \sqrt{\frac{1}{m} \sum_{m}^{i=1} (Pji - Mj)^3}$$

ColorCorrelogram

This feature is used as color feature in a large image database.It describes the geometric correlation of color change in an image. It helps to distinguish an image from other images from a dataset.This feature is very scalable for image retrieval and is extension of color histogram

$$\gamma cicjj(I) = P[p2 € Icj, |p1 - p2| = k, p1 € Ici$$

where p1,p2 are pixels and ci,cj are colors at point(i,j)

Application of Color Features

- Color features is widely in areas such as face recognition, medical disease prediction and object detection.
- Color feature is also applied in areas of pattern recog- nition and image processing.

Advantages of Color Features

- Color features have power to distinguish objects in an image very easily and more accurately.
- These features are robust to changes in rotation, zoom, lightening and viewpoints.
- As compared to other features, color features are often less expensive to compute and are used in real-life applications.
- Color features can be combined with other features as well, to improve their overall performance.

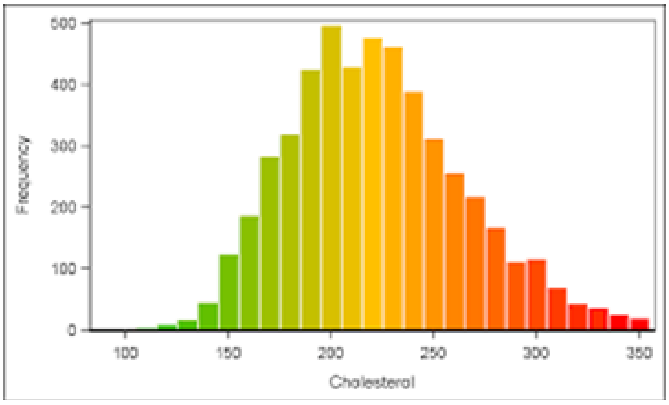

Fig. 2:Color Histogram of the image

Texture Features

It is another feature compo- nent in an image data.Texture often represent the arrangement of different structure in an image. Texture also tells us the information about any image.Texture is easy to recognize by human beings.Texture can be quantitative and qualitative.It is broadly classified into 2 parts:

Statistical Features

These features are used to under-

Contrast

It is the measure of intensity or local variations between a pixel and neighbouring pixels.It also measures the brightness of object in an image [14].

$$F = \sum_{m}^{Mg-1} m^2 [\sum_{i=0}^{Mg-1} \sum_{j=0}^{Mg-1} d, \theta(i, j)]$$

where m=mod(i,j) and (i,j) are diagonals

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Entropy
It is a measure of the level of disorder or disturbance present in an image. It also measures the amount of information in an image.

$$E = -\sum(P * \log(P))$$

where P is probability vector

Mean
It is defined as the amount of color or brightness present in an image.

$$\text{Mean} = \sum_{i=1}^{r}\sum_{j=1}^{t}\frac{q(i,j)}{rt}$$

where q(i,j) is intensity value of pixel at point (i,j)

Energy
It measures the intensity level distributions of an image.Energy can sometimes be positive or negative measure.

$$E = \sum[P(i)]i = 1$$

Haralick Feature
It is quantifiable measure of the texture feature.It is computed using GLCM.It looks for the adjacent pair of pixel value in an image and keep moving around the whole image.
Application of texture features-

- Texture Feature can be used in areas such as virus detection. Texture of virus can analyze malware efficiently and prevent harm from other viruses.
- Texture feature is used in OEPF model for picture position hiding with minimum distortion and disturbance.
- Texture feature has great application in action recognition.It identifies viewpoint, locations and changes in background which easily identify human actions in real- life.
- This feature can also be used in areas like remote sensing, biomedical imaging and image in painting.

Advantages of Texture Features

- Texture feature has the ability to take out important information from the pixels in an image.
- These features can differentiate different types of texture easily as compared to other features.
- It can easily capture or extract local or spatial arrange-ment information from an image.
- Texture feature are robust to change and are efficient for real life problems.

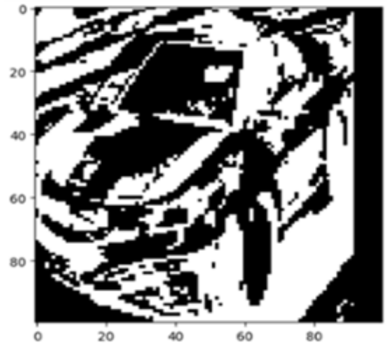

Fig. 3: Texture Feature from car image

Shape Features
It is an important feature of an image.Shape can either be region or boundary based.They are described when image has been segmented into different regions or objects.With the help of shape features objects can be recognised with their outline.Shape features can be categorized as follows: [13]

Boundary Based Features
These are the features that describe the characteristics of objects in an image.It is of following types:

Perimeter
The perimeter of any object boundary is the length of the smallest boundary in any region.We use chain code to calculate perimeter.

$$P = M + 2N$$

where M is value of counter(even) and N is value of counter(odd)

Circularity Ratio
It describes how much circle a shapecanbe.Itisdefinedasratiobetweenareaandperimeterofshape.

$$C = \frac{A}{P}$$

whereA is are aandPisperimeter
Eccentricity:
Wehaveminoraxisandmajoraxisina line.Ratio od major axis to minor axis is defined aseccentricityofshape.

Curvature
It is defined as rate of total border pixels tonumberofboundarypixels.

Solidity
Itdescribestheextenttowhichshapeisconvexandconcave.

$$So = \frac{As}{H}$$

whereAsisareaofshapeandHisconvexhullarea

Regional Based Features
These are the features thatdescribe the interior details of objects in an image.It is offollowingtypes:

Regional Area
This is calculated as number of pixels in a region.Value of pixels within region is 1 whereas value of pixels outside the region is 0.

$$A=\sum(x,y)$$

where(x,y) are points within region
Roundness
It measures the degree to which shape is circle.

$$C=\frac{4\pi A}{P}$$

where P is perimeter of region, A is area of region and C is denoting roundness

Regional Focus
It calculates the coordinates of all points present in the region.

$$x = \frac{1}{A\sum(x,y)\text{€}Rxy}$$

where A is the area of region R at point (x,y)

Application of Shape Features
- The shape feature is used in watermarking model to protect the illegal duplication editing and modification of data. This will help the model to work against geometric attacks.
- Shape features can be used for medical image retrieval. It uses region based feature for the retrieval of CT Scan images.
- Shape features is used in the area of fingerprint analysis, that helps in identification and pattern matching.
- New shape feature extraction method is used for all shape features of a plant leaf data. It helps to improve accuracy of plant leaf recognition.

Advantages of Shape Features
- Shape features are often robust to variations in lighten-ing, texture, rotation as compared to other image features.
- Shape feature can distinguish between two objects as they have the ability to identify unique properties of any objects.
- Shape feature are affine invariant i.e., they preserve their shape even after any changes are made on them.
- These features are robust to noise i.e., any strengths of noise cannot affect the shape.

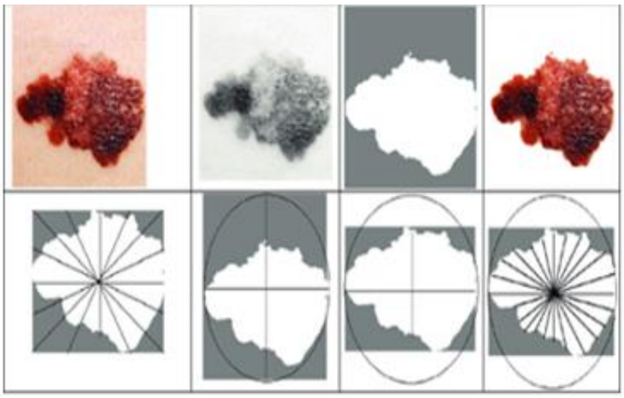
Fig. 4: Shape Feature example

Edge Features
Edges are those place in an image that define object boundaries.Edges are pixels where image brighter changes.It is of following types:

Step Edges
Step edges represent a sudden change in intensity or colour, creating a sharp transition from one region to another.

Ramp Edges
Ramp edges are more gradual transi- tions between regions, characterized by a gradual change in intensity or colour.

Noisy Edges
Noisy edges can be a result of sensor noise. It can be calculated as:

Gradient Magnitude

$$G(x, y) = \sqrt{Gx(x,y)^2 + Gy(x,y)^2}$$

Gradient Direction

$$\theta(x, y) = \arctan2(Gx(x, y), Gy(x, y))$$

where (x,y) are coordinates of an image,Gx and Gy are horizontal and vertical gradient coordinates and arctan2 is arctangent function that returns the angle

Application of Edge Features
- Edge feature is mostly used in area of fingerprint recognition because its enhances the quality of an image and helps in better image recognition.

- With the help of bilateral filtering based edge detection method, we can get better edge images which are more accurate and precise.
- Nowadays, we can make use of edge features in self-driving vehicles i.e., robotics, that will set the steering wheel on the basis of road.
- Edge features are also used in medical area for tumor detection in humans. It provide 3D reconstruction of human brain.

Advantages of Edge Features

- Features are robust to changes in intensity, discontinuity in image features.
- These features are used in various tasks such as image processing, computer vision and machine vision.
- These helps in representing image in a better way that reduce complexity.
- These are scale-invariant that means it can produce the edges regardless the size of images.

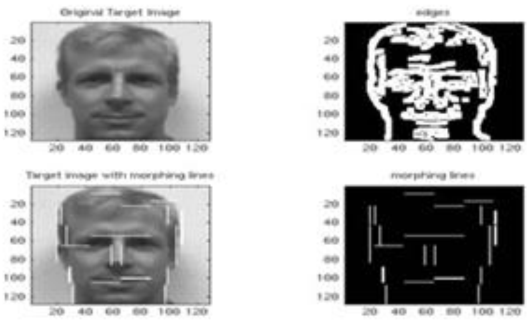

Fig. 5: Edge Feature from original image

Corner Features

Corners can be defined as a point in image where two different edges meet.It usually represents an interesting point in an image that has well- defined structure.It is considered as very effective features in an image.It can be mathematically represented as:

Harris Corner Detector

This detector calculates the corner using following function which is defined as:

$$\mathbf{R = \lambda 1 \lambda 2 - k(\lambda 1 + \lambda 2)^2}$$

where R is response function, λ1 and λ2 are eigen value around the structure around the pixel(x,y),k is constant

Shi-Tomasi Corner Detector

It is another version of harris corner detection based on minimum eigenvalue.

$$\mathbf{R = \min(\lambda 1 \lambda 2)}$$

Application of Corner Features

- Corner features is used in underwater target detection method of sonar images which provide them the target size of the images that helps in better prediction and more accuracy of images.
- Corner features can also be used in gesture recognition of human beings to detect their hands and fingerprints.
- These features can be used for image quality assessment that evaluate the sharpness, contrast, clarity and quality of image.
- 3D reconstruction of objects in an image can be done with the help of corner feature that can be applied in 3D modelling.

Advantage of Corner Features

- Corner feature are computationally efficient and have wide application in real-life like image and video processing.
- Corner features are often robust to changes in illumination that enhances the reliability of stability of various algorithms.
- These features are interpretable that means they have the ability to understand high level images that is used for various applications.
- These features provide sparse representation of an image focusing on the key points of an image.

Fig. 6: Corner Feature from car image

Key Point Features

This feature is used in computer vision tasks to identify the location of object in an image.Key point feature allow computer to identify and extract distinctive features from an image.It identifies sim- ple,distinctive points and locations within an image, that helps machine to analyze and interpret the images very ef- ficiently.Few types of key points features are: [15]

- **Human Pose Estimation:**This type identifies feature within human being.
- **Hand Pose Estimation:**This type of feature identifies human body parts like hand, fingers, etc.
- **Facial Key Points:**this type of feature identifies key points of human faces.

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- **Animal Key Points:**This last type of key point feature helps to identify key points of animals. Key points can be mathematically calculated as:

$$\mathbf{D(X, Y, \sigma) = (G(x, y, K\sigma) - G(x, y, \sigma)) * I(x, y)}$$

where G(x,y) is blurred image, σ is scale,k is scale factor, I(x,y) is original image.

Application of Key Point Features

- Key point feature is essential for object detection especially in area of robotics, where robot can identify objects in its environment and make a movement or prediction around the objects.
- Key point feature is also useful in area of augmented reality for gaming, marketing to deal with objects in real world.
- This feature is also useful for human pose detection.It identifies important key points of an human body like arms, elbows, hands.This is applied in areas like fitness tracking, sport analytics, etc,.

Advantages of Key Point Features

- These features are unique and can be easily differentiated from other features in an image.
- Key point features are invariant to rotation, scaling and lightening conditions.Even after some changes in objects, same key points can be detected.
- ey points can be easily identified across different regions of image.This property is essential for object detection and tracking.

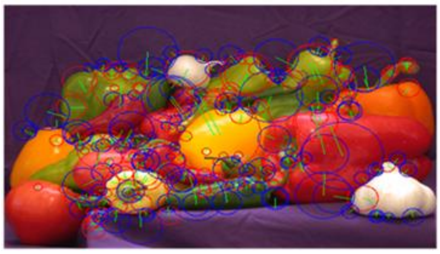

Fig. 7: Detected key point from image

Pixel Features

Pixels are considered as building blocks of an image.A pixel can be defined as color or light values that has specific place in an image.A pixel can be represented by set of numbers and range of these numbers is called colordepth.Pixels can be categorized into 2 parts:

- **GrayScale Image:**Here pixel has only 2 values that is 0 represents black and 255 represents white.
- **RGB Image:**the main color of this image are red, green and blue.Their value range is between 0 and 255 which tells the amount of given color. Its mathematical function can be calculated as:

$$\text{Numberofpixels} = w * h$$

where width(w)= total no. of pixels in horizontal direction height(h)= total no. of pixels in vertical direction

Application of Pixel Features

- Pixel features are mostly used in areas such as computers, TV and smartphones.Each pixels on these devices provide information like color, light.
- In photography and video, pixel plays a major role.As they capture large amount of images that are made up of pixels that helps to get better sharpness and clarity of images.
- These features are also helpful in medical area such as X-ray,CT Scan.As pixel are formed by detecting the intensity of light at each point of image.This help doctors to treat medical problems in proper manner.

Advantages of Pixel features

- Pixel features has the ability to preserve resolution and original information about an image.
- Pixel feature are computationally efficient and easy to implement.
- Pixel features capture the smallest-to-smallest information of any image content.This is helpful in area where very small information is required for an image.
- These feature are widely used in various real-life application for example classification, object detection and image segmentation.

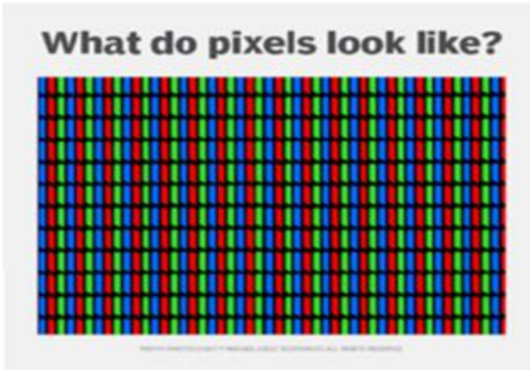

Fig. 8: Pixel of an image

Blob Feature

Blobs provide information about any region in an image.Region can have its property like brightness and color which can be different from other re- gions.Blobs can be identified by blob detection techniques which measures and locate blobs in an image.In an image, blobs are bright objects in dark background or dark objects in bright background.Mathematically blobs can be calculated as:

Laplacian of Gaussian

$$\nabla^2 L = Lxx + Lyy$$

Difference of Gaussian

$$\nabla^2 norm(L(x,y,t)) = t(L_{xx} + L_{yy})$$

where ∇^2 is gaussianoperator,L(x,y)=g(x,y)*f(x,y),t is scale,f(x,y)isimage

Application of Blob Features

- Blob feature has application in medical diagnosis. They identify unknown regions in an image that helps in faster diagnosis and treatment of disease.
- Blob feature helps to identify objects in moving images or videos.This is helpful in areas such as human being tracking, robotics etc,

Advantages of Blob Features

- Blob features are easy to implement and understand as they represent only regions of interest in an image.
- Blob provide accurate location of objects in regions in image. This helps in making accurate prediction of object detection and tracking.

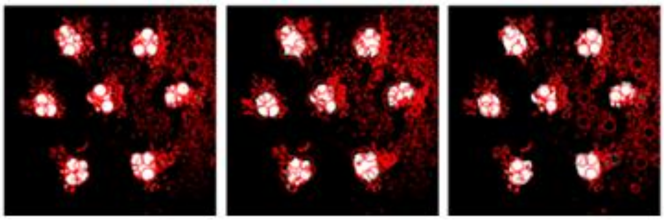

Fig. 9: Blob detection of an image

Geometric Features

These are the feature ofobjects build using set of geometric elements like points, lines, curves or surfaces.Geometric features can be categorized as follows: [2]

Area

It describes the total number of pixels surrounded by the boundary of an object in a particular image.

$$A = \frac{1}{2} \sum_{i=0}^{m-1} (pi * qi + 1) - (pi + 1 * qi)$$

where m is number of pixels, p is x-axis coordinates, q is y axis coordinates

Perimeter

It is defined as the length of the boundary or line around an object in an image.Objects can be any 2D shapes for example circle, square, rectangle.It can be calculated as:

$$P = n * (x)$$

where, n= number of ribs x= length of ribs

Centroid

It can be defined as the central position where all lines pass through it.All the pixels of an image are present at this point.

$$xo = \frac{\sum XoiAi}{\sum Ai}$$

$$yo = \frac{\sum yoiAi}{\sum Ai}$$

where (xo,yo) is axis value at center point,(xoi,yoi)are distance at which center of shape is far from from axis point (x,y), A is area of shape

Irregularity Index

It is used to calculate the boundaries of irregular shape.

$$Ir = \frac{4\pi A}{P}$$

where A is area and P is perimeter

Application of Geometric features

- Geometric features like area, perimeter, lines can be used in traffic stitching, that can be useful for traffic surveillance.
- Geometric features utilizes facial points and is used for facial recognition method that helps in image analysis.
- These features can be used in various watermarking schemes, as they are robust against various media attacks.

Advantages of Geometric Features

- Geometric features preserve topological structure be- tween pixels to improve accuracy and efficiency.
- Geometric features is useful for dimentionality reduction of an image or set of images.
- Geometric features can be used for human detection, pose estimation and scene recognition.

Morphological Features

These features provide a detailed information about the shape, size of an object, that help us to determine the characteristics or properties of an object within the image.It is of following types:

Dilation

This feature add more pixels to the bound- aries of object in an image.It fills up necessary holes in an image and makes objects more visible.

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$$(A \oplus B)(x, y) = U(i,j)A(x - i, y - j)$$

where A(x,y) is pixel value at point (x,y) in image A, B represents the structuring element,(i,j) are coordinates within the element B,U denotes union operator

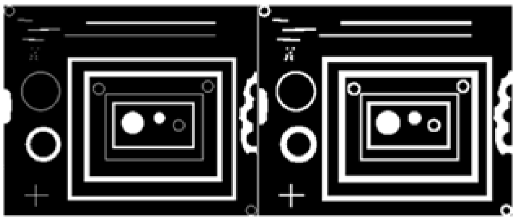

Fig. 10: Orignal image v/s processed image

Erosion:

This feature is used to remove un-required pixels from an image.This helps in making lines look thinner and makes shapes visibly small.

$$(A \ominus B) = (z|(B)z\epsilon A)$$

where(B)z represents translation of B by vector,z is vector

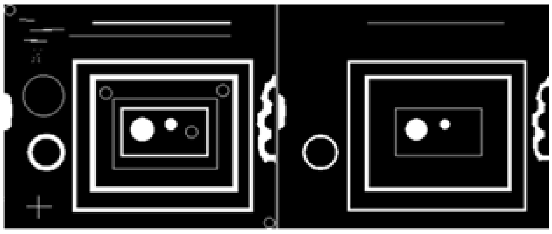

Fig. 11:Orignal image v/s processed image

Application of Morphological Features

- These features are useful for object segmentation as it removes noice, fill holes and enhances the visibility of objects.
- These features makes line look thinner which is helpful for fingerprint recognition.
- These features are applied in tumor detection for segmenting organs that helps in proper treatment of disease.

Advantage of Morphological Features

- They are useful for processing binary image.
- With the help of morphological features, perimeters of objects in binary image can be find out.
- It helps to reduce light structures connected to the image border.

Image Feature Extraction Methods

Feature extraction techniques are basically divided into two main parts i.e, Traditional feature extraction and deep learning feature extraction technique. Deep learning techniques include CNN, PCA and Auto encoder. But according to the current scenario, traditional feature extraction methods are mostly used because features are well-learned from training data. Traditional methods which we are using are categorized as follows [4]

SIFT (Scale Invariant Feature Transform)

It is broadly used in feature extraction methods in image classification and computer vision tasks. It is also used for feature detection and description. This method is invariant to the scale, and orientation of images and robust to features such as fluctuation, noise, rotation and another change.

SIFT algorithm draws out important key points of objects and store them in different image files. When a new image is taken, it is further compared with the already available images in the file and checks in case the features of current images matches with the rest of the images [16].SIFT works in following steps:-

Scale-Space Extrema Detection

SIFT starts by constructing the scale-space so that larger key points can be detected easily.Key points are detected at different values for that Laplassian of gaussian was used.But later on Difference of gaussian was used.

$$D(x, y, \sigma) = (G(x, y, k\sigma) - G(x, y, \sigma)) * I(x, y)$$

where D is difference of gaussian,σ is scale, k is scale factor, G is gaussian function, * is convolution, I is original image

Key Point Localization

Once potential key points are found, they need to be refined to find accuracy of these points.To find the accuracy, taylor series expansion of scale space is done.If points are located at point where threshold value is less than 0.03, then key points are rejected.

Orientation Assignment

Here orientation is assigned to each key point to deal with rotation in variance.For that, gradient magnitude and direction is calculated in that region.An orientation histogram is created and bin which is above 80 percent is calculated as orientation.Mathematically it is represented as:

$$\text{Magnitude}=\sqrt{(Gx^2) + (Gy^{2)}}$$

$$\text{Orientation}=\frac{Gy}{Gx}$$

where G is gaussian function at point(x,y)

Key Point Descriptor

This steps involves creation of descriptors of each key point.This descriptor is created by converting gradient magnitude and direction into vector.

SURF (Speeded-Up Robust Feature)

SURF Algorithm is newly developed and fast algorithm for local feature ex- traction.This algorithm is mostly used nowadays due to being scale invariant, contrast invariance, rotation invariant and can also detect images in different conditions. It is mostly used in areas such as object recognition and comparison of two or more images. [17]It works in following steps:

Scale-Space Representation and Key Point Localization

SURF makes use of box filters of various sizes to construct scale-space.The size of filters is often increased rather than decreasing the size.The size of the filter used is 9*9 filter. To find interest points, SURF uses Hessian matrix.Thedeterminant of Hessian matrix is taken to find the local change around the points and points with maximum determinant is chosen.Hessian matrix is calculated as-

$$H(p,\sigma)=(L_{xx}(p,\sigma)\ L_{xy}(p,\sigma)L_{xy}(p,\sigma)L_{yy}(p,\sigma))$$

whereLxx is convolution of second order derivative, p=(x,y) is point in an image, σ is scale in an image

Orientation Assignment

The orientation of the interested points is assigned in this step.This is done by computing Haar Wavelet responses in both X and Y direction with circular neighbourhood.The orientation is estimated by calculating the sum of all responses. The horizontal and vertical responses are calculated that are turned into vector.The longest vector is considered as orientation of interest point.

Descriptor based on the sum of the haar wavelet responses: A descriptor is constructed by dividing the region into smaller portion of size 4*4 and for each portion haar wavelet of x and y directions are calculated.

HOG (Histogram of Oriented Gradient)

HOG descriptor is an algorithm which captures edges from an image.It is mostly used for object detection and in areas like computer vision. The basic work of HOG algorithm is to describe appearance of an image and its shape by an edge direction without any knowledge of edge location. HOG algorithm is used for face detection [18]. HOG can be calculated in following step

Pre-Processing

The first step that is preferred in HOG feature extraction method is that we need to pre-process the image and to have an aspect ratio of 1:2(width and height) and we need to resize the image of size 64*128.

Calculating Gradients

The next step that is per- formed in HOG is calculation of gradient of each and every pixel in an image.We need to calculate gradient from x direction and gradient from y direction.The magnitude of gradient will be higher when there is an edge.

Calculating Magnitude and Orientation

After calculating gradient of each pixel in an image, we need to calculate magnitude and direction of each gradient. For calculating magnitude, we use Pythagoras Theorem:

$$\text{Magnitude}=\sqrt{(Gx^2)+(Gy^2)}$$

$$\text{Orientation}=\frac{Gy}{Gx}$$

Creation of Histogram

This is the last step in HOG feature extraction. In this step, we need to divide the cells into 8*8 cells, so that the HOG is calculated for each pixel. We calculate orientation of each pixel and put them in frequency table. This is how we calculate Histogram of Gradients.

LBP (Local Binary Pattern)

LBP algorithm is used to get texture information from an image. LBP is used in various applications. By applying LBP, texture information can be applied to histogram. LBP determines values for all image pixels. We use Euclidean distance method to check for different texture pattern obtained using LBP descriptor. Due to its speed and being computationally efficient, it is mostly used in areas like face detection. [19] [20].The LBP algorithm works in following steps:

- **Image Conversion:** Firstly, we need to convert the RGB image to grayscale image.
- **Calculate Pixels:** Secondly, we select any pixel from an image and selects its neighbourhood pixels in any direction.The coordinates of each pixel is calculated as:

$$gc = x\text{-}R\sin\frac{2\pi p}{P},$$

$$gc=y+R\cos\frac{2\pi p}{P}$$

wheregc is central pixel

- **Set Threshold Value:** Set a threshold value of pixel selected.
- **Set Intensity Value:** After selecting a threshold value, go through every pixel to check their intensity.Set pixel as 1, if intensity is greater than the threshold value and set pixel as 0, if intensity is less than threshold value.

Create Binary Pattern Histogram

Last step is to combine binary value of all neighbourhood pixels to create binary code of central pixels. These LBP values are used to create histogram.The histogram collects the frequency of texture pattern and can be used as feature vector.

Intensity Histogram

In Intensity Histogram, we check how many times each pixel value is repeated within an image. Thus, this feature depends on the amount of pixel intensity value, without considering the location of pixel in an image.In intensity histogram, the original intensity distribution of an image is separated into small intensity bins [21].Intensity histogram works in 3 steps:

- **Image Conversion:**First step is to convert the image to grayscale.
- **Find Intensity Value:**Next step is to go through all the pixels of an image and calculate the intensity value at each time.It's mathematical function is calculated as:

$$\mathbf{h(r) = n * p(r)}$$

where r= intensity,n= number of pixels,h(r)= histogram value at intensity r,p(r)=probability of occurrence of intensity

- **Plot Histogram:**Plot intensity value at x-axis and frequency of occurrence of intensity at y-axis to create an Intensity Histogram.

Canny-edge Detection

This feature extraction tech- nique is useful in area where we want to extract edge or boundaries from an image. It is very useful in areas where the image data is relatively simple and edges are easy to define.It works in following steps:

- **Image Conversion:** First step in canny edge detection is to convert coloured image to gray-scale image.
- **Noice Reduction:** In this step, we apply gaussian kernel to the input image.Gaussian kernel helps to reduce noice from an image and increases the accuracy of edge detection algorithm.Mathematically, gaussian kernel is calculated as:

$$G(x,y) = \frac{1}{2\pi\sigma^2} exp \frac{x^2+y^2}{2\sigma^2}$$

where (x,y) is coordinates of kernel,σ is standard deviation

Gradient Calculation

After reducing noice, next step is to find gradient of the pixels at each location.Gradients can be calculated by sobel kernel in both horizontal and vertical direction.This kernel moves over the entire image at each pixel and thus we obtain 2 gradient image.

$$\text{Magnitude}=\sqrt{(Gx^2) + (Gy^{2)}}$$

$$\text{Orientation}=\frac{Gy}{Gx}$$

Non-Maximum Suppression

In this step, we remove or don't consider small or unwanted edges and focus on the actual edge of image.It can be found out by calculating gradient and magnitude of each pixel and compare it with neighbouring pixel.If center pixel gradient and magnitude is greater than its neighbouring pixel, we consider it as edge otherwise we set pixel pixel value to zero.

- **Double Thresholding:** In this step, we divide the edges into 3 categories:
- **Strong Edge-**If gradient and magnitude is greater than threshold value.
- **Weak Edge-**If gradient lies between low threshold and high threshold value.
- **Non Edge-**If gradient and magnitude is less than thresh-old value.

Edge Hysteresis

This is the last step in canny-edge detection.In this part, we try to link strong edges with the weak edges by checking the neighbouring pixel edge of strong edge.If any weak edge is connected to weak edge, it is also considered as part of strong edges

Color Histogram

It is a technique that is used for extracting color feature from a particular image. Image appears from different point of view. It represents the occurrence of each color in an image. It is robust to changes like rotation, angle and translation. Color Histogram focuses on every single part of an image. It is used to collect pixels and save it.It's working is divided into 3 steps:

- **Image Conversion:**The first step involves conversion of image from RGB to HSV.
- **Creation of Bins:**Once the image is obtained, it is divided into set of bins.For each pixel, its color value is assigned to bin.This leads to histogram where all the pixels have their corresponding bins.
- **Normalization:** Last step is to do normalization.In this step, we divide each bin count by total number of pixels represented as:

$$H\text{norm}=\frac{H|(R,G,B,N)}{N}$$

where N is total number of pixels

Harris Corner Detector

It is a popular algorithm used for detecting corners in an image. It provides high accuracy and robustness. Harris Corner Detection aims to improve the speed, accuracy of algorithm. It is a valuable tool used in computer vision [22].It works in following steps:

- **Image Conversion:** In this step, we convert input image to gray-scale image.

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- **Spatial Derivative Calculation:** Here we find the gradient of the image by calculating the derivative in X and Y direction.

$$Ix(x, y)$$

and

$$Iy(x, y)$$

- **Structure Tensor Setup:** After finding the derivative i.e., we construct structure tensor M.

$$M=\sum (x',y')W(x',y')(Ixx\ \ Ixy\ Ixy\ Iyy)$$

where w(x’,y’) is weight function

Corner Response Function
This function calculates the corner like structure at each pixel.The response function at pixel (x,y) is calculated as:

$$R = \det(M) - k.\mathrm{trace}(M^2)$$

where k is emperical constant

- **Non-Maximum Suppression:**To find the strongest corners, this step is applied.Only corners with local maximum is selected as an optimal corner.

Kernel Based Methods
Gaussian blur kernel
This kernel is dependent upon the Gaussian function, a function which creates a distribution of values around the center point. This results in a kernel in which pixels near the center contribute more towards the new pixel value than those further away. The mathematical function to calculate gaussian kernel around an image is:

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

where (x,y) is point in an image, σ is standard deviation

Edge kernel
This kernel detects edges within an image.To calculate edge kernel, we perform convolution with edge kernel.

$$\text{Magnitude}=\sqrt{(Gx^2)+(Gy^{2)}}$$

$$\text{Orientation}=\frac{Gy}{Gx}$$

Sharpening kernel
This kernel is used to sharpen an image. The first step involves creating a Gaussian blurred copy of the image. This blurred copy is then subtracted from the original pixels above a given threshold are sharpened by enhancing light and dark pixels.To calculate sharp kernel, we have formula:

$$g(x,y)= w*f(x,y)$$

$$g(x,y)=\sum_{dx}^{a}\sum_{dy}^{b} w(dx,dy)f(x+dx,y+dy)$$

where g(x,y) is filtered image,f(x,y) is original image , w is filter kernel

Gradient kernel
We can find gradient of a particular image by convoluting a filter over it. [23]

III. IMPORTANCE OF FEATURE EXTRACTION

Feature extraction improves the overall functioning of different machine learning algorithms like accuracy and efficiency. There are few ways by which feature extraction helps to improve machine learning algorithms. [24]

1. Reduce Redundant Data
Feature extraction helps to reduce redundant data and reduce noise. This helps various learning algorithms to work easily with relevant data.
2. Improves Model Accuracy
Machine learning algorithms train themselves with labeled and unlabelled data and if that data is not accurate, then model accuracy can decrease.

3. Most Efficient Use of Computer Resources
Removing unwanted data from the model, can improve it accuracy and efficiency must faster. With less and unwanted data we can make best use of computing resource.

Fig. 12: Representation of I/P and O/P

IV. APPLICATIONS OF FEATURE EXTRACTION

1. Bag of Words
Bag of words is the most used technique for natural language processing. In this process they extract the words or the

features from a sentence, document, website, etc. and then they classify them into the frequency of use.

2. Image Processing
Feature extraction plays an important role in image processing. This technique is used to detect features in digital images such as edges, shapes, or motion. Once these are identified, the data can be processed to perform various tasks related to analyzing an image.

3. Autoencoders
Autoencoders are a form of unsupervised learning designed to reduce the noise present in data. In autoencoding, input data is compressed, encoded, and reconstructed as an output. This process leverages feature extraction to reduce the dimensionality of data, making it easier to focus on only the most important parts of the input.

V. CONCLUSION

The conclusion of the paper is that their are various image features available and to get these features from an image, we need to apply feature extraction methods on each and every image feature to extract even the smallest information from the image. This is helpful for image matching, object detection and prediction.Existing image feature extraction methods focus on reducing contrast and converting images into digital form for analysis.Later, we will compare the feature extraction methods by applying them on different machine learning algorithms and check their efficiency and accuracy.

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