An Efficient Parameters Selection for Object Recognition Based Colour Features in Traffic Image Retrieval

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Abstract: *This paper proposes a novel technique for object identification and representation in complex traffic scene based on the colour features integrated with line detection techniques. Objects of interest (vehicles) are represented by using a Minimum Bound Region (MBR) with a reference coordinate. Object appearance is represented by colour-based features computed from the proposed technique. The performance of the object identification based colour features depends on some parameters, which should be determined carefully to locate and identify objects that exists in the images successfully. Experiments have been conducted to determine the efficient parameters that should used and demonstrate that single and multiple known objects in complex scenes can be identified by the proposed approach.*

Keywords: *Colour features, content based image retrieval, colour object recognition.*

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1. Introduction

Humans recognize objects that exist in images with little effort, despite the fact that the objects in the images may be different in view points, scale, size and places. However, it is still a challenge for the computer vision system to do so.

Object searching in a database of color images is a particular problem of colour image retrieval similar to appearance-based object recognition [7]. Retrieving known objects from a complex scene is identifying and recognizing the known objects in the scene and determining the region occupied by these objects. Objects of interest in images are important to be identified and as highlighted in [11], it only requires interpreting major objects and their relationship in images and not requiring a complete understanding of images as a human being to perform effective image retrieval.

Generally, there is no single and perfect parameters that suit all the images and the efficient parameters value should be determined to gain the best performance of the object recognition in the images.

The layout of this paper is as follows: Section 2 discusses the related works in object recognition using colour features. Section 3 introduces the proposed object recognition techniques and its efficiency in parameter selection. The experimental results and analysis are presented in section 4. Finally, section 5 concludes the paper.

2. Related Works

In the context of object recognition, one of the most widely used image features is the colour histogram. The processing of the colour histogram [12], which characterizes the object requires a segmentation step in order to identify the pixels that represent the object. Since the colour vectors of the pixels depend on the illumination, the colour histograms of two similar images may be different. Therefore, the comparison between colour histograms may fail to recognize the same object is illuminated under different illumination conditions [7]. The object recognition technique [7] is improved the colour histogram approach by analyzing their colours when their images are acquired under different illumination conditions. The chromatic co-occurrence matrices are used to characterize the relationship between the colour component levels of neighboring pixels. Their matrices are transformed into adapted co-occurrence matrices that are determined so that their intersection is higher when the two images contain the same object lit with different illuminations than when they contain different objects.

However, the above approaches were designed for the object recognition with images that contained one single object placed on a uniform background or multiple objects observed under controlled illuminations. They are having problem when dealing with natural and complex background (with variety of colour exist and colour that are scatted). Image background may create confusion in recognizing object classes, the background can also provide useful cues to aid recognition, since many objects tend to occur in particular types of scene [6, 11, 14]. The use of colour histograms is simple and fast but it works mainly for non-cluttered scenes. Besides, the spatial distribution is important in describing complex objects and their relations in the image [1] but they are not takes into considerations for capturing the object that exists in the images and consequently it might always caused inaccurate or false objects detection.

There are several techniques proposed to integrate spatial information with colour histograms for better and accurate object recognition. The Histogram refinement based on colour coherence vectors [8] is proposed. The technique considers spatial information and classifies pixels of histogram buckets as coherent if they belong to a small region and incoherent. The colour correlogram for histogram refinements [5] is also proposed. Next, spatial information is integrated with colour histograms is introduced [4] by first selecting a set of representative colours and then analyzing the spatial information of the selected colours using maximum entropy quantization with event covering method. An image is partitioned into 5 partially overlapping, fuzzy regions in [10] to extract the first three moments of the colour distribution for each region, and then organize them into a feature vector of small dimension. The back-projection [9] is applied on binary colour sets to extract colour regions. The colour-based object classification [3] is proposed. It uses the Nearest Neighbour classifier (NN) which is based on a set of classified sample patterns representation of colour histogram.

Even though the colour spatial features has been taken into consideration for better object identification for the above approaches [4, 5, 8, 9, 10]. However, the object recognition using low level colour features is still not fully addressed. In fact, current colour features object recognition approaches are used either for histogram colour matching in term of similarity then evaluating the similarity between the scene histogram and model histograms or segmenting the image to capture the local features. Hence, it failed to reliably detect and recognize the object. Colour object classification methods [2, 3, 13, 15] also classified object into certain categories based on their colour similarity. So, it is not explicitly object recognition. They are lacking of the ability to find or recognise the object that exists in images.

3. The Proposed Solution

In this paper we proposed a strategy for identifying known objects and demarcating the approximate regions occupied by these objects in a complex scene using only colour features. The proposed colour object recognition can be divided into two main stages: colour features extraction and object identification and recognition.

3.1. Colour Feature Extraction

The colour features extraction process is used to extract the features of the images for object recognition purpose. The colour features extraction process has five stages and the data flow is shown in Figure 1.

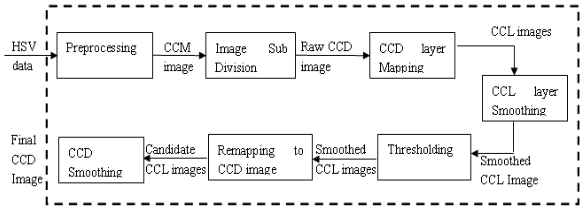


Figure 1. Feature extraction process data flow.

All images need to go through the preprocessing process where it needs to determine the colour value of every pixel in the image and compute its distances to all the colours in the predefined colour table. The pixel is assigned to the cluster colour in the colour table that has the smallest distance to the pixel. The computation and assignment of cluster colour to predefined colour tables is using the formula adopted from the works in [17]. The output of the preprocessing process produces a Colour Cluster Mapping Image (CCM Image). The feature extraction process is as follows:

- *Image Sub Division:* The CCM Image from the preprocessing process is divided equally into $m \times m$ sub areas. All the images go through the image sub division process for the purpose of calculating the population of every colour that exists in each sub area. This process produces a raw Colour Cluster Distribution Image (CCD Image).
- *CCD Layer Mapping:* The raw CCD Image is going to use for the CCD layer mapping process where the raw CCD Image will be extracted and represented into n Colour Cluster Layer Images (CCL Images), where n is the number of colours. The CCL Images then will be used as input for colour CCL smoothing process.
- *Thresholding:* All of the CCL Images go through the Smoothing process to reduce the noise of the images. The smoothed CCL Images will be used for thresholding process. The threshold value is used to identify the population of the colour in the image that are needed to be removed as it is considered as a noise of the image. Next, the list of n candidate CCL Images will be produced. The regions that are smaller than an area threshold will be removed from the final segmentation where the results contain only contiguous sets of pixels that have a relatively uniform colour distribution and the population of colours are large enough.
- *Remapping to CCD Image:* All candidate CCL Images will be re-mapping and produce another image containing only the dominant clusters, namely CCD Image.

- *CCD Image Smoothing:* Same as CCL Images, the CCD Image will go through the CCD Image smoothing. Window operation is applied to remove unnecessary noise to come out with a finalized smooth CCD Image. The window operation in CCM Image is different from CCL Image where this CCM is based on few colours in image while CCL is each single colour versus to background colour but the concept are the same. The output will be the final CCD Image.

3.2. Object Identification and Recognition

The final CCD Image will be used as input for object identification and recognition process. Object identification and recognition is needed to extract the object of interest in the images. The object identification and recognition process has 9 stages and the data flow is shown in Figure 2.

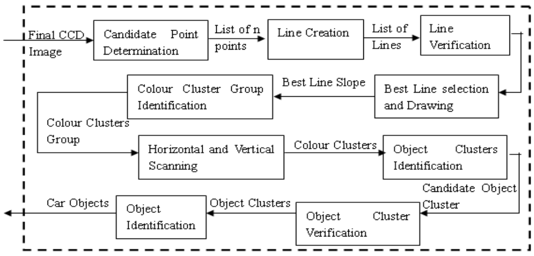


Figure 2. Object identification and recognition process data flows.

The final CCD Image will be used for road and building extraction in the traffic images. Firstly, it needs to go into changes point determination process to determine the colour changes point. The image is divided into m size at axis-x and the starting point is from the bottom left of the images. The changed point will be the first changes of colour area based on the axis-x. This process is continued until get *n* of points, *n* is the number of changing points that predefined. The object identification and recognition process is as follows:

- *Line Creation:* The road slope is used as the reference slope for getting the object of interest (vehicles). In the line creation process, all possible lines will be created based on the *n* points from the changed point determination process.
- *Line Verification:* Line verification is needed to get the candidate lines by removing all the negative slope lines. All candidate lines will go into slope of line calculation process to get the value of the slope for each possible pair of line. Since this research domain images are traffic images with perspective view. So, assumption has been made as below:

  1. There is no negative road slope.
  2. The best slope value (reference slope) is approximate 0. 20 (This value is obtained based on human perception judgment from collection of database images).

Given changed points of ($x1, y1$) and ($x2, y2$) of the angle between 2 lines, the slope of line, m can be calculated using equation 1:

$$Road\ Slope, m = \frac{y2 - y1}{x2 - x1} \tag{1}$$

- *Best Line Selection and Drawing:* All candidate lines with their slope values will be compared with the slope reference value. The line with slope value that is nearest to the reference slope value will be chosen as reference slope of the image. So, the two coordinates of the reference slope will be used as two reference points to get the best line of the road that act as a z-axis due to the image view is slanted.
- *Colour Cluster Group Identification:* All colour cluster groups are identified based on all the colour representatives that are available in the images. For each colour cluster, two coordinates from axis-x and axis-y which are the nearest and farest from axis-x and axis-y respectively will be chosen as the representative coordinate to form a colour minimum bound rectangle that is used to represent the colour cluster group.
- *Horizontal and Vertical Scanning:* All the colour cluster groups will be divided into an individual colour clusters by the horizontal and vertical scanning process.
- *Object Cluster Identification:* The individual colour clusters will be used as an input for the object cluster identification process to get the candidate object clusters. The candidate object clusters are classified into two groups which are region/object clusters and reference object clusters. Since the object of interest is a vehicle. So, assumption need to make that all vehicles will have black tyre and most of the time, there is a shadow below the vehicle. So, the black colour cluster will be used as reference objects to search for candidate object.
- *Object Cluster Verification:* Object cluster verification is the process to verify the candidate objects. The object cluster and reference object cluster will be combined if they satisfied the predefined object distance and the road distance value. The colour cluster object distance value used for determining the value distance between colour clusters are considered to be merged and the road distance value that used for determining the distance value from the road slope to the colour cluster are considered to identify as object as interest. The combination of reference object cluster with object cluster will formed the list of objects clusters.
- *Object Identification:* All object clusters (vehicle objects) will be represented by a Minimum Bound Region (MBR) and left bottom of MBR will be used as reference coordinate of the vehicle objects and the colour of the vehicles will be used as attributes for the car.

4. Experiments of Colour Object Recognition

The objective of the experiment is to evaluate the accuracy and effectively of the proposed colour object recognition method in recognizing the objects of interest (vehicles) in the domain of traffic images.

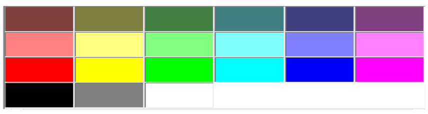
4.1. Parameter Setting

There are 3 parameters need to be determined for the best performance of object recognition. There are total number of colour cluster, sub area sizes of images and also the colour cluster distance.

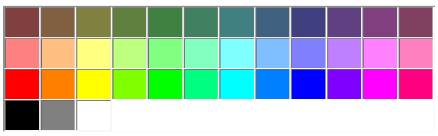
4.1.1. Colour Cluster

The colour cluster is used as the colour representation of the image. The number of colour cluster is defined by the user based on the type of images. Less colour cluster is needed if there is a dominant and limited colour exists in images and vice versa. The value of Hue, Saturation and Value (HSV) can be predefined by users and it will auto generate a list of colour clusters that used to represent the images. The colour clusters generated using different HSV setting is shown in Figure 3.

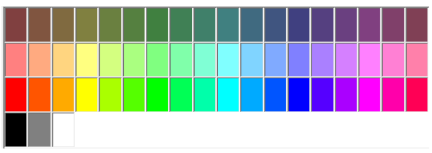
To obtain the best parameter setting of the number of colour cluster to be used in the experiments, 21 colour clusters (6H 3S 3V), 39 colour clusters (12H 3S 3V) and also 57 colour clusters (18H 3S 3V) were generated for colour representation used in the visual and object extraction in the traffic images.



a) Hues = 6, sats = 3, vals = 3, total color = 21.



b) Hues = 12, sats = 3, vals = 3, total color = 39.



c) Hues = 18, sats = 3, vals = 3, total color = 57.

Figure 3. Colour cluster generated using different hsv settings.

The results of the colour features extracted object cluster images using different colour cluster setting is shown in Figure 4.

From the experiment colour feature extracted object cluster images using different colour cluster setting, the extracted colour cluster objects images based on 57 colour cluster having the closest colour representation to the original images compared to 21 and 39 colour clusters. Besides, the results (images 1-c and 2-c) shows that the 57 colour clusters extracted image having more accurate object detection compared 21 and 39 colour cluster extracted images.

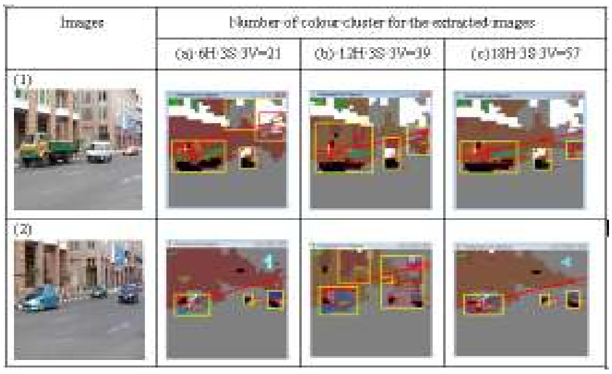


Figure 4. Colour features extracted object cluster images using different colour cluster setting.

4.1.2. Size of Sub Area for the Images

Size of sub area for the images needed to be set in order to divide the image for image extraction and object recognition. To obtain the best parameter setting of the size of colour cluster to be used in the experiments, different size of sub area for the images are used. The experiments of using image size 8×8, 16×16 and 32×32 were carried out for the visual and object extraction in the traffic images.

The results of the colour features extracted object cluster images using different size of images setting is shown in Figure 5.

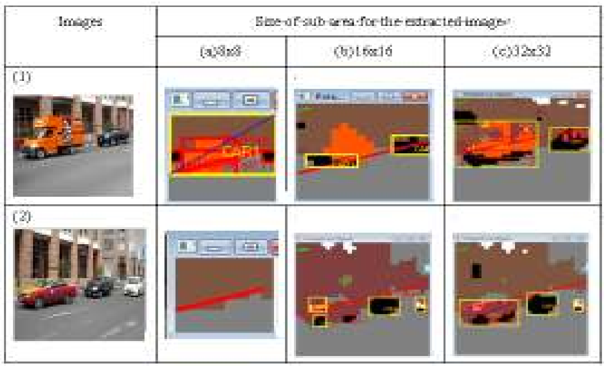


Figure 5. Colour features extracted object cluster images using different sub area size of images.

From the experiments based on the different sub area size of images, the extracted colour cluster objects images size of 8×8 and 16×16 failed to locate correct objects that exist in the images while the images of size 32×32 able to locate all the objects in images accurately compared to image of size 8×8 and 16×16.

4.1.3. Colour Cluster Distance

The colour cluster object distance value used for determining the value distance between colour clusters are considered to be merged. To obtain the best parameter setting of the colour cluster distance to be used in the experiments, different colour cluster distance are used. The experiments of using colour distance of 1, 2 and 3 were carried out for the visual and object extraction in the traffic images.

The results of the colour features extracted object cluster images using different colour cluster distance setting is shown in Figure 6.

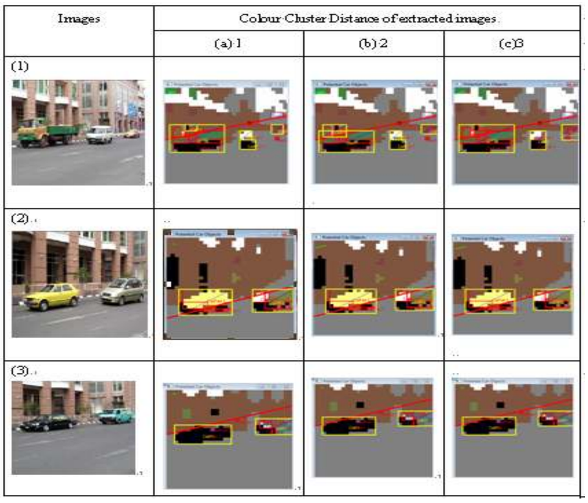


Figure 6. Colour features extracted object cluster images using different colour cluster distance.

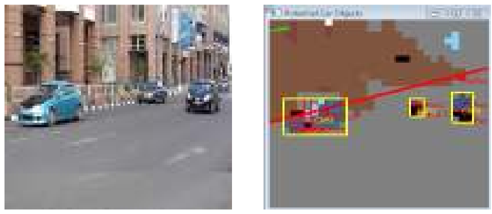
From the experiments based on the different colour cluster distance, the extracted colour cluster objects images based on the colour cluster distance of 3 able to get more accurate object recognition that show in images 1-c, 2-c and 3-c while the colour cluster distance of 1 and 2 only able to get the accurate object recognition for images 2-a, b and 3-a, b due to the variety and scattered colour exists in the images 1. For images with relatively larger amount of contiguous colour, relatively less complex colour appearance, the setting of the low colour cluster distance can be considered to eliminate possible noise.

As summary, the parameter of 57 colour clusters created from 18H, 3S, 3V, the parameter of sub area size 32×32 of images and also parameter of colour cluster distance of 3 are chosen to use in the colour object recognition and retrieval performance experiments due to the better result obtained from the parameter selection experiments.

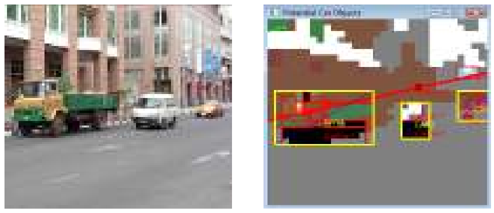
4.2. Experiment and Setting

The proposed design of the colour object recognition as discuss in section 3 were implemented using Microsoft visual basic 6.0 and Microsoft access has been used to build our database and with access to the Active Data Object (ADO) data access library. The user can browse and select the desired image, the system will extract and detect the interest object and locate it using a yellow boxes as show in Figure 7. The detected vehicles by the proposed colour feature object recognition compared with vehicle outlines selected by a user on the same images. A successful detection is considered as detected and correct if the detected vehicles by the proposed algorithms are same as the vehicles selected and defined by users. If the prototype missed the detected cars or the prototype detected the car which is not defined by the users it is considered as unsuccessful detection. The experiment was carried out for single and multiple vehicles detection and recognition in complex and natural images.

Image Object Detection



a) Detected vehicles-experiment B.



b) Detected vehicles-experiment C.

Figure 7. Successful detection (indicated using yellow MBR).

Three experiments were carried out and the characteristics of the sample images are shown in Table 1.

Table 1. The experiments and characteristics of the sample images.

Experiments/ Characteristics	Single Vehicle	Multiple Vehicle
A	√	
B		√
C	√	√

The results of the experiments are summarized and shown in Table 2.

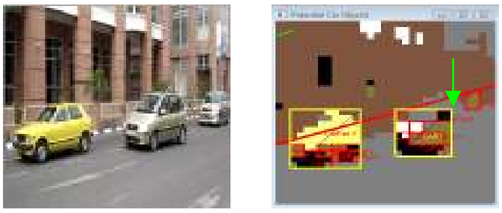
Table 2. The experiment results of the proposed colour features object recognition.

Experiments	Total Vehicles	Detected Vehicles	Undetected Vehicles	Detection Rate
A	50	48	0	96%
B	80	75	3	94%
C	100	93	4	93%
Average				94.33%

The proposed method produced very good result for all of the experiments. It is able to achieve average detection accuracy of 94.33%. The results accuracy is 96% for the detection of single vehicles in the images while achieve accuracy of 94% and 93% respectively for the detection of multiple vehicles and combination of single and multiple vehicles in the images. The proposed vehicle detection method is accurate and robust under complex and natural background and it also supports multiple vehicles detection and recognition. This technique has been used as input for Semantic object spatial relationships extraction and representation.

Some of the object detection and recognition results from proposed method is shown in Figures 7 and 8.

Image Object detection



a) Missed detection.

b) False detection.

Figure 8. Unsuccessful detection (pointed by green arrow).

There are some unsuccessful detection shows in Figure 8. The white car is not detected as show in Figure 8-a due to the noise created from the smoothing process. There are some false detection as show in Figure 8-b due to the variety colour of the building and cars (especially with high object density) besides some noise created from smoothing process.

5. Conclusions and Future Works

In conclusion, an efficient parameters setting and the object extraction and recognition method with efficient searching for identifying and extracting the objects in a complex scene based on the colour features has been proposed and developed.

Experiments have been carried out and it is proved that the proposed method works well in detecting both single and multiple objects in natural and complex background for traffic image retrieval with an efficient parameter setting. The accuracy of the object recognition method still can be improved such as when dealing with the variety colour of building and high density number of cars. And next it can be further extended by determining the type of the vehicle. This method is designed especially for use in the automatic semantic object spatial relationship extraction and representation that designed in our work in [16].

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