Colour recognition using colour histogram feature extraction and *K*-nearest neighbour classifier

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Abstract

K-nearest neighbours (KNN) is a widely used neural network and machine learning classification algorithm. Recently, it has been used in the neural network and digital image processing fields. In this study, the KNN classifier is used to distinguish 12 different colours. These colours are black, blue, brown, forest green, green, navy, orange, pink, red, violet, white and yellow. Using colour histogram feature extraction, which is one of the image processing techniques, the features that distinguish these colours are determined. These features increase the effectiveness of the KNN classifier. The training data consist of saved frames and the test data are obtained from the video camera in real-time. The video consists of consecutive frames. The frames are 100 × 70 in size. Each frame is tested with *K* = 3,5,7,9 and the obtained results are recorded. In general, the best results are obtained when used *K* = 5.

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1. Introduction

Recognition system is the most important technological field with various criteria such as visual recognition, speech voice recognition and handwriting–text recognition [6] The colour recognition system automatically recognises the colours of digital image processing. Many image techniques are used to apply the colour of the images for recognition purposes. Due to its simple implementation and exclusive performance, the *K*-nearest neighbours (KNN) method [3], [7] is commonly used and most popular in the fields of image processing, machine learning, etc. [10], [12] Therefore, in this study, a colour recognition application that works with the KNN algorithm has been developed. With recent advances in computer engineering, it is possible to recognise the colours with high-level success. This paper is, therefore, proposed as a colour-based approach using the methodology of clustering KNN.

The main idea is to equate each data points with all the data in the training set in the classification data set. Distance between the unknown data and the training data should be calculated. The distance can be found using a variety of methods, such as Euclidean distance, defined distance and absolute distance. In this study, for colour recognition purposes, the Euclidean distance metric is used for calculating the distances in the KNN. Euclidean is used to measure the distance between the attributes of the unknown colour with the stored or provided real-time colour examples.

The algorithms find out the nearest or closest examples to unknown colours. Colour examples referred to as the dataset must contain various colours to be able to recognise the input colour image [2].

Many colour recognition methods are studied recently and these studies are applied to this field. In this study, the histogram taking method is used with the KNN method. The developed application first extracts histograms of pictures or real-time images, and colour recognition is performed using the KNN algorithm. In this developed application, the pixel division technique is not used, but the pixel quality of images is very important for histogram extraction and colour recognition. The higher the pixel value, the higher the success rate of the application.

This study is structured as follows: the Introduction section presents a general survey of this paper from a general perspective. The 'Literature review and related works' section summarises past studies in the literature and explains its relationship and interaction with this study. The 'Background and methodology' section presents a short background focusing on the KNN, colour recognition, distance calculation methods, etc. The 'Implementation' section presents the development of software and it presents the experimental methods used in this study, such as datasets, programming language, etc. The 'Results' section shows the performance of the developed application. Several findings are recorded when the developed programme is executed. Finally, we conclude with the 'Conclusion' section.

2. Literature review and related works

When we reviewed the literature, it was seen that there were not enough researches focusing on colour recognition with the KNN algorithm. However, researchers have developed some algorithms and recognition system approaches in the past which are briefly described in this section.

Colour image segmentation using the neural networks is analysed in [1] (2010) study and the KNN algorithm is used to improve the efficiency of segmentation processes and good results are obtained. The contour analysis method [14] was introduced to identify, store, compare and locate the object in the form of external outlines and to solve the key pattern recognition problems for rescaling the object image. The hue saturation and value (HSV) colour space method is described in a study by [11] It is like the light of the human eyes. The RGB image is converted to an HSV image with this method. Picture segmentation is a series of pixels that collectively covers the whole picture or a set of image contours [16]. Eigen space-based face recognition studies [13], [17] have surpassed one of the common methodologies for digital image and facial recognition. Starting with the Eigen face

algorithm, various Eigen space-based methods for facial recognition is suggested in the use of simple or differential images before/after projection, as well as the resemblance criteria or classification system used.

3. Background and methodology

In this section, the algorithms, materials and methods, data classification techniques, distance calculations and working principles of the application are presented. A flowchart diagram of the proposed implementation, the classification of the KNN algorithm, the selection of the K value and the colour feature extraction (FA) with colour histogram are presented.

3.1. Flowchart diagram of the proposed implementation

In the proposed study for histogram, extraction uses the colour feature and KNN for colour recognition. A simple flowchart diagram for the proposed implementation is shown in Figure 1. It shows how to refer a colour image to the demand image processing for colour recognition using KNN. The role is that of extracting the histogram of the image or extracting the histogram of the various objects generated from the digital camera. The appropriate classification steps shown in Figure 1 are carried out with the KNN algorithm.

3.2. K-nearest neighbours algorithm and classification

The KNN algorithm is usually used as a method of classification and the KNN classification works well when similar classes are grouped around certain feature spaces [9], [15].

This classification algorithm is extremely costly for conventional serial computation paradigms with large data sets [4]. However, KNN can be used beyond direct classification for approximating the geometric structure of data (Thirumuruganathan, 2010), graph data structure [5], etc. In this study, the KNN algorithm is used for colour classification.

The KNN classifier has shown impressive data efficiency with a large example range, such as exceeding infinity, rough error rate, etc. Nevertheless, the collection of the *K* value and distance measurements influences the efficiency of the KNN classification. A KNN classifier's efficiency is determined mainly by the choice of K and the distance metric used [8]. How to pick a suitable K size is an important issue that primarily affects the KNN's classification efficiency. The correct selection of the value of K is essential to provide more accurate results.

3.3. Calculation of the distance of the neighbours in the KNN

There are several distance measurement methods used in the KNN algorithm. However, as for the measurement of distance, the Euclidean distance is the most common way of representing the distance between the two or more points. Thus, in this study, it is used. In the Euclidean space, Equations (1)–(3) are calculated to find the distance between the two points.

$$x_{1,...,}x_n \text{ and } y_{1,...,}y_n \tag{1}$$

$$d(x,y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 + \cdots + (x_n - y_n)^2} \tag{2}$$

$$d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \tag{3}$$

Standardised Euclidean distance or Euclidean distance is given by Equations (4) and (5) and is used to classify the objects by using KNN. The Euclidean technique measures the distance between the test

data point and the training data set. The query point value is the nearest to the training data set than the closest object (the minimum distance).

$$d_{st}^2 = (x_s - y_t)(x_s - y_t)' \tag{4}$$

$$d_{st}^2 = (x_s - y_t)V^{-1}(x_s - y_t)' \tag{5}$$

3.4. ColourFA with colour histogram

The colour function is the most commonly used visual technology for image recovery and is less dependent on the image's scale, position and angle. In this study, a colour histogram is used to extract the colour feature. The colour histogram represents the distribution of the colour of the picture or the probability of each colour appearing [18]. In order to calculate the image's colour histogram, the colour space is divided into certain colour cells and each cell becomes a bin histogram.

Then, by calculating the number of pixels, the colour histogram is obtained. A global colour function is the colour histogram that refers to the proportion of each colour in the entire image of each colour.
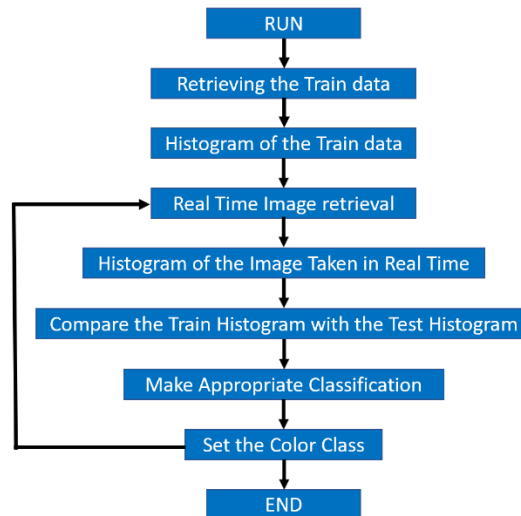

Figure 1.Flowchart diagram of the proposed algorithm

4. Implementation

In this section, the KNN algorithm is used in the application and the algorithm is programmed with digital image processing technology. This study focuses on colour classifying by KNN which is trained by RGB colour histogram. It is capable of classifying some colours, and these colours are violet, white, orange, black, blue, brown, forest green, green, navy, pink, red and yellow. Datasets of all colours are obtained from photographs where colours are introduced and each colour has several training data. The data set can be expanded for further processes.

4.1. Working steps of the implementation

Colour recognition is carried out in two steps: FA of training and test data and classifying new test data using the KNN algorithm. FA is an image processing histogram extraction method used to obtain RGB values of the training and test images. The KNN classifier trains by RGB colour histogram values. The classification of test data takes place by reading the digital camera frame by frame and carrying out FA on each frame by classifying its mean colour by a trained KNN classifier.

5. Results

The application results show that when the KNN algorithm is used together with the digital image processing methods, it provides accurate results if the correct dataset is used. KNN algorithm is useful for colour recognition and this algorithm is open to learning. Of course, the datasets used in learning the KNN algorithm are very important. Since the application gives the right results, it is seen that the dataset makes learning easier. Some outcomes of the developed programme are shown as follows. The accuracy obtained for the colours using 25 training data and 10 test data are presented in Table 1. As shown in Table 1, $K = 3$, $K = 5$, $K = 7$ and $K = 9$ values are used for each colour recognition and the most successful results are obtained with $K = 5$ value.

Table 1. The accuracy table

Colours	Accuracy			
	K=3	K=5	K=7	K=9
Red	70%	70%	60%	50%
Black	80%	90%	60%	80%
White	70%	80%	70%	70%
Green	40%	80%	50%	70%
Yellow	40%	80%	70%	70%
Pink	70%	90%	80%	60%
Blue	60%	70%	70%	60%
Brown	40%	70%	50%	50%
Forest green	70%	70%	60%	50%
Navy	20%	40%	40%	30%
Orange	60%	80%	60%	40%
Violet	40%	70%	50%	60%

The receiver operating characteristic (ROC) curve is a graph that displays the efficiency of a classification model with sensitivity and specificity parameters at all classification thresholds. Before producing the ROC curves for performance evaluating, true positive, false positive, true negative and false negative values should be calculated for all colours. These values are presented in Table 2.

Table 2. Values of all colours

Predicted	Actual			Predicted	Actual		
	Positive		Negative		Positive		Negative
Red	Positive	7	1	Blue	Positive	8	6
	Negative	3	119		Negative	2	114
	Positive		Negative		Positive		Negative
Black	Positive	9	6	Violet	Positive	7	0
	Negative	1	114		Negative	3	120
	Positive		Negative		Positive		Negative
White	Positive	8	3	Orange	Positive	5	3
	Negative	2	117		Negative	5	117
	Positive		Negative		Positive		Negative
Pink	Positive	9	2	Brown	Positive	7	3
	Negative	1	118		Negative	3	117
	Positive		Negative		Positive		Negative
Green	Positive	8	2	Yellow	Positive	7	0
	Negative	2	118		Negative	3	120
	Positive		Negative		Positive		Negative
Forest green	Positive	7	2	Navy	Positive	4	1
	Negative	3	118		Negative	6	119

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The ROC curves are produced to show all positive and negative values for all colours used in this study as actual and predictive to find out the performance of the developed software. Figure 2 shows the ROC curve with peak values. The *y*-axis shows sensitivity and the *x*-axis shows the specificity of the ROC curve.
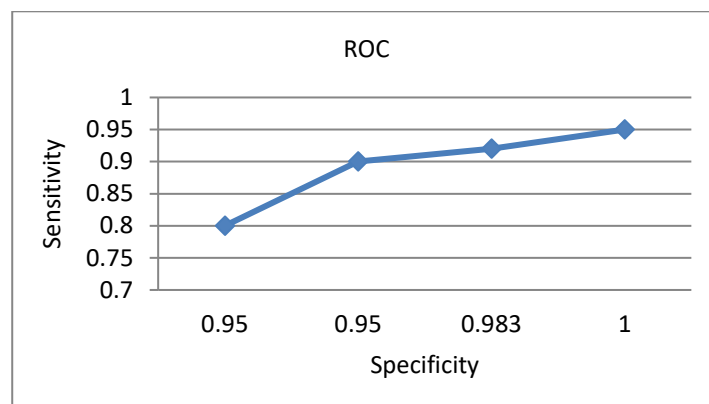

Figure 2. All values for all colours and peak values for all colours

6. Conclusion

If a dataset contains a lot of different points with suitable and accurate information, then the data set is useful for colour recognition with the KNN algorithm. Python is a popular language for professionals to develop colour recognition applications. In this study, black and pink have the best accuracy (90%) with *K*=5. However, violet and yellow have the best ROC curve values. It can be seen from the results that training data and K value are very important in classification accuracy, and the accuracy can be higher with more suitable training data and correct selected K values. Another important factor is lighting and shadows; the images should be taken in good lighting conditions with shadows to be classified as accurate (sensitivity–specificity).

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