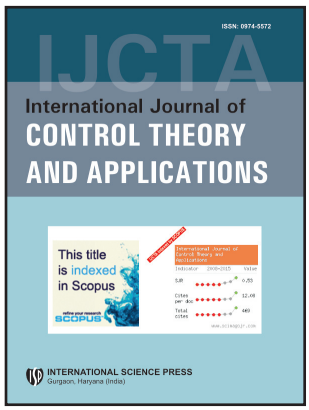

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Content Based Image Classification using Edge Detection Techniques

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Abstract: Massive increase in the degree of data in online data repositories desires the need of efficient data retrieval and management. Content based image classification performs the grouping of images according to the similarities inherent in the image contents. Existence of wide variety of disciplines and themes in real world leads to steady increase in number of image types especially based on its contents. The task of image classification is indeed humungous when the system intended to be designed is generic. In this work, research attempts are directed towards the grouping of images which are commonly found in research articles, text books, thesis and other text documents. The eight types of images are employed for experimentation which includes graphical images, circuit images, formula images, text images, tabular images, logos, flow charts and color textured images. The dilated versions of images are subjected to undergo convolution process using various edge detection operators to detect horizontally oriented edges, vertically oriented edges, corners and other curves like structures. Canny edge detection is employed for detection of images with only horizontal and vertical edge like structures. Further Harris corner detection and Hough transform is used for detection of contents including corners, curve like structures along with horizontal/vertical edges. The features such as count of horizontal lines, count of vertical lines, corners and Hough peaks are employed for classification using nearest neighbour classifier and accuracy is found to be 94%.

Keywords: Content based image classification, edge detection, Hough features, text documents, Graphical components.

1. INTRODUCTION

Image classification based on contents has gained a wide popularity in the field of Computer vision and information retrieval. The steady increase in advancements of internet technologies, multimedia and imaging devices creates the scope for generation of varied image types with respect to wide variety of concepts. It is highly subtle to discretely specify the number of image categories based on its contents. Hence the image classification tasks are usually carried out by restricting them to a specific domain [1] in most of experimentations.

In this work, the classification of images is confined to the image types where its contents are pertaining to the domain of research articles, text books and other document images. The image categories in this context

include graph images, circuit images, formula images, text images, tabular images, logos, flow charts and GUI interfaces. Classifying these images optimizes the task of retrieval of images relating to scholarly domain. The various applications include image searching based on keywords, automatic identification of formulas, tables as images leads to strictly follow the research article policies and guidelines, grouping and indexing of images based on its contents, image based searching for matching with similar types of images, rapid retrieval of research article or text book statistics according to type of images (figures) etc.

A good number of works are reported in the literature with respect to various categories and domains. Summary of the few important works are as discussed below.

Park et. al., [2] had proposed an approach for classification of foreground and background objects in an image. Region based segmentation is applied to extract the foreground objects and are subjected to a shape based texture feature extraction. The classification is performed using back propagation neural networks and achieved an accuracy of 76.7% for 30 classes. Sergyan et. al., [3] had devised a method for content based image retrieval from web using color histogram features. The low level histogram features are employed for classification due to which the classification is carried out rapidly. Smith et. al., [4] had contributed a method for classification and querying of objects in the images using its spatial characteristics and composite region templates. The templates are also used for annotating images, assigning symbols and measuring similarities between objects in images. Chapelle et. al., [5] had devised an approach for classification of images using high dimensional histogram features. RBF kernels with support vector machines are adapted for classification of features. Blaschke et. al., [6] had provided an overview of object based classification methods on images captured through GIS using the functionalities of GIS and image processing. Guillaumin et. al., [7] had proposed a semi supervised learning approach using the contents of an image along with the keywords and labels associated with images. In overall 58 classes of objects are employed for training from ASCAL VOC'07 and MIR Flickr sets from which the labels are learned from image tags. Sivic et. al., [8] had devised a methodology for identification of object categories from large image collections. Generative models of probabilistic Latent Semantic Analysis (pLSA), and Latent Dirichlet Allocation (LDA) are used for unsupervised learning along with region descriptors of SIFT. Im et. al., [9] had proposed a technique for object based categorization of images using correlation analysis and image segmentation technique. The changes in images is detected using the temporal information and per pixel changes intensity along with geographical information of neighbourhood objects. Nowak et. al., [10] had proposed a technique for classification of image types using bag of features comprising of histogram and multi scale interest operators.

To the best of our knowledge, the literature is reviewed and observed that, most of the works focus on classification of image objects using region based segmentation techniques, histogram based techniques and texture, SIFT or statistical descriptor features. Some of the works are also devised a semi supervised learning methods where the knowledge of the image tags/labels are used for classification. The experimentations are conducted on varied image types and are not for the identification of object type in document images. Therefore this work focuses on the identification image types in document images helpful in simplification of image retrieval from various research articles, book chapters, text books and other image repositories.

2. PROPOSED METHODOLOGY

The proposed methodology for classification of objects in documents is comprised of four stages. The stage one assumes the input of images or figures from various image collections obtained from varied document types. The stage two performs the pre-processing and further the pre-processed images are subject to edge detection process in stage three. The gradient detected images are subject to computation of features and classification in the final stage.

Figure 1 depicts the block diagram of proposed system.

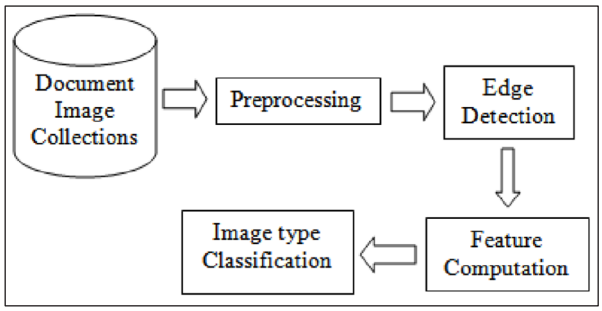

Figure 1: Block diagram of image classification

The detailed modelling of each stage is elaborated in the subsequently.

A. *Pre-Processing:* The images collected from various document collections are assumed as input to the proposed system. Figure 2 represents few instances of document image categories.

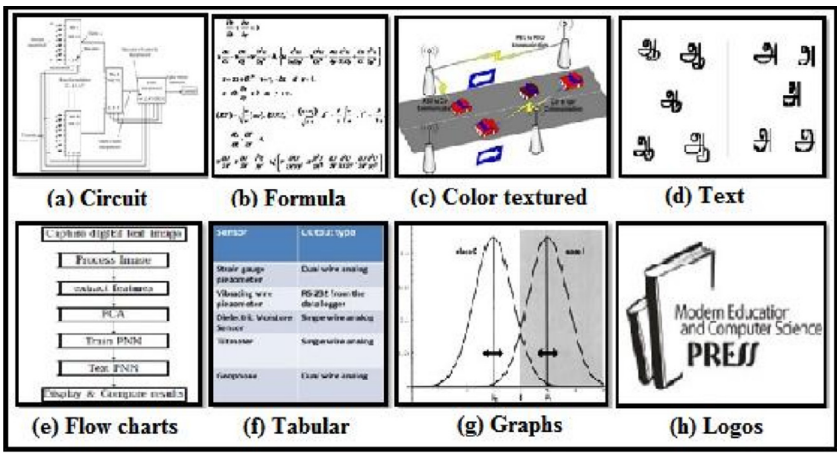

Figure 2: Document image types

To simplify computations, the input images are converted to binary images as shown in Figure 3.

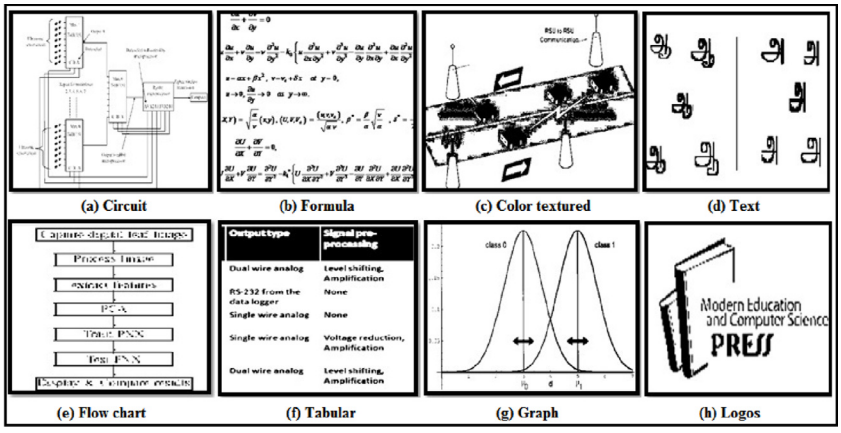

Figure 3: Binarized versions of input images

Further the binarized images are preceded for edge detection as discussed subsequently.

B. *Edge Detection:* The edge detection is carried out on the binarized images to separate the images with horizontal and vertical edge detected images. The curve like edge structures and other arbitrary shapes are detected using Hough transform [11]. Initially the vertical edges are detected using the Canny edge detection method [12] by employing vertical structuring element. Similarly the horizontal edge detected images are also detected using a horizontal structuring element through Canny edge detection method. The outcomes of horizontal and vertical edge detection using Canny operator are as depicted in the Figures 4 and 5.

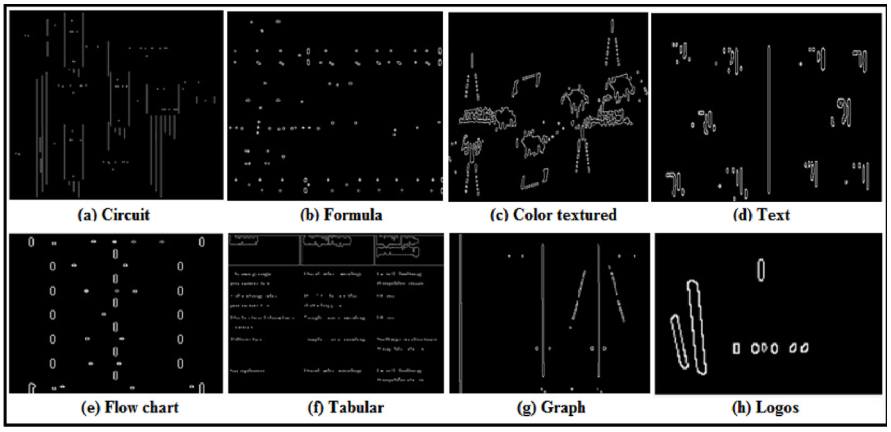

Figure 4: Images with vertical edges detected

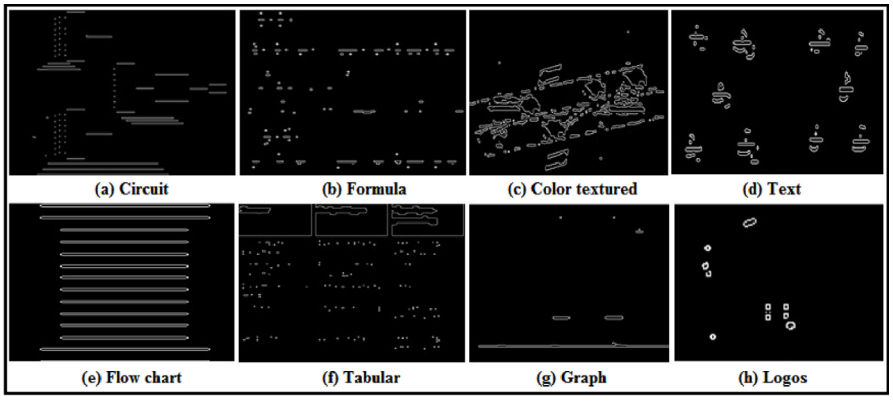

Figure 5: Images with horizontal edges detected

The edge filtered images are in turn subject to feature computation stage and other edge like structures and arbitrary shapes are detected using Hough transform which are discussed in the subsequent sections.

C. *Feature Computation:* In the proposed method, the feature computation is carried heuristically by employing the features as count of vertical lines, count of horizontal lines, number of corners detected and Hough peaks of edge detected images.

1. *Count of vertically and horizontally oriented edges:* If obj_1, obj_2, obj_3, ..., obj_n represents the objects in a vertical edge filtered image I_v, then count of objects in vertical edge filtered image I_v is given by (1).

   $Count(obj\ \_\ I_v) \square\ Num\_objs(obj_1,obj_2,obj_3...obj_n)\ of\ I_v$ (1) Where $obj\ \_\ I_v$ are the objects of a vertical edge filtered image.

Similarly, if I_h represents the horizontal edge detected image, then count of objects in horizontal edge filtered image I_h is given by (2).

$Count(obj\ \_\ I_h) \square\ Num\_objs(obj_1,obj_2,obj_3...obj_n)\ of\ I_h$ (2) Where $obj\ \_\ I_h$ are the objects of a horizontal edge filtered image.

Figure 6 and 7 indicates the objects detected in the edge filtered images and the Table 1 provides the statistics of the various images categories in Figures 6 and 7.

Table 1
Number of objects features- Varied image categories

Type of image	*No. of objects*	
	Vertical edge filtered	*Horizontal edge filtered*
Circuit	2254	1522
Formula	7270	2888
Color	29614	25893
textured Text	35894	16522
Flow chart	22848	16882
Tabular	23698	6243
Graph	8398	5315
Logos	221	255

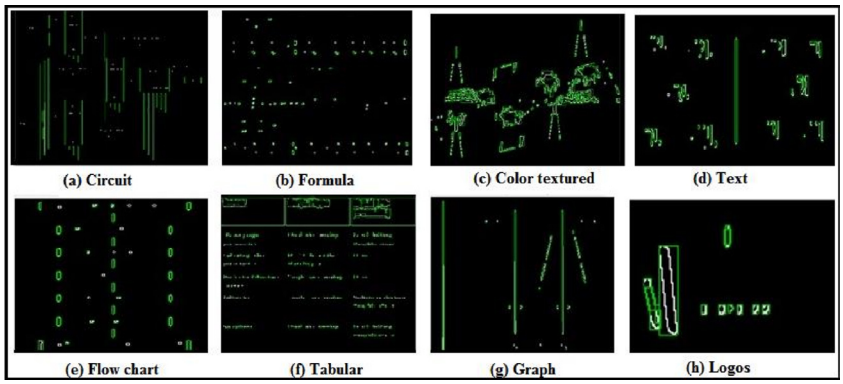

Figure 6: Object detection-Vertical edge filtered images

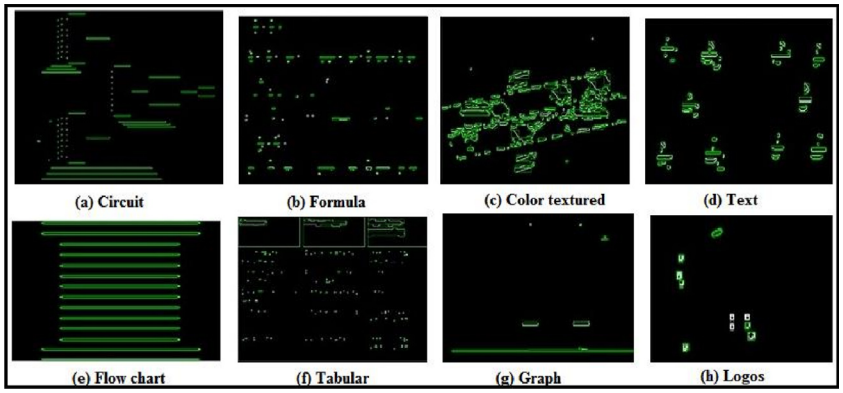

Figure 7: Object detection-Horizontal edge filtered images

2. *Hough features:* Hough peaks features are efficient at isolation of features of one object from other by converting them in the form of parametric equations [13, 14]. The features are variant with respect to object shapes comprising of curves, text, lines, curves etc. Therefore, in the proposed method Hough peaks features are adapted as one of the features for image classification. The outcome of Hough peaks features detected are as depicted in the Figure 8.

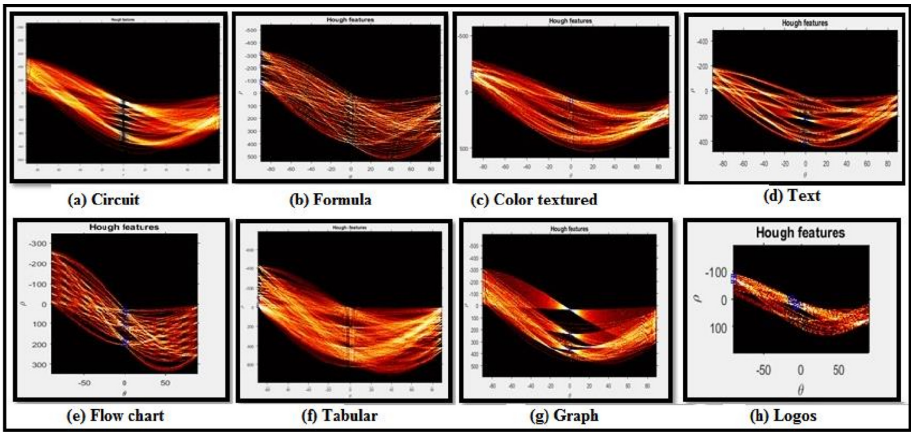

Figure 8: Hough peaks features of binarized images

3. *Corner Detection:* As the images to be classified include more edge like structures, it is also significant to consider the corners detected as one of the features for classification. The features of corners detected are accomplished using Harris corner detection algorithm [15]. The features of Harris corner detection are rotation, scale and illumination variation independent. Hence, Harris method is adapted in the proposed method.

The features of count of horizontal, vertical, corners detected and Hough peaks are fed to a classifier. In the proposed method, classification is conducted using the nearest neighbour classifier [16]. The performance metrics of classifier for the given input instances are discussed in the subsequent section.

3. EXPERIMENTAL STUDY

The analysis of the proposed methodology is carried using around 768 images comprising of varied image types collected from various text documents. The performance of classifier is measured in terms of classifiers metrics like accuracy. The details of number of images for each category are tabulated in the Table 2.

Table 2
Dataset employed for analysis

Image Type	*No. of Images*
Circuit	80
Formula	95
Color textured	100
Text	148
Flow chart	77
Tabular	88
Graph	120
Logos	60

The accuracy of the classification is the number of images recognized correctly to the total number of input images. The performance of nearest neighbour classifier is as described in the Figure 9.

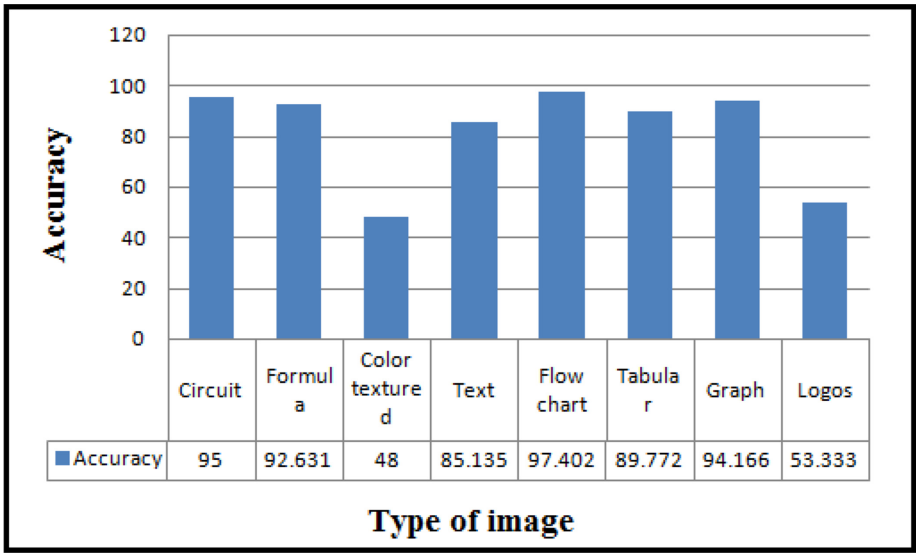

Figure 9: Performance of Classifier - KNN

4. CONCLUSION

Image classification in varied text document categories is one the interesting research problem employable majorly for optimizing the image search and retrieval of varied image types commonly seen in text documents. As most of the content based image classification focus on the purely color images, it is significant to classify other image types hidden in various text documents. In the proposed method, edge detection techniques are employed for segmentation of objects and various object types are separated with respect to its orientation in the images. The features of edge filtered images along with the Hough peaks features are fed to KNN and SVM classifier for categorization of image types. The count of objects oriented horizontally and vertically proves to be implicative in classification image types considered. The evaluation of proposed methodology is also conducted on even other types of color images that are collected from web sources for which the satisfactory results are achieved.

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