An Approach for Image Classification

Shruti Kulkarni
M.E. EEE SGBAU University
Amravati India
kulkarnishruti.first@gmail.com

***Abstract*— Main key issue, here, is the choice of the methodology for the image segmentation. Different techniques are available to perform the image segmentation, but the prominent one from image classification point of view is the watershed transform, as presented work concern with the approach based on graph kernels. To develop the graph kernel, it is necessary to have the identification of the different regions of the image. To get the different regions from the image, the watershed transformation based image segmentation have to be performed. Later the next important thing is that the image classification. For this purpose the Support Vector Machine (SVM) is selected as the classifier. In view of the image classification, firstly, the image database of different classes is referred, to generate the attributes of the images in particular and that of the classes in general. These attributes consist of the feature based on the graph kernel which is obtained after performing the image segmentation using watershed transformation and the features for the whole image. In this way, the feature database for the particular classes is developed. Later, to identify the belongingness of the query image, once again the same attributes are extracted for the query image and then, query image feature and the feature database for the various classes is referred to classify the given query image. For this purpose the confusion matrix is evaluated through the SVM classifier. Experimentations are carried out with the five classes of images. Every class consists of 100 images. Obtained results are encouraging and motivating.**

***Keywords*— image processing, image segmentation, SVM, image classification**

I. INTRODUCTION

1.1 Image and Image Processing

An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y, and the amplitude values of f are all finite, discrete quantities, is a digital image.

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

1.2 Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (edge detection). Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s).

Marker-controlled watershed segmentation follows this basic procedure:

- Compute a segmentation function.
- Compute foreground markers.
- Compute background markers.
- Modify the segmentation function so that it only has minima at the foreground and background marker locations.

1.3 Image Classification

Image classification as a machine learning task enjoys numerous applications, such as image retrieval or object recognition. Images are naturally high-dimensional data, which demands mandatory pre-processing targeted towards dimensionality reduction. Most techniques require a preprocessing step, which can be global as in color histogram binning or local through feature extraction.

Classification includes a broad range of decision-theoretic approaches to the identification of images (or parts thereof). All classification algorithms are based on features and that each of these features belongs to one of several distinct and exclusive classes. The classes may be specified *a priori* by an analyst (as in *supervised classification*) or automatically clustered (as in *unsupervised classification*) into sets of prototype classes, where the analyst merely specifies the number of desired categories.

Image classification analyzes the numerical properties of various image features and organizes data into categories.

1.4 Graph Kernels in Image Classification

Graph kernel is a kernel function that computes an inner product on graphs. Graph kernels can be intuitively understood as functions measuring the similarity of pairs of graphs. They allow kernelized learning algorithms such as support vector machines to work directly on graphs, without having to do feature extraction to transform them to fixed-length, real-valued feature vectors. They find applications in bioinformatics, in chemo informatics and in social network analysis. A scalar can be modeled as a graph with one single node labeled by the value of this scalar. Vectors and matrices can be modeled as graphs, with one node per entry and edges between consecutive components within a vector and matrix, respectively.

1.5 Support Vector Machine

SVMs are a class of algorithms that use only key vectors from the training set to determine the decision boundary. These vectors are called support vectors. The idea behind using only a subset of the training set to contribute to the decision boundary is to limit the number of computations between the training vectors and the testing vectors.

In its basic form, a Support Vector Machine (SVM) classifier uses two sets of discriminative examples for training; these examples belong to a vector space endowed with a dot product. The main advantage of this classifier is the fact that it minimizes the classification error while maximizing the distance from the training examples to the separating hyperplane. It also allows the definition of a soft margin to prevent the mislabeled examples from perturbing too much the classification. Although SVMs have been originally designed as linear classifiers, they have been extended to perform nonlinear discrimination by using a ``kernel trick´´, that replaces the dot product needed in computation by a non-linear positive definite kernel function. Measuring graph similarity can be addressed by considering kernels function on graphs. This function can be interpreted as an inner product on two graphs, obtained by comparing edges and vertices that have been crossed during random walks on the graphs. Then a major particularity of this kernel is the use of kernels between vertices and edges. It means that labels can be complex structures, like vectors, histograms or set of histograms, instead of a single real value, which is the case for most of graph matching algorithms.

1.6 Contribution

In view of image classification, the image segmentation approach is developed. Based on this the features are evaluated for the graph. For this purpose the graph kernels are used. Other features are evaluated through the wavelet transform and histograms. Obtained results are satisfactory from the image classification point of view. Different features are used, namely, the regional features, color features, and the moments for the image based on wavelet transform. For image classification, the SVM classifier is used, based on the confusion matrix, the results are obtained.

II. LITERATURE SURVEY

A. Image Segmentation Related Work

Anju Bala (2012) [1] discussed watershed transformation based segmentation. This approach includes image enhancement and noise removal techniques with Prewitt's edge detection operator which detects the edges instead of Sobel Operator as in existing marker controlled watershed transformation. This approach reduces the over segmentation effect and achieve good segmentation. This approach uses preprocessing methods to reduce the noise of image and adjust the image intensity. Athira Devi and Venugopal (2012) [3] introduced a multi region graph cut image partitioning through kernel mapping of the image data. The approach uses two terms: an original kernel-induced term which evaluates the deviation of the mapped image data within each region from the piecewise constant model and a regularization term expressed as a function of the region indices. Using a common kernel function, the objective functional minimization is carried out by iterations of two consecutive steps: minimization with respect to the image segmentation by graph cuts and minimization with respect to the regions parameters via fixed point computation. Change in kernel function, in such a way that can improve optimization process is first step in medical analysis. Leibe and Schiele (2003) [5] explained approach for object recognition at level where a large number of previously seen and known objects can be identified. In this paper, the authors analyzed the performance of several state-of-the-art appearance and contour-based recognition methods for the more general task of multi-class object categorization. Later, the authors used the multiple cue decision tree. In this paper, the authors explored the two approaches to find segmented regions.

Fowlkes et al. (2004) [6] explained the Spectral graph theoretic approach for the problem of image segmentation. However, due to the computational demands of these type of approaches, applications to large problems such as spatio temporal data and high resolution imagery have been slow to appear. The approach presented in this paper reduces the computational requirements of grouping algorithms based on spectral partitioning making and it can be applied to very large grouping problems. This approach is based on a technique for the numerical solution of eigen function problems known as Nystrom method. In this paper, authors have presented a technique for the approximate solution of spectral partitioning for image and video segmentation based on the Nystrom extension.

Gomila and Meyer (2003) [7] discussed about graphs and graphs offer a compact representation of 2D or 3D images, as each node represents a region with its attributes and the edges convey the neighborhood relations between adjacent regions. Such graphs may be used in the analysis of video sequences and the tracking of objects of interest. Each image of a sequence is segmented and represented as region adjacency graph. Object tracking becomes a particular graph-matching problem, in which the nodes representing the same object are to be matched. The intrinsic complexity of graph matching is greatly reduced by coupling it with the segmentation. In this paper, object tracking is formulated as a joint problem of segmentation and matching.

Malik et al. (2001) [15] explained an algorithm for partitioning grayscale images into disjoint regions of coherent brightness and texture. Natural images contain both textured and untextured regions, so the cues of contour and texture differences are exploited simultaneously. Contours are treated in the intervening contour framework, while texture is analyzed using textons. Each of these cues has a domain of applicability, so to facilitate cue combination introduced a gating operator based on the texturedness of the neighborhood at a pixel. The spectral graph theoretic framework of normalized cuts is used to find partitions of the image into regions of coherent texture and brightness.

Yi et al. (2012) [19] described the approach for multiscale segmentation which is always needed to extract semantic meaningful objects for object-based remote sensing image analysis. This paper discusses a simple scale-synthesis approach which is highly flexible to be adjusted to meet the segmentation requirements of varying image-analysis tasks. In this approach, the whole image is divided into multiple regions where each region consisted of ground objects that have similar optimal segmentation scale. Then, synthesize of the suboptimal segmentations of each region is carried out to get the final segmentation result. The result is the combination of sub optimal scales of objects. This is a simple scale-synthesis approach for High Spatial Resolution Remote Sensing image (HSRI) segmentation. This approach simplifies image segmentation by dividing the segmentation task into multiple subtasks of different land-cover categories. An edge-embedded marker-based watershed (EEMW) algorithm has been first implemented to get an initial over segmentation result. Then, a bottom-up region-merging method has been implemented with a MumFord-Shah segmentation model to establish linking hierarchy multi scale segmentation network. The final segmentation result has been generated by synthesizing the selected segmentation results together.

Farmer and Jain (2005) [23] explained framework for segmentation and classification that follows the wrapper methods of feature selection. This approach wraps the segmentation and classification together, and uses the classification accuracy as the metric to determine the best segmentation. By using shape as the classification feature, authors explained segmentation algorithm that relaxes the requirement that the object of interest to be segmented must be homogeneous in some low-level image parameter, such as texture, color, or grayscale. The summary of image segmentation related work is given in Table 2.1 (a) and Table 2.1 (b).

Table 2.1 (a):Image segmentation related work

Ref no, Authors, year	Performance parameter used	Data base used	Issues Addressed	Authors Remark	Our Findings
[1] Anju Bala 2012	Noise, Intensity	Synthetic image	Prewitt's operator, gradient magnitude	Image is segmented according to object, color, shape	To avoid over segmentation Prewitt's operator is used to detect the edges instead of Sobel operator
[3] A. Devi C P and A Venugopal 2012	Segmentation time, Pixel count and label, region parameters	Synthetic image	image segmentation by graph cuts and Kernel mapping	minimization with respect to the image segmentation by graph cuts minimization with respect to the regions parameters via fixed point computation	Kernel function is used to improve optimization process
[5] Bastian Leibe, Bernt Schiele, 2003	Contour, Color, texture ,global and local shape of image	COIL, RSORT ETH - 80	high-resolution color images	Object Categorization Contour methods	Combination of Different methods is used

[6] C. Fowlkes, S. Belongie, F. Chung, and J. Malik, 2004	Textons, histogram, eigen vectors	Synthetic image	Spectral grouping of images by k-means pairwise clustering, Nystrom method	The specific application is classification of MRI scan data according to the nature of the corpus callosum, introduced A variation of the spectral segmentation with multi-scale graph decomposition Mechanism.	Color and texture segmentation, spatio temporal segmentation issues are addressed

Table 2.1 (b) : Image Segmentation related work

Ref no, Authors and year	Performance parameter used	Data base used	Issues Addressed	Authors Remark	Our Findings
[7] C. Gomila and F. Meyer, 2003	Successive positions of the same object.	Synthetic image	Object tracking is formulated as a joint problem of segmentation & matching	JSM for 2D and 3D images, efficient solution to reduce the complexity of the matching algorithms	Region splitting, Matching partition. Matching of occluded region is carried out
[15] J. Malik, S. Belongie, T. K. Leung, and J. Shi., 2001	Textons, eigen vectors, canny edge detector ,cue, contour ,texture	Synthetic image	partitioning grayscale images into disjoint regions	Contour and texture Analysis Canny edge detector	Pixels which are not oriented/oreinted are considered
[19] Lina Yi, Guifeng Zhang, and Zhaocong Wu,2012	Classification accuracy	Synthetic image	Extract semantic meaningful objects	scale-synthesis method, EEMW algorithm HSRI segmentation	Land cover category type of image for multi scale segmentation, region segmentation is used
[24] Michael E. Farmer, and Anil K. Jain,2005	Classification accuracy	Synthetic image	Wrapping segmentation, Classification, FSS and EM algorithm	Classification accuracy, Feature extraction, Context-based segmentation	image segmentation, feature extraction, classification

Morales-Gonzalez et al. (2013) [2] described about graph-based data representation is an important research topic due to the suitability of this kind of data structure to model entities and the complex relations among them. In computer vision, graphs have been used to model images in order to add some high level information (relations) to the low-level representation of individual parts. In this paper, authors proposed combined graph-based image representation and frequent approximate subgraph (FAS) mining algorithm in order to classify images. Here, FASs is used as features which are used in a classification framework. The FASs are obtained by means of FAS miners.

Elsayed et al. (2010) [4] explained an approach to classify magnetic resonance (MR) image data. A variation of the spectral segmentation with multi-scale graph decomposition mechanism is introduced. Aldea et al. (2007) [8] proposed an image classification technique based on kernel methods and graphs. This work explores the possibility of applying marginalized kernels to image processing. This work consists of two distinct parts. In the first one, authors described a model to represent the images by graphs to be able to represent their structural properties and inherent attributes. In the second one, authors used kernel functions to project the graphs in a mathematical space that allows the use of performant classification algorithms.

Huang and Cun (2006) [11] explained an approach for the detection and recognition of generic object categories with invariance to viewpoint, illumination, and clutter. They presented a hybrid system where a convolutional network is trained to detect and recognize generic objects, and a Gaussian-kernel SVM is trained from the features learned by the convolutional network. Here, convolutional nets and SVM are investigated with results on a generic object categorization dataset which includes two step learning process. Perronnin et al. (2012) [12] explained several objective functions for large-scale image classification by comparing one-vs-rest, multiclass, ranking and weighted average ranking SVMs.

Suard et al. (2006) [13] presented an approach for object categorization which is based on two complementary descriptions of an object. First, described its shape through labeled graphs. This graph is obtained from morphological skeleton, extracted from the binary mask of the object image. The second description uses histograms of oriented gradients which is aimed at capturing objects appearance. The histogram descriptor is obtained by computing local histograms over the complete image of the object. These two descriptions are combined using a kernel product.

Cuturi et al. (2005) [21] discussed positive definite kernels on measures, characterized by the fact that the value of the kernel between two measures is a function of their sum. These kernels can be used to derive kernels on structured objects, such as images and texts, by representing these objects as sets of components, such as pixels or words, or more generally as measures on the space of components. It is observed that the computational complexity is high for the k-IGV kernel. The summary of image classification related work is given in Table 2.2 (a) and Table 2.2 (b).

Table 2.2 (a): Image classification related work

Ref no, Authors and year	***Performance parameter used***	***Data base used***	***Issues Addressed***	***Authors Remark***	***Our Findings***
[2]A. M.Gonzalez, N,A.Mendoza, A.G.Alonso, E.B.G-Reyes, Jose E.M-Pagola 2013	Support Thres-hold, Isomor-phism Threshold	COIL 100 ETH 80	Positive definite kernels between labeled graph VEAM, APGM Algorithm	FAS Mining Algorithm classifying images to improve graph efficiency	FAS in terms of edge and vertex Authors explore classification framework
[4]A.Elsayed, F.Coenen,C. Jiang, F.G.Finana,V.Sluming,2010	gSpan algorithm TCV, Quad tree, use of feature vectors constructed from Frequent sub-graphs	Synthetic image	Isomorphism Threshold, Support Threshold	MR Image Classification, Image Mining	Technique for approximate solution of spectral partitioning for image & video segme-ntation based on Nystrom extension
[8] E. Aldea, J. Atif, and I. Bloch, 2007	Driac, RBF,Marginalized kernel, SVM Classifier	Synthetic image	computation specific properties of image-based graphs	Average gray value of region, Region surface in pixels	Image based graph concept described by authors

Table 2.2 (b): Image classification related work

Ref no, Authors , year	**Performance parameter used**	**Data base used**	**Issues Addressed**	**Authors Remark**	**Our Findings**
[11] F.J.Huang and Y.LeCun ,2006	SVM, Convolutional net, Reconigition accuracy	COIL NORB	SVM with Gaussian Kernel	investigated two types of popular discriminative learning methods: Support Vector Machine	Convolutional networks, on the other hand, yield good Recognition accuracy with low computational complexity.
[12] F	Accuracy	ImageN	Multi	Stochastic	Binary one vs

Perronnin, Z Akataa, Zaid Harchaouib and C Schmid, 2012		et10K	scale SVM	gradient algorithm	rest SVM, Weighted Aprro SVM
[13] F. Suard, A. Rakotomamonjy and A. Bensrhair,2006	Gradient computation, l1 norm and l2 norm	ETH-80	3D structure of objects Graph Kernel HOG kernel	a method for object categorization. The aim is to depict images by labeled graphs and histograms of oriented gradients.	histograms of oriented gradients, improvement in classification results.
[21]M. Cuturi, K. Fukumizu, and J.-P. Vert, 2005	Gaussian kernel SVM	MNIST	Semi group kernel Entropy kernel	Integral representation of positive definite kernel	Positive definite kernels for image classification

Bach et al. (2004) [9] discussed classical kernel-based classifiers which are based on a single kernel, in practice it is often desirable to base classifiers on combinations of multiple kernels. They considered conic combinations of kernel matrices for the support vector machine (SVM), and showed that the optimization of the coefficients of such a combination reduces to a convex optimization problem known as a quadratically-constrained quadratic program (QCQP).

Bach et al. (2004) [10] explained the problem of learning a sparse conic combination of kernel functions or kernel matrices for classification or regression which is achieved via the regularization by a block 1-norm. They presented an algorithm that computes the entire regularization path for these problems. The path is obtained by using numerical continuation techniques and involves a running time complexity that is a constant times the complexity of solving the problem for one value of the regularization parameter. They explained effect of the block 1-norm regularization differs notably from the non-block 1-norm regularization commonly used for variable selection and that the regularization path is of particular value in the block case and also presented an algorithm to compute entire regularization paths for the problem of multiple kernel learning. Suard et al. (2005) [14] presented an approach for pedestrian detection with stereovision and graph comparison. Images are segmented by the NCut method applied on a single image, and the disparity is computed from a pair of images. This segmentation keep only shapes of potential obstacles, by eliminating the background. The comparison between two graphs is accomplished with an inner product for graph, and then the recognition stage is performed. Learning is done among several pedestrian and non-pedestrian graphs with SVM method.

Shi and Malik (2001) [16] explained image segmentation as a graph partitioning problem, the normalized cut, for segmenting the graph. The normalized cut criterion measures both the total dissimilarity between the different groups as well as the total similarity within the groups. A computational technique based on a generalized eigen value problem is used to optimize this criterion and approach to segment static images, as well as motion sequences. Normalized cut is an unbiased measure of disassociation between subgroups of a graph and minimized normalized cut leads directly to maximizing the normalized association, which is an unbiased measure for total association within the subgroups. A computational method based on this idea has been developed and applied to segmentation of brightness, color, and texture images. Shawe-Taylor and Cristianini (2004) [17] described the concepts about the pattern analysis, clustering, kernel methods, kernel matrix, and different types of kernels.

Wu and Rehg (2009) [18] presented common visual codebook generation approach used in a Bag of Visual words model, e.g. k-means or Gaussian Mixture Model. Histogram Intersection Kernel (HIK) is used in place of the Euclidean distance to generate the codebooks. In this paper, author demonstrated that HIK is used in an unsupervised manner to generate the visual codebooks. Authors claimed that the HIK codebook has higher recognition accuracy over k-means codebooks. Zhang et al. (2013) [20] discussed an approach for object classification based on multi-view segment graphs. For given set of multi-view images for an object, each of them is segmented in terms of its color intensity distribution. Inter and intra-view segment graphs are constructed to describe the spatial relations of the segments between and within view images respectively. Then, these two types of graphs are integrated into a multi-view segment graph Kernel between objects which is computed by accumulating all matching of walk structures between their corresponding multi-view segment graphs.

Singha and Hemachandran (2012) [22] described content based image retrieval approach where the texture and color features are extracted through wavelet transformation and color histogram. Nilsback and Zisserman (2009) [23] described an approach for automatically segmenting flowers in color photographs. This approach consist of two models- a color model for foreground and background, and a light generic shape model for the petal structure. The segmentations are produced using MRF cost function optimized using graph cut. Farmer and Jain (2005) [24] presented a framework for segmentation and classification that follows the wrapper methods of feature selection. This approach wraps the segmentation and classification together, and uses the classification accuracy as the metric to determine the best segmentation. By using shape as the classification feature, authors explained segmentation algorithm that relaxes the requirement that the object of interest to be segmented must be homogeneous in some low-level image parameter, such as texture, color, or grayscale.

Demirci et al. 2006 [25] explained matching configurations of image features, represented as attributed graphs. Noisy segmentation of images and imprecise feature detection may lead to graphs that represent visually similar configurations that do not admit an injective matching. The framework utilized a low distortion embedding function to map the nodes of the graphs into point sets in a vector space. The Earth Movers Distance (EMD) algorithm is then used to match the resulting points, with the computed flows specifying the many-to-many vertex correspondences between the input graphs. Hein and Bousquet (2004) [26] investigated the problem of defining Hilbertian metrics and positive definite kernels on probability measures. They also discussed about the structural kernel which is independent of the dominating measure.

Neuhaus and Bunke (2006) [27] discussed an approach in structural pattern classification to define a dissimilarity measure on patterns and then apply a distance-based nearest-neighbor classifier. They have elaborated he approach for classification using kernel functions based on edit distance. This approach is applicable to both string and graph representations of patterns. By means of the kernel functions introduced in this paper, string and graph classification can be performed in an implicit vector space. Kernel functions described in this paper provided direct link between the structural pattern space and the kernel space in that the Euclidean distance in the kernel space is identical to the edit distance in the pattern space. Salman (2006) [28] discussed combination of K-means, watershed segmentation method, and Difference In Strength (DIS) map which is used to perform image segmentation and edge detection tasks. An initial segmentation is obtained which is based on K-means clustering technique. Authors used two techniques; the first is watershed technique with merging procedure based on mean intensity value to segment the image regions and to detect their boundaries. The second is edge strength technique to obtain edge maps of images without using watershed method.

Acosta-Mendoza et al. (2012) [29] discussed the use of approximate graph matching for frequent subgraph mining. In this paper, an approach for mining frequent connected subgraphs over undirected and labeled graph collections VEAM -Vertex and Edge Approximate graph Miner is presented. Slight variations of the data, keeping the topology of the graphs, are allowed in this approach. Approximate matching in existing algorithm (APGM) is only performed on vertex label set. In VEAM, the approximate matching between edge labels set in frequent sub graph mining is included in the mining process. Also, a framework for graph-based image classification is introduced. This approach identifies the frequent patterns in collections of images allowing slight angular differences between the positions of image segments. Guan et al. (2012) [30] explained gradient approach for solving non-negative matrix factorization and its variants. Nesterov's gradient approach is used to alternatively optimize one factor with another fixed. In particular, at each iteration round, the matrix factor is updated by using the PG method performed on a smartly chosen search point, where the step size is determined by the Lipschitz constant. Authors presented a nonnegative matrix factorization solver NeNMF, which sequentially optimizes one matrix factor with another fixed by using Nesterov's method.

Tsuda et al. (2007) [31] explained an approach where each image is represented as a graph where nodes correspond to local image features and edges encode geometric relations between features. In this paper author proposed a way to bridge the gap between high prediction performance and interpretability. Chapelle and Zien (2004) [32] discussed three semi-supervised algorithms where first one is deriving graph-based distances that emphasize low density regions between clusters, followed by training a standard SVM, second one is optimizing the transductive SVM objective function, which places the decision boundary in low density regions, by gradient descent and third is combining the first two to make maximum use of the cluster assumption. These algorithms are based on two different principles: the regularization by margin maximization on the labeled points, and the cluster assumption by margin maximization on the unlabeled points. Poorani et al. (2013) [33] presented features extraction mechanism which is used for retrieving the images. These features include color, shape and texture. These features are extracted by different techniques. Color feature is extracted by Color Histogram and Color Descriptor. Shape feature is extracted by Hu Moment and Edge detection Method. Texture feature is extracted by Gray Level co-occurrence matrix and texture descriptor.

Peng and Gu (2005) [34] implemented watershed transform using a multi-degree immersion simulation in which simulation procedure changed to multi-degree, such that flood step is different on each degree of intensity, the presented implementation resists the over segmentation problem. Lazebnik et al. (2006) [35] presented an approach for recognizing scene categories based on approximate global geometric correspondence. This technique works by partitioning the image into increasingly fine sub-regions and computing histograms of local features found inside each sub-region. Vishwanathan et al. (2007) [36] defined unifying framework for random walk kernels on graphs using extensions of linear algebra concepts for Reproducing Kernel Hilbert Spaces (RKHS). RKHS can be applied to directed and undirected graphs. Gartner (2003) [37] explained kernels on labeled directed graphs with general structure, computing a strictly positive definite graph kernel is just like solving the graph isomorphism problem and inner product in a feature space indexed by all possible graphs, where each feature counts the number of sub graphs isomorphic to that graph.

Jebara (2003) [38] explained the approach for modeling images and related visual objects as bags of pixels or sets of vectors. Bag of pixels subspace benefits from automatic correspondence estimation, giving rise to meaningful linear variations such as morphings, translations, and jointly spatio-textural image transformations. Wang et al. (2011) [39] explained Conventional linear subspace learning methods like principal component analysis (PCA), linear discriminant analysis (LDA) derive subspaces. Also proposed Subspace Indexing Model on Grassmann Manifold (SIM-GM) partitions the global space into local patches with a hierarchical structure; the global model is approximated by piece-wise linear local subspace models. Grassmann manifold distance is applied in such way that, SIM-GM is able to organize localized models into a hierarchy of indexed structure. Fu and Huang (2008) [40] explained the approach for image classification based on correlation tensor analysis (CTA), which is designed to incorporate both graph-embedded correlational mapping and discriminant analysis in a Fisher type of learning manner. CTA learns multiple interrelated subspaces to obtain a low-dimensional data representation reflecting both class label information and intrinsic geometric structure of the data distribution. LeCun et al. (2004) [41] explained the learning methods for generic object recognition with invariance to pose, lighting and surrounding clutter. They have also explained about jittered-textured and jittered cluttered dataset, where the classifier must simultaneously detect and recognize objects. Harchaoui and Bach (2007) [42] explained different type of kernel families like walk kernel, tree walk kernel, histogram kernel, weighted tree kernels. In this paper, three features are explained, first is histogram with gradients, integrated it with multiple kernel learning such as SIFT features, second one is extensions of kernels on structured data used in bioinformatics, such as the non-tottering trick, third is kernel-based framework carries directly over clustering, semi-supervised classification, and dimensionality reduction. The summary of Graph kernels related work is given in Table 2.3 (a) through Table 2.3 (g).

Table 2.3 (a): Graph kernels related work

Ref no, Authors and year	Performance parameter used	Database used	Issues Addressed	Authors Remark	Our Findings
[9] F.R.Bach,G.R.G.Lanckriet, M.I.Jordan,2004	Conic duality and optimality Conditions	ionosphere and breast cancer subset of Adult dataset	l1norms l2 norms MY regularized SKM	the algorithm selects kernels that define non-linear mappings on subsets of input features.	SMO-based algorithm is significantly more efficient
[10] F. R. Bach, R. Thibaux, and M. I. Jordan, 2004	Running time complexity, regularisation weight, eigen values	Boston dataset and liver dataset	Block l1norm regularizations, Conic combination of kernels	Presented an algorithm to compute entire regularization paths for the problem of multiple kernel learning.	empirical results shows suggested algorithm scales quadratically in the number of kernels, but cubically in the number of data points.
[14] F. Suard, V. Guigue, A. Rakotomamonjy, and A. Benshrair, 2005	Classification rate	Bench mark images with good lighting	Kernel methods-SVM Classifier &graph kernels	Described a pedestrian with a graph	presented a kernel method based on graph for pedestrian recognition.

Table 2.3 (b): Graph kernels related work

Ref no, Authors and year	Performance parameter used	Data base used	Issues Addressed	Authors Remark	Our Findings
[16] Jianbo Shi and Jitendra	Computation time,Gaussian	Different Synthetic	Graph theoretic approac	Normalised cut citeria for segmentati	computational metho

Malik ,2000	noise,eigen vectors	images	hes to image segmentation	ng graph also presented an efficient algorithm for computing the minimum normalized cut	d has been developed and applied to segmentation of brightness, color, and texture images
[17]J.Shawe-Taylor, N. Cristianini, 2004	-	-	kernel methods and Pattern analysis	Ranking, Clustering, diffusion kernels	Kernel algorithm
[18] J. Wu, J.M. Rehg 2009	Accuracy	Caltech 101 object recognition dataset , 15 class scene recognition dataset , and the 8 class sports events dataset	K median clustering Histogram interaction on kernel-HIK codebook	Histogram Intersection Kernel (HIK) is used as the similarity measure in clustering feature descriptors that are histograms .	Authors Proposed a HIK based codebook generation method which runs almost as fast as k-means and has consistently higher accuracy than k-means codebooks
[20]L.Zhang,M. Song,X. Liu,J.ju Bu, C.Chen	Classification accuracy , Color intensity	Paris , Oxford ETH-80	Inter and intra view segment graph, Multi-	Multiview segment graph–grassman manifold,,fixed-point iterations-	FMSGK, used to build representatio

2013	distribution		view object classification, Direct walk kernel Fast segment graph kernel	based acceleration and conjugate gradients-based acceleration.	n of multi-view images
[21]M. Cuturi, K.Fukumizu,J.-P.Vert, 2005	Regularization Width of Gaussian kernel	Semi-group kernel, Entropy kernel, k-IGV kernel	Inverse generalized variance on RKHS associated with kernel	positive definite kernels through an integral representation theorem proved	Authors presented semigroup Kernels, these kernels can be naturally applied on complex objects seen as molecular measures.

Table 2.3 (c): Graph kernels related work

Ref no, Authors and year	Performance parameter used	Data base used	Issues Addressed	Authors Remark	Our Findings
[22]Manimala Singha K.Hemachandran, 2012	Color feature, Color histogram, Haar discrete wavelet transform	WANG	Wavelet based color histogram, Quantization, Similarity Matching, Haar Wavelet, Precision &	Similarity between the images is ascertained by means of a distance function.	WBCH based image retrieval reduces computational steps and increase in retrieval speed.

			Recall.		
[23]Maria-Elena Nilsback, Andrew Zisserman, 2009	Colour distribution, petal detection	Oxford 17 Flower Dataset	Flower segmentation using color and shape model	flower segmentations can be significantly boosted by using image-specific colour distribution	Image specific background and foreground color models and ground truth labelled into foreground and background regions using a trimap
[25]M.F. Demirci,A. Shokoufandeh,Y. Keselman,L. Bretzner, Sven J. Dickinson, 2011	L1norm ,EMD algorithm	Sample silhouettes dataset, MPEG-7 dataset, Kimia dataset	Dissimilarity between object pairs, Distortion tree, PCA, Graph edit distance , euclidean distance	approximate graph representation in geometric space through an isometric Embedding technique problem overcome	The proposed framework embeds the input trees isometrically into a geometric space under the l1 norm.To match many to many EMD algorithm under l1 norm used
[26] M. Hein and O. Bousquet,2004	Homogeneous hibertian metrics, convariance metrics	WebKB and Reuters data set USPS dataset	Structural kernels, gaussian kernels, Hibertian metrics vs positive definite kernels	proposed a structural kernel which is independent of the dominating measure	Structural Kernels on probability measures

[27]M. Neuhaus and H. Bunke,2006	Chicken pieces dataset Tool dataset Pendigits dataset Chromosome dataset	string and graph datasets	String and edit distance , Graph matching, Edit distance based kernel functions, Kernel methods in pattern recognition	kernel method is able to improve classifiers based on tree edit distance	nearest-neighbor classifiers can be outperformed by support vector machines using the proposed kernel functions

Table 2.3 (d): Graph kernels related work

Ref no, Authors and year	Performance parameter used	Data base used	Issues Addressed	Authors Remark	Our Findings
[28] Nassir Salman, 2006	gradient operator, Edge pixel pointer. Edge length (N). Edge strengths. edge pointer	Synthetic image	Gradient calculation, K means clustering Region growing and edge detection	To perform image segmentation and edge detection tasks region growing & edge detection techniques.	Authors presented problem of undesirable over segmentation results produced by the watershed algorithm, when used directly with raw data images is solved
[29]N.Acosta-Mendoza, A. Gago-Alonso, Jose E. Medina-Pagola , 2012	Substitution matrix Sub isomorphism threshold Isomorphism threshold accuracy	Synthetic landscape images,sea scape images	Graph based image reperesentation VEAM, APGM algorithm, Frequent approxi	a graph-based image representation and a framework for graph-	Random image generator is used to obtain the collection of

			mate sub graph, RBF Kernel Function.	based image classification are proposed	images. quad-tree to represent each image in a tree form. a graph to represent each image in the collection is constructed from each respective tree
[30] N. Guan, D. Tao, Z. Luo, B. Yuan, 2012	Efficiency, accuracy	Synthetic 1 Synthetic 2 Reuters-2157 TDT-2	NeNMF, Optimum gradient, NENMF for regularized NMF	Discussed NENMF for l1 norm regularised, NENMF for l2 norm regularised and NENMF Manifold regularized	Authors presented nonnegative matrix factorization solver which sequentially optimizes one matrix factor with another
[31] Nowozin, K. Tsuda, 2007	Harris-Laplace interest point operator and the SIFT feature descriptor The interest point operator threshold is	VOC 2005 Dataset	Methods for supervised object classification, Supervised classification, Unsupervised image	derived and validated two practical methods for unsupervised ranking and supervi	Image categorization with high accuracy Svm used with histogram feature

	adjusted for each image such that a fixed number of features is extracted		marking, Substructure mining, image search	sed object classification based on the LP Boost formulation.	s and code book

Table 2.3 (e): Graph kernels related work

Ref no, Authors and year	Performance parameter used	Data base used	Issues Addressed	Authors Remark	Our Findings
[32] O. Chapelle and A. Zien, 2004	Fixed parameters of Svm, Tsvm, Manifold algorithm	g50c g10 Coil 120 Text Uspst	Labelled and unlabelled points, Semi supervised classification graph	LDS (Low Density Separation), combining TSVM and SVM algorithms.	pairwise distances computed by the graph algorithm attempt to reflect the cluster assumption
[33] Poorani M, Prathiba T, Ravindran G, 2013	Precision Recall	Wang database	Shape features are extracted using Hu Moments, CBIR, Color Descriptor, Color Histogram,	computational steps are effectively reduced with the use of Wavelet transformation	similarity measure using integrated features can be carried out using Euclidean distance provide high accuracy
[34] Shengcai Peng, Lixu Gu, 2005	Time Memory Water shed regions	Brain MRI data, cardiac CT data	Threshold set of images The application that was manifestations of disease from CT/MRI data	proposed method achieves good result with lower cost in comparison with topographical distance based approach	resisted over-segmentation problem effectively. It decreases the amount of segmented areas to 0.3%-1.2%

					without losing its accuracy
[35] S. Lazebnik, C. Schmid, and J. Ponce	Classification accuracy	Caltech 101 dataset Graz dataset	multi-degree concept, scene category reconigition,feature extraction, pyramid matching	Image categorization based on a modification of pyramid match kernels subdividing an image and computing histograms of image features over the resulting sub regions	authors introduced kernel-based recognition method that works by computing rough geometric correspondence on a global scale using approximation technique adapted from the pyramid matching
[36] S.Vishwanathan,K. M.Borgwardt N.N.Schraudolph 2007	Sylvester equation, conjugate gradient (CG), and fixed-point iteration (FP)	MUTAG and PTC, Protein, enzyme Dataset	Linear system, Random walk,product graph,fixed iterations	Computed random walk graph kernels is essentially equivalent to solving a large linear system.	Authors discussed iterative methods, including those based on Sylvester equations, conjugate gradients, and fixed-point iterations

Table 2.3 (f): Graph kernels related work

Ref no, Authors and year	Performance parameter used	Database used	Issues Addressed	Authors Remark	Our Findings
[37] T. Gartner, P. A. Flach, and S. Wrobel, 2003	Labeled graph, polynomimal computation time of graph kernel, isomorphic graphs with matrix power	Experiments carried out on blocks world with three different goals	kernels on labeled directed graphs with general structure. Computing a strictly positive definite graph kernel is same as solving the graph isomorphism problem	Presented approach conceptually based on label sequences of all possible walks in the kernel. Efficient computation of these kernels is made possible by the use of product graphs	computation of kernel function recognizing the structure of graphs and family of kernels based on walks which includes the kernel being polynomially computable.
[38] T. Jebara, 2003	Gaussian mean, covariance, appearance subspaces	images of digits, intensity images of single faces, intensity images of multiple individuals	manifold of multiple configuration, PCA Manifold Learning, Bag of pixels vs vectors	Proposed a bag of pixels or vector set representation for images. a gray scale image can be considered as a collection of N pixels each with spatial coordinates (X;Y) and an intensity	Authors explored permutation invariance for dealing with images that are organized into collections of tuples, vector sets or bags

				coordinate (I).	of pixels
[39] Xinchao Wang, Zhu Li, Dacheng Tao,2011	Recomgition performance , Running time	Microsoft Research Asia Multimedia (MSRA-MM) Image dataset and Essex University human face dataset	Linear system, tree structure, Hierarchy model, Random walk kernel	Indexing Model on Grassmann Manifold (SIM-GM) for large subject set pattern recognition. SIM-GM partitions the manifold space into local patches with a hierarchical structure, and train local subspace models for classification.	1) compare the recognition rate of SIM-GM against those of global models, e.g., global PCA; 2) compare the recognition rate of SIM-GM against those of local models; 3) compare the execution time of SIM-GM against those of global model

Table 2.3 (g): Graph kernels related work

Ref no, Auth	Performance parame	Data base	Issues Addre	Authors Remark	Our Findings

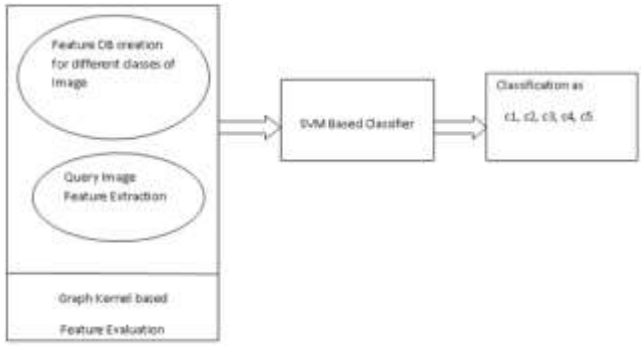
ors and year	**ter used**	**used**	**ssed**		
[40] Yun Fu and Thomas S. Huang,2008	recognition accuracy, face recongition error rate	CMU PIE Yale-B Extended Yale-B	Correlation based on similarity measure incorporated with supervised multilinear subspace learning can additionally improve classification performance, CTA benefits from graph embedding tensor analysis	Incorporating both correlation measure and tensor representation, CTA	Authors proposed to use correlation tensor analysis for appearance-based discriminant subspace learning. Authors evaluated the performance of proposed CTA algorithm for face recognition
[41] Y.LeCun, F.-J.Huang and L.Bottou,2004	Test error rate for unseen objects in background	NORB dataset 4 sets: normalized-uniform set jittered-uniform set jittered-textured	problem of recognizing generic visual categories with invariance to pose, lighting, and surrounding clutter.	paper reports results of generic shape recognition using popular image classification methods operating on various input representations	linear classifier, K Nearest Neighbor , Pairwise Support Vector Machines with Gaussian kernels, and Convolutional Networks are used as classifier for datasets

		set jittered-cluttered set			
[42] Zaid Harchaoui and Francis Bach, 2007	Several parameters tuned for each kernel. Some are Kernels between Segments Coefficient in kernel μ between kernel histogram is optimal value and λ for longer walk	Coil100 Corel 114	Semi supervised and Multiple kernel learning	Histogram,Tree walk, Weighted tree explained with results	Tree Walk Kernel for Segmentation, Image classification

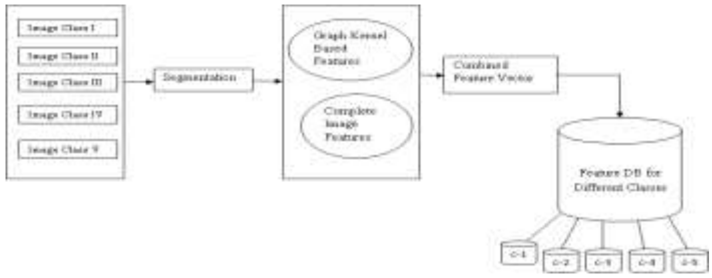
III.PROPOSED APPROACH

3.1 Main idea

Different techniques are available to perform the image segmentation, but the prominent one from image classification point of view is the watershed transform, as presented work concern with the approach based on graph kernels. To develop the graph kernel, it is necessary to have the identification of the different regions of the image. To get the different regions from the image, the watershed transformation based image segmentation have to be performed. Later the next important thing is that the image classification. For this purpose the Support Vector Machine (SVM) is selected as the classifier. In view of the image classification, firstly, the image database of different classes is referred, to generate the attributes of the images in particular and that of the classes in general. These attributes consist of the feature based on the graph kernel which is obtained after performing the image segmentation using watershed transformation and the features for the whole image. In this way, the feature database for the particular classes is developed. Later, to identify the belongingness of the query image, once again the same attributes are extracted for the query image and then, query image feature and the feature database for the various classes is referred to classify the given query image. For this purpose the confusion matrix is evaluated through the SVM classifier. The block schematic for the proposed approach is depicted in Figure 3.1.



3.1 Block Schematic of proposed approach



3.2 Feature Database Extraction

3.2 Feature database Extraction

Feature database for the different image classes is created by using the concept of graph kernel. The images are segmented to get the different regions, based on these regions the various features for the regions are evaluated and the whole image features are also evaluated.

Five image classes are identified and for every class, 100 images are collected. The process of feature extraction is repeated for the every image of every class. Combined feature vector for every image of every class is recorded in the feature database. The complete process of the feature database creation is depicted through the block schematic in Figure 3.2.

An approach for the feature extraction is summarized below:

An Approach For The Feature Extraction of Image

Input:- Color or Gray Image

Output:- Feature Vector for image

Procedure:- Step by step representation

Step 1 → Read or refer the given image (from image database or query image)

Step 2 → Perform the watershed segmentation

Step 3 → Obtain the features for different regions based on graph kernel

Step 4 → Obtain the features for complete image

Step 5 → Form the feature vector for the given image

Step 6 → Store the feature vector

Step 7 → If feature database creation

Then

Repeat the Step 1 through Step 5

Else

STOP

Step- 2 in Approach for the Feature Extraction of Image

(Watershed Segmentation)

Input :- Color or Gray Image

Output :- Segmented Image

Procedure:- Step by step representation

Step 1 → Read the Color Image and Convert it to Grayscale

Step 2 → Use the Gradient Magnitude as the Segmentation Function

Step 3 → Mark the Foreground Objects

Step 4 → Compute Background Markers

Step 5 → Compute the Watershed Transform of the Segmentation Function

Step 6 → Visualize the Result

Step- 3 in Approach for the Feature Extraction of Image (Graph kernel based features)

Input :- Segmented Image

Output :- Region Features

Procedure:- Step by step representation

Step 1 → Read the Segmented Image

Step 2 → Mark the Region as the Nodes

Step 3 → Connect the Adjacent Regions

Step 4 → Find the Attributes of the Nodes

Step 5 → Record the Attributes of the Nodes

Step 6 → Form the Feature Vector

STOP

Step 7 → Mark the centroids in the segmented region

STOP

Step- 4 in Approach for the Feature Extraction of Image

(Feature of the complete image)

Input:- Color or Gray Image

Output:- Complete Image Features

Procedure:- Step by step representation

Step 1 → Read or refer the given image (from database or query image)

Step 2 → Color Features and Wavelet Transform of the Image

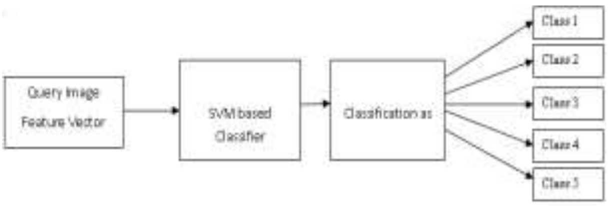
Step 3 → Obtain the Features

Step 4 → Record the Features

Step 5 → Form the Feature Vector

STOP

3.3 SVM Based Classification



An Approach For The Image Classification

Input:- Color or Gray Image (Query)

Output:- Feature Vector for image and Class of the image

Procedure:- Step by step representation

Step 1 → Load the Feature database for different classes of Image

Step 2 → Obtain the Feature Vector for Query Image

Step 3 → Record the Query Image Feature Vector

Step 4 → Evaluate the Confusion Matrix

Step 5 → SVM based Classification of Query Image using Step 1 through Step 4

STOP

IV. Experimental Results

Experimental set up:

The approach discussed in Chapter 4 is implemented using (MATLAB 7.10.0.499) (R2010a). The experimentations are carried out on Intel (R) Core (TM) i5-4200U CPU @ 1.60GHz 2.30 GHz processor, RAM 4GB and HD 500GB. The operating system is Windows. The experimentations are carried out on different images taken for the five image classes.

There are five different types of classes of images, namely, Horses, Roses, Cars, Parrots, and Pandas. Each class contains 100 images. Each image having different poses, different backgrounds. That means 100 images with 100 poses and 100 different backgrounds. The scope is there to add new class images for the feature database creation. For every image of respective class, the feature database is created based on the graph kernel and the wavelet transforms which includes HSV histogram, color autocorrelation, color moments, mean amplitude, msenergy, and wavelet moments.

Screen 1

Screen 2

Screen 3 : final output

V. Conclusion

Based on the implementation and obtained results, following conclusions are drawn:

- Image segmentation is the key step in any image classification approach; therefore, the results related to the segmentation leave the impact on the image classification results. In presented work, the image segmentation is carried out with the watershed transformation.

- Graph kernel based implementation provides, the insight of the given image, as the attributes are related to the different regions formed.
- Region node and the adjacency of the regions provided the first part of the features and the second part of the features is associated with the wavelet transform. Second part, also, includes the feature related to the hsv histogram and color correlation.
- Through extensive experimentation, it is observed that the classification accuracy of the presented approach is satisfactory.
- The obtained results are encouraging and motivating for the further optimization in number of features used.
-

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