A

SEMINAR REPORT

ON

IMAGE PROCESSING

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in

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of

SAVITRIBAI PHULE PUNE UNIVERSITY

DEPARTMENT OF INFORMATION TECHNOLOGY

MIT ACADEMY OF ENGINEERING

ALANDI(D)

2014-2015

MIT | Academy of Engineering

DEPARTMENT OF INFORMATION TECHNOLOGY

Certificate

This is to certify that,

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has successfully completed the seminar entitled **Image Processing**,under my guidance in partial fulfillment of the requirement for the award of the Third Year of Engineering in Information Technology of MIT Academy of Engineering by Savitribai Phule Pune University for the academic year 2014-2015.

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Acknowledgment

I take this opportunity to thank our seminar guide Mrs.Pranali.P.Chaudhari and Head of the Department Prof.S.M.Bhagat for their valuable guidance and for providing all the necessary facilities, which were indispensable in the completion of this seminar report. I am also thankful to all the staff members of Information Technology of MIT Academy of Engineering Alandi(Pune).

I would also like to thank the institute for providing the required facilities, Internet access and important books.

NIKITA NALAWADE

Abstract

Image processing is a technique in which an image is digitized and various operations are performed on it in order to get an enhanced image and extract useful information from it.We can take the input of images through scanner and video camera in various formats of images like jpg,png etc and output through printers.

There are various various fields in which image processing can be processed as it has got many applications.Some of the fields are like Medical Science,Animation,Remote Sensing,Color Processing etc.We can use various algorithms to process the images to make it more better or restore the images to its original condition.

In this seminar comparison of various techniques and different fields has been seen in which image processing can be used.

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Chapter 1

Introduction

An image refers to an intensity function f, where x and y denotes spatial co-ordinates and the value of f at any point (x,y) is proportional to the brightness or gray levels of the image at that point. A digital image is an image f(x,y) that has both in spatial co-ordinates and brightness. The elements of such a digital array are called picture elements or pixels.The images operate on 256 grey scale images.

Figure 1.1: An Image

As shown in the **Figure 1.1**[10],the pixel are numbered from 0-255 where 0 represents black,255 represents white and the values in between are the shades of grey.

Image processing is basically a technique in which an image is converted into a digital form and there are various operations performed on it in order to get an enhanced image and to extract useful information from it. The images are digitized with the help of a scanner or by a video camera which is connected to the frame grabber board in computers. This digitization is done so that it can be stored in computers memory or in a form of media storage like

CD-ROMs and hard disks. The image used as input in this technique can be a video frame or photograph and the output received may be an image or some characteristics associated with that image. It is a type of signal dispensation which treats an image as two-dimensional signal by applying already set signal processing methods. In todays world, with rapid growth of technology, image processing is being used in various fields and is playing a very important role.

Image processing is done by following the below three steps

- Importing the image with optical scanner or digital photography.
- Image is then analyzed and manipulated for data compression, image enhancement and pattern recognition as they are not clearly visible to human eyes.
- Output is the last stage in which result can be altered image or report that is based on image analysis.

Division of Image Processing Operations

- Image Compression
  This operation is used in order to save the amount of memory which is being used to store the digital image in the computer.
- Image Restoration and Enhancement
  The defects which have being caused in digitization process or while image setup can be corrected through this operation.
- Measurement Extraction
  Extraction of useful information after the image is in good condition is done by this operation.

1.1 Purpose of Image Processing

The purpose of image processing is divided into 5 groups. They are

- Visualization Observe the objects that are not visible.
- Image sharpening and Restoration To create a better image.
- Image retrieval seek for the image of interest.
- Measurement of pattern Measures various objects in an image.
- Image Recognition Distinguish the objects in an image.

1.2 Applications of Image Processing

Some of the major fields in which digital image processing is widely used are mentioned below

- Image sharpening and restoration
- Medical field
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Color processing
- Pattern recognition
- Video processing
- Microscopic Imaging

Chapter 2

Literature Survey

2.1 Object Recognition

This is a process of finding out and identifying different images or video sequences. These images of the objects may vary in view points, scales and sizes, and they also may be rotated or translated .Recognition of such factors through human eyes is a very difficult task and therefore object recognition is carried out. There are various fields in which object can be recognized. Its done through pattern recognition, shape matching, and color processing and edge detection.

Pattern recognition and image processing tells us about the various aspects of image processing and pattern recognition with their relationship. The two topics are separate disciplines but are closely related. Image processing which considers only two dimensional patterns works on areas of coding, filtering, enhancement, restoration, analysis and recognition while on the other hand pattern recognition considers both two and three dimensional patterns and works on areas of feature extraction and classification, preprocessing and descriptions of patterns. Pattern recognition is description and classification of measurements which is used mostly to reduce noise and redundancy in measurements. There are mathematical techniques for this process. One is Decision Theoretic (or discriminant) where a set of characteristic measurement called features are extracted from the patterns. This pattern is represented by feature vector and recognition is done by portioning the feature space. The other is Syntactic techniques where each pattern is expressed as composition of components called subpatterns.recognition is done by parsing the pattern structure according to given syntax rules. Also it has described the various ways of image processing like image enhancement and restoration, image segmentation and restoration.

A comparison of various edge detection techniques. Edge detection in image processing is a techniques used for feature extraction. The various techniques compared are: Sobel, Roberts, Prewitts, Laplacian of Gaussian and Canny edge detection. Sobel operators is a simple but sensitive to noise technique which uses 3*3 convolution mass to determine edges in x and y directions. This mask can be applied to images independently and absolute magnitude of the whole image can be obtained by combining the output magnitudes. Prewitt operator is computationally efficient but is very sensitive to noise so the size of kernel filters and coefficients are fixed. The 3*3 masks are used to find gradient in x and y directions and it can be used for high resolution images. Laplacian of Gaussian is second order derivative technique which uses zero crossing for edge detection. It does not function properly at the curves and corners where intensity changes and is also sensitive to noise but helps in finding correct places of the edges. Roberts is uses to highlight the regions of high spatial frequency which is performed by 2-D spatial measurement of the gradient on digital image. Being the differential operator, the Roberts operator is to approximate the gradient of an image through the discrete differentiation is obtained by calculating the sum of the squares of the differences between diagonally adjacent pixels. Canny edge detector is a conventional algorithm which performs better than any order edge detectors but is computationally expensive. It is popular due to its optimum performance in which three different criterias localization, low error rate and single response to single edge is addressed.
The comparison of all the techniques have been discussed in the research paper which is been discussed above.

2.2 Feature Extraction

Feature extraction is dimensionality reduction technique in which a particular part of an image in extracted as a compact feature vector. It is useful when we have to deal with large image sizes and a quick retrieval and matching of reduced features are needed. It is used to solve computer vision problems like object detection and recognition, content based-image retrieval, face detection and texture measurement.

The feature extraction is done in character recognition.Perfomance of character recognition depends upon feature extraction algorithm to extract useful information, reduce the dimension and to represent the input pattern. There are also statistical feature extraction which includes zoning, projection, crossing and stance method out of which zoning is widely used. In this the image

is fitted in a particular size and then divided into zones and the length of black runs is converted into feature using various techniques. We see the feature extraction where the database is divided into two parts: Training and Testing data. Each part individually has features extraction and selection which goes through A1 and A2 techniques. Firstly feature extraction takes place by converting the image into binary image where it is fitted in 15*15 size .Then it is put in a matrix P where Pij is said to be 1 if the black runs pass through all the cells otherwise it is 0.The matrix is then divided into 16 regions to extract one feature from each. These regions have different shapes with their identification numbers and they are so selected that the region should mostly have the classes of 1.In the A1 approach the variation of 1s oration does not change the writing style which shows the robustness towards different writing variations. In A2, the 1s element is measured by considering the top right corner of the matrix as origin (0, 0) and reference as point 6.The normalized feature value of any region is then calculated by dividing the sum vectors of 1s elements in a region by the sum vector distances of all the elements in the region. In feature selection and recognition, the binary image is allocated with feature extraction index and the evaluated to give their ranking. The higher ranking FEI is put at the top position and the required numbers of features are then selected. The selected feature subset then goes for recognition where the unknown sample is recognized through the knowledge base where the reference class features are assigned to it. This KB is constructed using mean and standard deviation involved in the training sample interclass region features.
This is how the paper discusses its feature extraction technique.

2.3 Image Enhancement

It is technique used to make improvements to digital image to make it a pleasing one. There are different alterations done to improve the quality of the image so that the output image is an improved one which suits our set of objectives.

It is one the simplest techniques to bring out the details which have got lost or are hidden due to optics, electronics or environment. To enhance the images we require certain algorithms to convert a distorted image into an advanced one. The techniques can be broadly divided into spatial domain and frequency domain. In spatial domain directly the grey pixels are altered which in result enhances the overall image which may not be a desired result in many cases. We use spatial techniques like point operation where image pro-

cessing is done to individual pixels only, Mask operation where each pixel is modified according to values in small neighborhood, Global operation where all pixels are considered for performing operations. Frequency domain takes the orthogonal transform of the image rather than the original one and then processes it according to the frequency content. The orthogonal transforms are discrete cosine transform, discrete Fourier transform, Hartley Transform. The transform domain enables operation on the frequency content of the image, and therefore high frequency content such as edges and other subtle information can easily be enhanced.
Therefore, it is concluded that we can use different enhancement techniques to get better and satisfactory results.

2.4 Image Restoration

Image restoration is a technique which allows us to get the original image from the degraded one knowing the degraded factors. There may be many reasons due to which an image gets distorted, the effect of noise, blur and camera misfocus. Image restoration allows us to compensate for or undo the changes to revert back to original.

Image restoration allows us to remove noise which may be generated at the time of image generation or transmission. There are different kinds of noises like the ones in photographic films are Grain noise, in photo electric detectors we have Thermal noise and Photoelectric noise and in image transmission we have Salt-pepper noise. This noise is a very difficult to remove and this can be done through filters. Filtering is a technique used for enhancing the image. There are two types of filters: linear and non linear. Linear filers are the linear combination of output pixels in the neighborhood which provided blur in the image thus we use non linear filters. The median Filter (MF), Recursion Median Filter (RMF), Min Max Exclusive Mean (MMEM) and Detection Estimated Based Filer can be used only when the noise ratio is small (Noise Percentage>=20).Noise reduction can be done by these but still the performance is very low. Weighted Median (WM), Centered weighted median (CWM) Filters are used which works properly but the original pixel corrupted and noise reduction is substantial under high noise condition. Hence this technique has also blurring affect on the image. Min Max detector based (MMDB) Filter work more efficiently than the above mentioned filters and also considers parameters like Salt and Pepper noise. The best technique out of all these is the Histogram Adaptive Fuzzy Filter (HAF).This gives us an enhanced image on very good percentage. These techniques have been

evaluated on the basis of Peak Signal Noise Ratio (PSNR), where HAF gives best results in terms of it.
Thus, we can use this filter for noise reduction and for restoration of image.

2.5 Image Segmentation

This is a process of portioning digital images into various segments so as to simplify or change the representation of the image more meaningful and easier to be analyzed. It is basically a process of assigning a label to every pixel in the image so that these pixels form a group of pixels with the same label and share certain characteristics.
It is used to locate boundaries and objects in images or a set of contours extracted from the images.

A color image segmentation method which divides color space into clusters using competitive learning. The efficiency of this method from both theoretical and experimental sides is studies to give us useful information for better understanding of the algorithms. Theoretically, the competitive learning converges to a local optimum solution of clustering based on the least sum of squares criterion. Experimentally, the efficiency of competitive learning in clustering in gray scale image and showed examples of color image segmentation through clustering and vector quantization techniques and also a detailed discussion is done on the effect of transformations where we see images with no transformations, whitening transformation and L*u*v transformations that transfer the vectors to input vectors for clustering.

2.6 Content Based Image Indexing

It is also named as "description-based" or "text-based" image indexing/retrieval. It refers to retrieval from text-based indexing of images that employs keywords, subject headings, captions, or natural language text .We propose an image database architecture which can be used for most industrial problems and also handles structural representation of images. Indexing is done by object based, spatial relation based, and also combination of both. The query can be a textual query or a image content based query. We propose how the image query is processed, how similarity based retrieval is performed over images and how the image database is organized. Results are presented based on an application of ultra sonic images.

2.7 Artificial Neural Network

It is a system of interconnected neurons which compute values from inputs and is capable of machine learning and pattern recognition. It is a family of statistical learning algorithms inspired by biological neural networks. These are used to estimate functions the depends on big number of unknown inputs. They convey electrical signals from input to output from the brain, processing being the intermediate state. The communication which neurons make is still a topic of research. There are basically two types of neural networks. One is the hardware based and the other is software based. Hardware based is represented by physical components whereas software is through computer model. They use a variety of topology and learning algorithms. Evolutionary methods, gene expression programming, simulated annealing expectation-maximization, non-parametric methods and particle swarm optimization are some commonly used methods for training neural networks.

Table 2.1: Referred Research Papers

SR.NO	TITLE OF THE PAPER	PUBLISHED IN	WORKS ON	ADVANTAGES
1.	IEEE Transactions on Computers, Vol: C-25, Issue:12	December 1996	Pattern Recognition and Image Processing	Better understanding of both processes with good technique explanation.
2.	International Journal of Advanced Research in Computer Science and Software Engineering, Vol:3,Issue:12	December 2013	Comparative Analysis of Various Edge Detection Techniques	A detailed explanation of all algorithms with individual pros and cons.
3.	International Journal of Advanced Research in Computer Science and Software Engineering, Vol:2,Issue:5	May 2012	Feature Extraction/Selection and Statistical Classification Technique for Character Recognition	Feature Extraction techniques on basis of Pattern recognition helps us to understand the work flow of the algorithms.
4.	International Journal of Advanced Research in Computer Science and Software Engineering, Vol:2,Issue:4	April 2012	Image Enhancement and its Various Techniques	Both techniques pros and cons are studied and show a need of using better techniques for grey level images.

SR.NO	TITLE OF THE PAPER	PUBLISHED IN	WORKS ON	ADVANTAGES
5.	International Journal of Advanced Research in Computer Science and Software Engineering, Vol:39	February 2012	Image Restoration Technique with Non-Linear Filter	Shows disadvantages of linear filters and detailed study of non linear filter algorithms out of which HAR turns out to be the best.
6.	IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol :16 Issue:12	December 1994	Color Image Segmentation using Competitive Learning	Transformation of all techniques has been compared in an easy way for understanding.

Chapter 3

Basic Concept and Specification

As we have seen, the digital image processing is a technique which allows an image to be taken as an input, process some operations on it by applying various efficient algorithms and give us a desired better and enhanced image as an output.

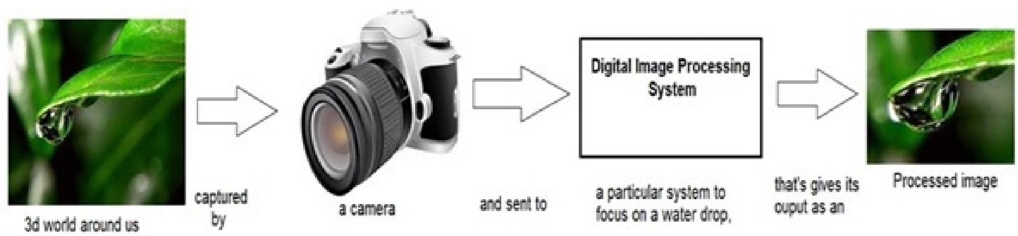


Figure 3.1: Digital Image Processing

The **Figure 3.1**[10] above explains us the working of image processing where the image of a leaf with a dew drop is taken. The camera is used as an image acquisor.DIP system performs some operations which include applying various techniques algorithms so as to get a zoomed image of the dew drop on the leaf. We get the output of just the dew drop after image processing has been done.

3.1 Fundamental Steps for Image Processing

A precise description of image processing has been mentioned in the following steps.

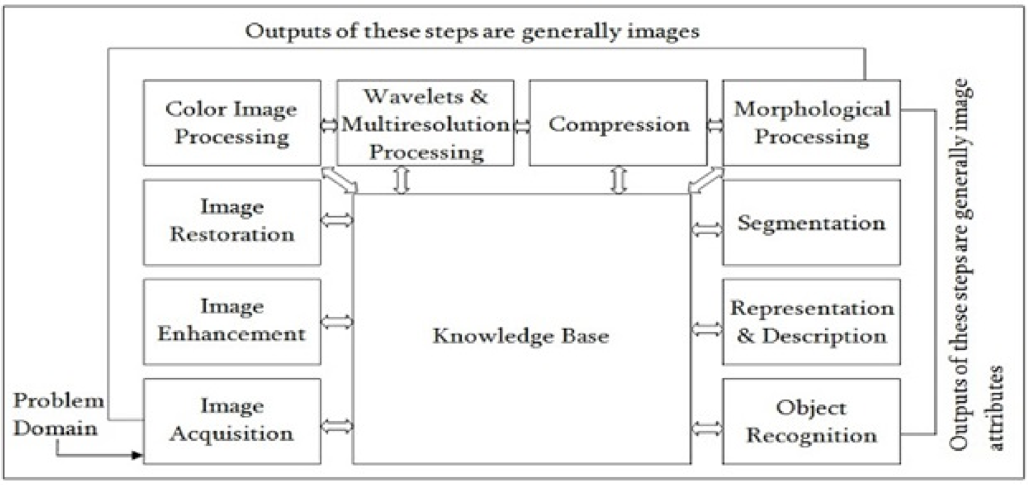


Figure 3.2: Block Diagram Of Image Processing

As shown in the **Figure 3.2**[9],description is given for better understanding.

- Image Acquisition
  This is the first step of digital image processing. It involves acquiring an image in a digital form which also has some preprocessing techniques which are used for the improvement of image so to increase the chances of success of other steps. Preprocessing involves scaling, translating etc.

- Image Enhancement
  Image enhancement is used so as to bring out the detailed information of the image or to make the resultant image more suitable than the original image. We can enhance the image by changing brightness, contrast, sharpening etc.

- Image Restoration
  Image restoration is an objective method which is used to improve the appearance of the image. An image can get distorted by various reasons

like blurring noise etc so its only way to revert back the original image is through this method.

- Color Image Processing
  This step helps us to get the digital images in different color models like RGB, CMY to have different presentation if the image. This has gained a lot of importance due to the use of digital images over the internet.

- Wavelets and Multiresolution Processing
  Wavelets are the foundation to represent images in degrees of resolutions. Images are subdivided into smaller regions so as to have data compression and for pyramid representation.

- Compression
  Images which are taken as an input may be of various sizes. Sometimes it is very difficult to process such a large sized image. Therefore, data compression is done on the image just to reduce the size of the image through which it can be stored in computers memory in lesser amount and there will be no wastage of memory. This technique makes no changes to the original image but just decreases the size of it.

- Morphological Processing
  It deals with tools that are used for representation and description of shape by extracting the image components.

- Segmentation
  This step does partitioning of the image into its constituent parts or objects. Rugged segmentation is done so as to have successful solutions to imaging problems for identifying the objects individually. An autonomous segmentation does not prove to be a solution one.

- Representation and Description
  Representation is used to convert the input data to a suitable form for computer processing. Description extracts features that results in quantitative information from the image. It differentiates one class subjects from the other. This step is always an output to segmentation which has raw pixel data, having the boundary of a region or all pints in the region itself.

- Object Recognition
  In this step, a label is assigned to the object based on the information

provided by the descriptor. It gives a meaning to the object after it has been recognized.

- Knowledge Base
  This may be simple as detailing the information which is to be located in the entire image which males our job easier or can be complicated as to find the defects in a material inspection problem.

3.2 Image Processing an Input to Image Analysis

Image analysis is a technique which is used to extract meaningful and useful information from the digital images by means of image processing techniques .Image analysis uses some image processing techniques like Object recognition which in turn has different fields like pattern recognition, color processing, edge detection, shape matching which is inter-connected to feature extraction and image segmentation. To analyze images through these techniques the images have to get processed in these fields with certain algorithms which results to be an input from extraction.

3.2.1 Object Recognition

Edge Detection Algorithms

The comparisons are done on the basis of first order derivative of edge detection. The basic algorithm has been given which needs operators to be calculated. These operators are been given by different algorithms as follows after the algorithm.

- Gradient is a measure of function changes and is a type of two-dimensional equivalent of the first order which is also called as a vector.
  $G(x, y) = \begin{bmatrix} Gx \\ Gy \end{bmatrix} = \begin{bmatrix} \partial f/\partial x \\ \partial f/\partial y \end{bmatrix}$

- The vector G (x, y) direction is same as the direction of the maximum rate of change of increasing function f (x, y)
  $|G(x, y)| = \sqrt{(Gx^2 + Gy^2)}$

- Second, the gradient amplitude
  $\alpha(x, y) = arctan\frac{Gx}{Gy}$

- For digital images, partial derivative of the edge is almost same as differences. So the edge often lies on the differential value of the maximum, minimum, or zero.
  $Gx = f[x+1,y] - f[x,y]$
  $Gy = f[x,y+1] - f[x,y]$

- When we calculate the gradient, the same location (x, y) of real partial derivatives is essential in computing space. Gradient approximation is not in the same location using the above formula. So the 2x2 first order Differential template is used to calculate partial derivatives in x and y direction of the interpolation points$[x+1/2, y+1/2]$, then

  $$Gx = \begin{bmatrix} -11 \\ -11 \end{bmatrix}$$
  $$Gy = \begin{bmatrix} 11 \\ -1-1 \end{bmatrix}$$

Sobel Operator

It is in the form of filtering operator which extracts edges. Each point in the image has two nuclear convolutions that is represented as 3*3 mask. One checks for maximum response of vertical edge and the other check for horizontal edge. A very simple technique to implement.

$$Gx = \begin{bmatrix} -1-2-1 \\ 000 \\ 121 \end{bmatrix}$$
$$Gy = \begin{bmatrix} -101 \\ -202 \\ -101 \end{bmatrix}$$

Robert's Operator

Roberts operator is a first-order operator, which uses a partial differential operator to find the edge. Roberts operator is defined as:

$$G(x,y) = [\sqrt{f(x,y)} - \sqrt{f(x+1,y+1)}^2] + [\sqrt{f(x+1,y)} - \sqrt{f(x,y+1)}^2]^{1/2}$$

Gradient size of Roberts operator represents the edge strength of the edge and direction of the gradient and the edge are vertical. The operator edge has higher positioning accuracy, but it is easy to lose a part of the edge. The operator with a steep low-noise image corresponds best.

$$Gx = \begin{bmatrix} 10 \\ 0-1 \end{bmatrix}$$
$$Gy = \begin{bmatrix} 01 \\ -10 \end{bmatrix}$$

Prewitt Operator

The Prewitt operator is one type of an edge model operator. It is also similar to Sobel operator. Model operator is made from the ideal edge sub-image composition. Detect the image using edge model one by one, and take the maximum value of the model operator that is most similar to the Detected region as the output of the operator.

$Gx = \begin{bmatrix} -101 \\ -101 \\ -101 \end{bmatrix}$

$Gy = \begin{bmatrix} 111 \\ 000 \\ -1-1-1 \end{bmatrix}$

Laplacian of Guassian

LOG operator finds the optimal filter of edge detection by ratio of the signal to noise of image. Firstly, a Gaussian function is used to low-pass soothingly filter image; then high-pass filter The Laplacian operator, according to the second derivative of zero to detect the edges. Gaussian filter function is:

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

The convolution matrix is given by

$Gx = \begin{bmatrix} -111 \\ 1-81 \\ 111 \end{bmatrix}$

$Gy = \begin{bmatrix} -12-1 \\ 2-42 \\ -12-1 \end{bmatrix}$

Canny Edge Detector

Canny edge detector is a conventional algorithm which performs better than any order edge detectors but is computationally expensive. It is popular due to its optimum performance in which three different criterias localization, low error rate and single response to single edge is addressed.

Steps in Canny Edge Detection

- Convert to Grayscale
  First convert the image to grayscale using some type of RGB to grayscale conversion.

- Noise Reduction
  Noise reduction implies some sort of blurring operations. Gaussian filter is usually used to reduce noise. Commonly used filter is 5*5 filter.

- Compute Gradient Magnitude and Angle

The derivatives (Dx(x, y) and Dy(x, y)) of the image in both x and y directions are calculated. Then the angle of the gradient and the gradient magnitude are also calculated. The angle of gradient is computed as follows
$\theta = arctan[(Dx(x, y))/(Dy(x, y))]$

- Non-Maximum Suppression
The non-maximal suppression keeps only those pixels on a edge which have the maximum gradient magnitude. The maximal magnitudes should always occur right at the edge boundary, and then the gradient magnitude should always fall off with distance from the edge. So, three pixels in a 3*3 around pixel (x, y) are examined

- If $\theta(x, y) = 0\,\deg$, then the pixels (x + 1, y), (x, y), and (x-1, y) are to be considered.

- If $\theta(x, y) = 90\,\deg$, then the pixels (x, y + 1), (x, y), and (x, y-1) are to be considered.

- If $\theta(x, y) = 45\,\deg$, then the pixels (x + 1, y + 1), (x, y),and (x-1, y-1) are to be considered.

- If $\theta(x, y) = 135\,\deg$, then the pixels (x + 1, y-1), (x, y),and (x-1, y + 1) are to be considered.

If pixel (x, y) has the highest gradient magnitude out of all the three pixels which are considered, it is kept as an edge. If one of the other two pixels has a higher gradient magnitude, then Pixel (x, y) is not on the center of the edge, thus, should not be considered as an edge pixel.

3.2.2 Image Segmentation

Segmentation Algorithms

The algorithms explained below are verified on three different evaluation schemes

- Correctness of the algorithm
- Stability with respect to parameter choice
- Stability with respect to an image choice

The performance is measured by Normalized Probability Rand index (NPR) which is given by

Normalised index=(Index-Expected index)/(Minimum index-Expected index)

Mean Shift Based Algorithm
This technique is divided into two parts which is of mean shift filtering of the original image and a clustering of filtered data.

- Analysis of probability density function underlying the image data in feature space is done.
  Feature space consisting of the original image data represented as the (x, y)
  Location of each pixel, plus its color in L*u*v* space is $(L*, u*, v*)$.

- We then find the gradient.
  For a data point x in feature space, the density gradient is estimated as being proportional to the mean shift vector

  $$\check{\nabla}(fx) = \alpha \frac{\sum_(i=1)^n x_i g(\begin{bmatrix} x - x_i \\ h \end{bmatrix})}{\sum_(i=1)^n g(\begin{bmatrix} x - x_i \\ h \end{bmatrix})} - x$$

  Where x_i are the data points, x is a point in the feature space, n is the number of datapoints (pixels in the image), and g is the profile of the symmetric kernel G.

- We use the simple case where G is the uniform kernel with radius vector h. Thus the above equation simplifies to

  $$\check{\nabla}\alpha[\frac{1}{S_{x,h_s,h_r}} \sum x_i \in S_{x,h_s,h_r}\, x_i] - x$$

  Where S_{x,h_s,h_r} represents the sphere in feature space centered at x and having spatial radius h_s and color (range) radius h_r , and the x_i represent the data points within that sphere.

- If two points x_i and x_j are far from each other in feature space, then $x_i \in S_x j_{,hs,hr}$ and hence x_j doesnt contribute to the mean shift vector gradient estimate and the trajectory of x_i will move it away from x_j . Hence, pixels on either side of a strong discontinuity will not attract each other and each data point is replaced by its corresponding mode.

- Clustering is described as a simple post-processing step in which any modes that are less than one kernel radius apart are grouped together and their basins of attraction are merged. This suggests using single linkage clustering, which effectively converts the filtered points into segmentation a region adjacency graph (RAG) is created to hierarchically cluster the modes. Also, edge information from an edge detector is combined with the color information to better guide the clustering.

Efficient Graph Based Algorithm
This method works directly on the data points in feature space, without first performing a filtering step, and uses a variation on single linkage clustering. To find the edges Kruskals algorithm is first More specifically, let G = (V, E) be a (fully connected) graph, with m edges and n vertices. Each vertex is a pixel, x, represented in the feature space. The final segmentation will be $S = (C1, ..., Cr)$ where C_i is a cluster of data points.

- Sort $E = (e_1, ..., e_m)$ such that
  $|e_t| \leq |e_t^{'}| \forall_t < t^{'}$
- Let $S^0 = (x_1,...x_n)$, in other words each initial cluster contains exactly one vertex.
- For $t = 1$, ..., m
  Let x_i and x_j be the vertices connected by e_t .
  Let ${C_{x_i}}^{t-1}$ be the connected component containing point x_i on iteration t1, and $l_i = max_{mst} {C_{x_i}}^{(t-1)}$be the longest edge in the minimum spanning tree of $C_{x_i}^{t-1}$. Likewise for l_j
  Merge ${C_{x_i}}^{(t-1)}$ and ${C_{x_j}}^{(t-1)}$ if
  $|e_t| = min[l_i + \frac{K}{{C_{x_i}}^{(t-1)}}, l_j + \frac{K}{{C_{x_j}}^{(t-1)}}]$
  Where k is a constant.

Hybrid Segmentation Algorithm
It is a combination of the previous two algorithms: first we apply mean shift filtering, and then we use efficient graph-based clustering to give the final segmentation.
For $h_r = 15$ the quality of the segmentation is high. Also, the rate of granularity change is slower than either of the previous two algorithms, even though the parameters cover a wide range.

3.2.3 Feature Extraction

Extraction Algorithms

An image object has characteristics like color, texture and shape. These properties can be measured by object features which can be grouped in a scalar array called as feature vector or feature descriptor. On the basis of these descriptors we have compared algorithms like SURF, HOG, HAAR and LBP. On the basis of vehicle tracking we will use these different descriptors. To evaluate the classifiers performance, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were used. All these measures can be calculated based on four values: true positive (TP), false positive (FP), false negative (FN) and true negative (TN).
We can find these parameters through,
Sensitivity=TP/TP+FP
Specificity=TN/(TN+FP)
PPV=TP/(TP+FP)
NPV=TN/(TN+FN)
Accuracy=(TP+TN)/(TN+FP+TP+FN)

For the calculations we use different algorithms as descriptors which are

Speed Up Robust Features Algorithm
The SURF descriptor is based on the Scale-invariant feature transform. It uses the same concepts of SIFT, but the algorithm is optimized without any drastic reduction in the description quality. The SURF algorithm was designed to obtain features independently of scale, rotation, illumination changing and viewpoint. It returns two arrays, namely: interest points and descriptor.

- Internal image is used of which convolution of the image with square is done.
  The integral image is defined as

  $S(x, y) = \sum_{i=0}^{i \leq x} \sum_{j=0}^{j \leq y} I(i, j)$

- To find the point of interest, it uses blob detector dependent upon Hessian matrix.
  Given a point x = (x, y) in an image I, the Hessian matrix H (x, σ) in x at scale σ, is defined as follows

  $H(x, \sigma) = \begin{bmatrix} Lxx(x, \sigma) Lxy(x, \sigma) \\ Lxy(x, \sigma) Lyy(x, \sigma) \end{bmatrix}$

Where $Lxx(x, \sigma)$ is the convolution of second order derivative $\frac{\partial x}{\partial x^2 g(\sigma)}$ with the image in the point x, y similarly with $Lxx(x, \sigma) and Lyy(x, \sigma)$.

- The box filters 9x9 are approximations of a Gaussian with $\sigma = 1.2$ and represents the lowest level (higher spatial resolution) for computerized maps Blob response. Is denoted D_{xx}, D_{yy}, D_{xy}
  Then, the following image is generated:
  $Det(Haprox) = D_{xx}D_{yy} - (wD_{xy})^2$

- The relative weighting (w) of the filter response is used to balance the expression for the Hessian determinant.

  $w = \frac{||L_x y(1.2)||F||D_y y(9)||F}{||L_y y(1.2)||F||D_x y(9)||F}$

  0.9 factors appears such a correction factor using squares instead of Gaussians. It can generate several images det (H) for several filter sizes. This is called multi- resolution analysis.
  $||x||F$ Is the Frobenius norm

  To find the descriptor now, a square region is constructed centered on the interest point oriented along the orientation selected in the previous section. The size of this window is 20s. The interest region is split up into smaller 4x4 square sub-regions, and for each one, it is computed Haar wavelet responses at 5x5 regularly spaced sample points, and weighted with a Gaussian.
  For each sub-region the results of D_x, D_y and their absolutes are summed in a vector, the descriptor

  $V = (\sum d_x, \sum d_y, \sum |d_x|, \sum |d_y|)$

Histogram of Gradient Algorithm
It is a feature descriptor that calculates an image histogram of oriented gradients and the final descriptor is an one-dimensional array of histograms extracted from the image. The algorithm is based on the local object shape and appearance, which in an image can be represented by intensity gradients or edge directions.

- Divide the image into small connected regions called cells, and for each cell compute a histogram of gradient directions or edge orientations for the pixels within the cell.

The filter kernels will be

$[-1, 0, 1]$ and $[-1, 0, 1]^T$

- Discrete each cell into angular bins according to the gradient orientation.
- Each cell's pixel contributes weighted gradient to its corresponding angular bin.
- Groups of adjacent cells are considered as spatial regions called blocks. The grouping of cells into a block is the basis for grouping and normalization of histograms.
  Let v be the normalized vector containing all histograms in a given block, $||v||k$ be its k-norm for k=1,2 and e be some small constant.
  Then the normalization factor can be one of the following:
  $L2norm : f = \frac{v}{\sqrt{||v||^2+e^2}}$

  L2-hys: L2-norm followed by clipping (limiting the maximum values of v to 0.2)

  L1 norm:f=$v/||v|| + e$

  L1 sqrt:f=$\sqrt{\frac{v}{||v||+e}}$

- Normalized group of histograms represents the block histogram. The set of these block histograms represents the descriptor.

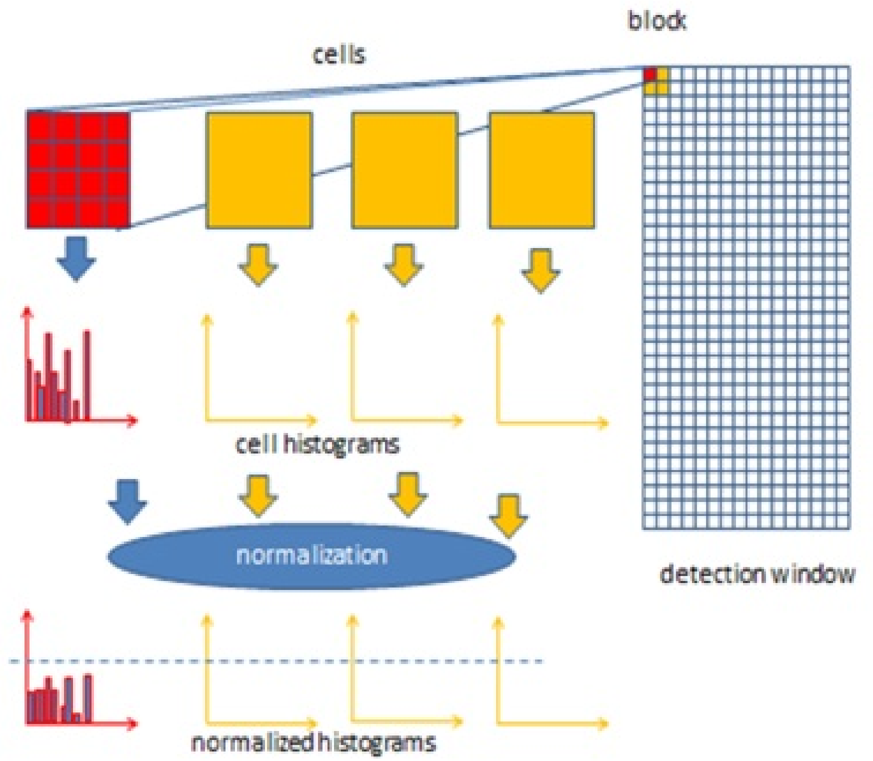


Figure 3.3: Explanation of Histogram of Gradient Algorithm

The **Figure 3.3**[11] above explains the histogram algorithm.

Haar Algorithm
It is a multiresolution wavelet transform which is used in pattern recognition and image processing. The HAAR functions are widely applied in numerical calculations because they produce a uniform function system approximation of a function system with various arguments.
The Haar wavelet's mother wavelet function $\varphi(t)$ can be described as
$\varphi(t) = (1 \quad 0 \leq t < 1/2 \quad -1 \quad 1/2 \leq t < 1 \quad 0 \quad otherwise)$
Its scaling function $\phi(t)$ can be described as
$\phi(t) = (1 \quad 0 \leq t < 1 \quad 0 \quad otherwise)$

Local Binary Patterns Algorithm
The LBP has a good performance in applications like classification and tex-

ture, image recovery and surface inspection. The original LBP labels the image pixels for a threshold neighborhood of 3*3. Each pixel is compared with the central pixel and the result is the binary number.

- The following notation is used for the LBP operator: $LBP^{u2}_{P,R}$. The subscript represents using the operator in a (P,R) neighborhood. Superscript u2 stands for using only uniform patterns and labeling all remaining patterns with a single label. After the LBP labeled image f1(x,y) has been obtained, the LBP histogram can be defined as
  $H_i = \sum_{x,y} I[f_{lx,y} = i], i = 0,,n-1$
  in which n is the number of different labels produced by the LBP operator, and IA is 1 if A is true and 0 if A is false.

- When the image patches whose histograms are to be compared have different sizes, the histograms must be normalized to get a coherent description
  $N_i = \frac{H_i}{\sum_{j=0}^{n-1} H_j}$
  Following the above steps we can get the results which are considered for finding out the parameters.

Chapter 4

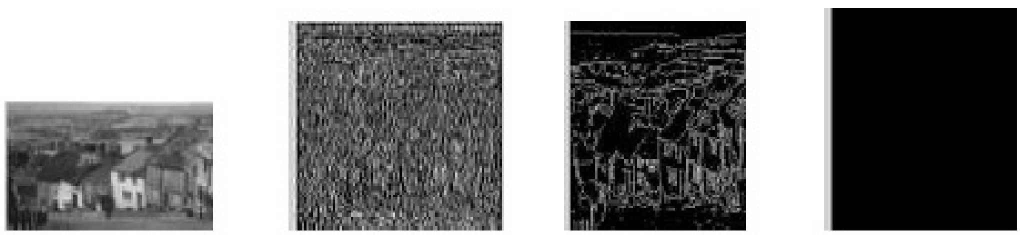
Comparison of Algorithms

There are various techniques and their algorithms which have been discussed in previous chapter. These techniques were used for image processing which served to be an input for image analysis. This chapter discusses about the performance and testing results of all the algorithms.

4.1 Object Recognition

4.1.1 Edge Detection Algorithms

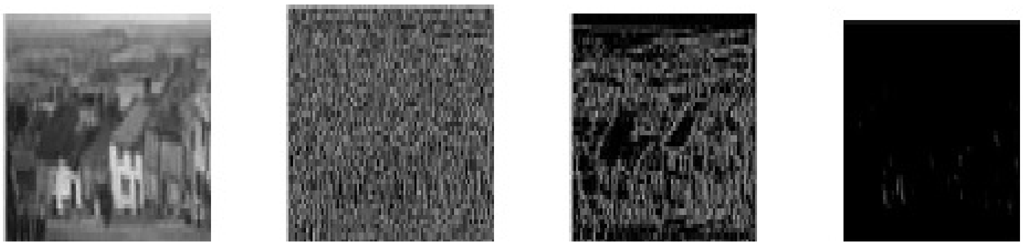
Sobel Operator



Original Image (a)Threshold=0.00 (b)Threshold=0.05 (c)Threshold=0.3

Figure 4.1: Analysis of Sobel Opertaor

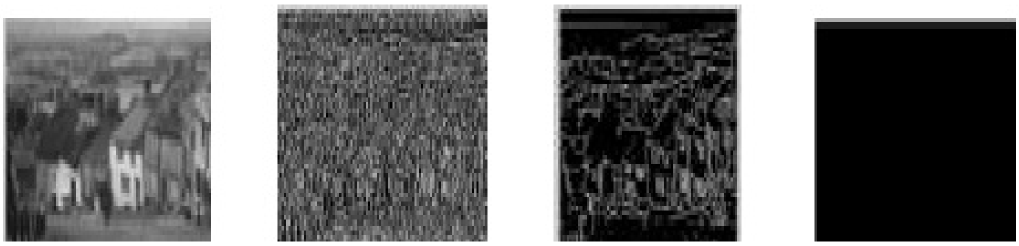
Robert's Operator



Original Image (a)Threshold=0.00 (b)Threshold=0.05 (c)Threshold=0.3

Figure 4.2: Analysis of Robert's Opertaor

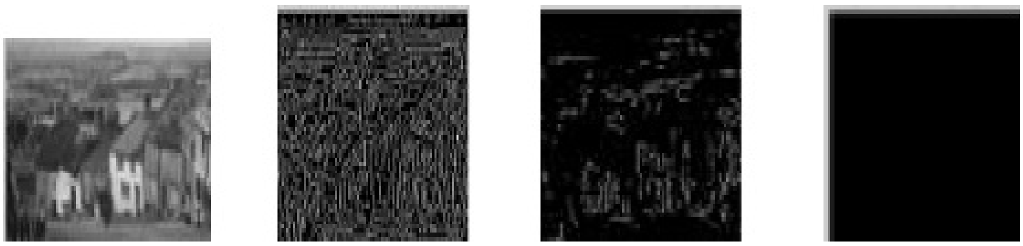
Prewitt Operator



Original Image (a)Threshold=0.00 (b)Threshold=0.05 (c)Threshold=0.3

Figure 4.3: Analysis of Prewitt Opertaor

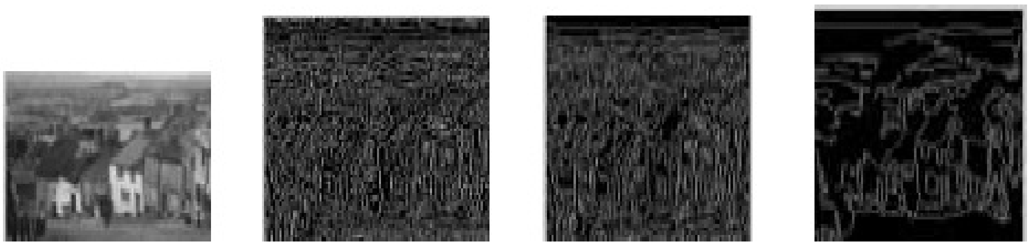
Laplacian of Guassian



Original Image (a)Threshold=0.00 (b)Threshold=0.05 (c)Threshold=0.3

Figure 4.4: Analysis of Laplacian of Guassian

Canny Edge Detection



Original Image (a)Threshold=0.00 (b)Threshold=0.05 (c)Threshold=0.3

Figure 4.5: Analysis of Canny Edge Detection

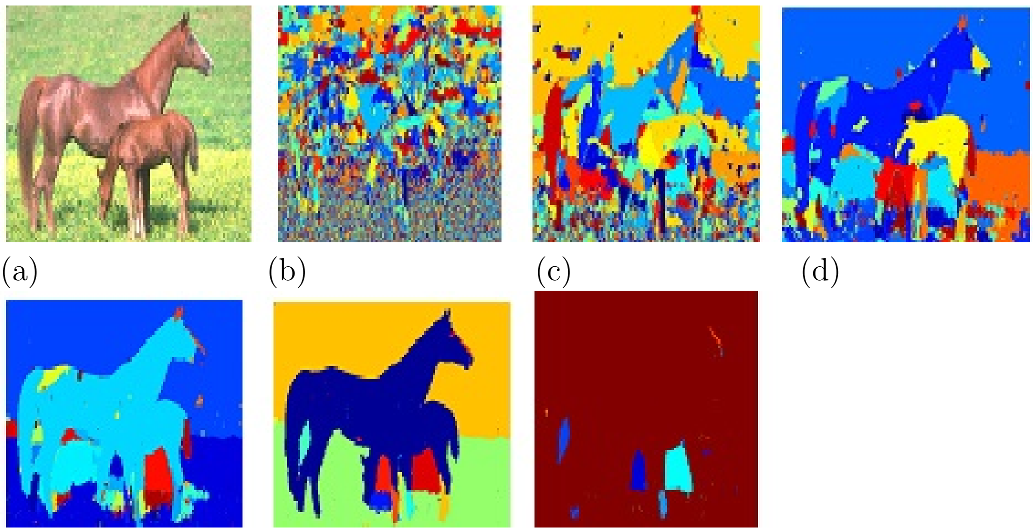
As shown in **Figure 4.1,Figure 4.2,Figure 4.3,Figure 4.3,Figure 4.5**[3][6],shows comparisons in the algorithms.

- ADVANTAGES AND DISADVANTAGES
  The Sobel operator is the simplest method and is sensitive to diagonal edges more than horizontal and vertical ones but it sensitive to noise. The Prewiit Operator is also sensitive to noise and therefore the value of kernel filter and coefficients cannot be changes, it is also sensitive to horizontal and vertical edges.LOG is rarely used technique for edge detection but is used for finding whether the pixel is dark or bright. It does not function properly at the curves and edges where intensity changes.
  The best technique in all the above mentioned is the Canny Edge Detection technique. It is used to detect strong and weak edges and is not sensitive to noise by which true weak edges can be determined. But this technique is computationally more expensive than the others.

4.2 Image Segmentation

4.2.1 Segmentation Algorithms

Mean Shift Algorithm



(a) (b) (c) (d)

(e) (f) (g)

(a)Original image, (b)-(g) mean shift segmentations
Using scale bandwidth (h_s) =7 and color bandwidths (h_r) = 3, 7, 11, 15, 19 and 23 respectively.

Figure 4.6: Analysis of Mean Shift Algorithm

Effecient Graph Based Algorithm

(a)Original image (b)graph based segmentations
Using scale bandwidth (h_s) =7 and color bandwidths (h_r) =7 and k=300.

Figure 4.7: Analysis of Effecient Graph Based Algorithm

Hybrid Segmentation Algorithm

(a) (b) (c)

(a)Original image, (b)-(c)hybrid segmentations
Using scale bandwidth (h_s) =7 and color bandwidths (h_r) =7 and k=(3, 5), (3, 25) respectively.

Figure 4.8: Analysis of Hybrid Segmentation Algorithm

As shown in **Figure 4.6,Figure 4.7,Figure 4.8**[1][2],shows comparisons in the algorithms.

- Advantages And Disadvantages
  Mean Shift algorithm is very sensitive to its two parameters h_s and h_r but eases the burden of parameter tuning given to object recognition. Efficient graph-based is sensitive to its parameter k but merging allows clustering to be sensitive to edges in areas of low variability, and less sensitive to them in areas of high variability. This is intuitively the property we would like to see in a clustering algorithm.
  When the three comparisons were done we find out that in correctness all three performed to be good but in performance hybrid algorithm and mean shift algorithm works more efficiently than graph based algorithm. Second comparison of stability with respect to parameters, the hybrid algorithm showed less variability when its parameters were changed than the mean shift segmentation algorithm. The amount of improvement did decline with increasing values of k. The graph-based segmentation did show very low variability with k=5,changing the value of k decreased its stability drastically.
  Third comparison of stability of particular choice of parameter, the graph-based algorithm has low variability when k=5,however its performance and stability decrease rapidly with changing values of k.The

comparison between the mean shift segmentation and the hybrid method is much closer here, with neither performing significantly better.
When all three conditions are tested, we see that hybrid and mean shift algorithm can create realistic images; however hybrid algorithm has slightly improved stability than both. Thus, we would choose to incorporate the hybrid method into a larger system.

4.3 Feature Extraction

4.3.1 Extraction Algorithms

The analysis is done on two classification techniques
Support Vector Machine (SVM)
Radial Basis Function Network (RBFN)

On these two techniques the comparative results are

Table 4.1: Analysis according to SVM

Image Database	**TP**	**FP**	**TN**	**FN**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
HAAR	530	112	2464	139	0.7922	0.9565	0.8255	0.9466	0.9226
HOG	565	64	2512	104	0.8445	0.9752	0.8983	0.9062	0.9482
LBP	627	35	2541	42	0.9372	0.9864	0.9471	0.9837	0.9763
SURF	614	36	2540	55	0.9178	0.9860	0.9446	0.9788	0.9719

Table 4.2: Analysis according to RBFM

Image Database	**TP**	**FP**	**TN**	**FN**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
HAAR	602	55	2521	67	0.8998	0.9786	0.9163	0.9741	0.9624
HOG	603	93	2483	66	0.9013	0.9639	0.8664	0.9741	0.9510
LBP	630	99	2477	39	0.9417	0.9616	0.8641	0.9845	0.9575
SURF	609	45	2531	60	0.9103	0.9825	0.9312	0.9768	0.9676

- Advantages And Disadvantages
  The HOG descriptor has been set up with a 9 histograms by 9 partitions window, was the best. This way, a vector of 81 features is generated.
  The LBP was used with a window of 3*3 corresponding to 9 histograms.

The neighborhood used was 3*3 for the computation of the label. A grayscale image was used for the processing. The LBP descriptor describes the local texture structure by pattern joint distribution.
The HAAR Wavelet algorithm obtained satisfactory rates too. Its efficiency can be explained by the use of filtering which resulted in noiseless information and compression in the images. This causes the classifier learning to be easier and the correct classification of input data.
The results for the SURF descriptor are satisfactory too. This situation can be explained by the use of visual dictionaries. Without the visual dictionaries, the results were not satisfactory (near 0.85 accuracy rate).
In all the tested situations, the SVM classifier obtained the highest accuracy rates. The values obtained were 0.9226 for the HAAR descriptor, 0.9482 for the HOG descriptor, 0.9763 for the LBP descriptor and 0.9719 for SURF descriptor. Therefore, note that the best result was obtained when the SVM classifier was used with the LBP descriptor.

Chapter 5

Project Definition

PROBLEM STATEMENT
To implement image based map reduce tasks using Hadoop image processing interface.
To implement this problem statement, we have divided this topic into the following steps

- Hadoop installation
- HIPI framework installation
- Collection of datasets and deciding the problem
- Image Processing
- Image Analysis

Images are an indispensible source of information. Information extracted from images can be used for making strategic decisions in various fields. That is why implementing map based image analysis is finding increasing applications.

In order to implement image based map reduce for any application, we first need to install Hadoop. After installing Hadoop, we need to install HIPI framework. After installing HIPI we can collect datasets of the required images from various sources depending on the problem at hand. For example, in the field of Sales where we will be deciding the production rates of a particular make of a car based on image analysis.

Once the data sets have been acquired we can process the images using techniques like Canny Edge Detection, Hybrid Segmentation, HAAR wavelet histogram, HOG for image segmentation. The processed result of images will be used for image analysis. We can use techniques like Object Recognition, Feature Extraction and Image Segmentation for analysis.

The above mentioned steps are explained in the **Figure 5.1** below.

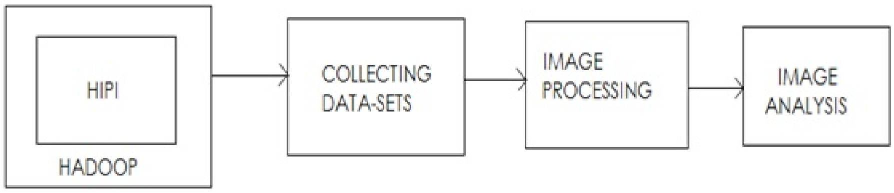


Figure 5.1: Work Flow

Chapter 6

Conclusion

Our project topic is Hadoop Image Processing Interface (HIPI) using Map Reduce. We divided the project into four parts: Hadoop, Hadoop Image Processing Interface (HIPI), Image Processing and Image Analysis to study each topic in detail.

Image Processing is a technique through which we do digitization of images and perform operations on it,to get enhanced images and to extract useful information through it. This technique can be used in various fields like remote sensing, medical fields, transmission and encoding, color processing, pattern recognition etc.

This uses various algorithms to extract useful and desired information through edge detection, pattern recognition,image segmentation and feature extraction. After doing a study on various techniques and comparing them I have a got result of the best ones to be used for better and faster implementations. For edge detection the best algorithm which can be used is Canny Edge Detection technique. Likewise for image segmentation I have seen Mean Shift and Hybrid Algorithms works very efficiently and for feature extraction Local Binary Pattern algorithm. Thus, by doing this study I get a better knowledge of image processing.

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