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Colour image segmentation using fuzzy clustering techniques and competitive neural network

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ABSTRACT

This paper explains the task of segmenting any given colour image using fuzzy clustering algorithms and competitive neural network. The fuzzy clustering algorithms used are Fuzzy C means algorithm, Possibilistic Fuzzy C means. Image segmentation is the process of dividing the pixels into homogeneous classes or clusters so that items in the same class are as similar as possible and items in different classes are as dissimilar as possible. The most basic attribute for image segmentation is the luminance amplitude for a monochrome image and colour components for a colour image. Since there are more than 16 million colours available in any image and it is difficult to analyse the image on all of its colours, the likely colours are grouped together by means of image segmentation. For that purpose soft computing techniques namely Fuzzy C means algorithm (FCM), Possibilistic Fuzzy C means algorithm (PFCM) and competitive neural network (CNN) have been used. A self-estimation algorithm has been developed for determining the number of clusters. The images segmented by these three soft computing techniques are compared using image quality metrics: peak signal to noise ratio (PSNR) and compression ratio. The time taken for image segmentation is also used as a comparison parameter. The techniques have been tested with images of different size and resolution and the results obtained by CNN are proven to be better than the fuzzy clustering technique.

1. Introduction

Partitioning of an image into several segments made up of sets of pixels is called image segmentation. Segmentation plays an important role in any automated image recognition system, because it is at this moment that one extracts the objects of interest, for further processing such as description or recognition. Segmentation of an image is the classification of each image pixel to any one of the image parts. Image segmentation has been the subject of considerable research activity over the last few decades. Many unsupervised algorithms have been developed for segmenting gray scale as well as colour images.

In computer vision literature, various methods dealing with segmentation and feature extraction are discussed. Those methods can be broadly classified into region based techniques, edge based techniques, hybrid methods which combine edge and region methods, and so on. However, because of the variety and complexity of images, robust and efficient algorithm for colour image segmentation is still a very challenging task. Automatic segmentation procedures are far from satisfying in practical situations.

Mukherjee et al. [1] used Fuzzy C means classification algorithm for obtaining the meteorological information from Sodar facsimile records. Chen [2] has developed a hybrid technique for the job completion time prediction is a critical task to a semiconductor fabrication factory. In the proposed FCM–BPN approach, input examples are firstly pre-classified with FCM before they are fed into the BPN. Then, examples belonging to different categories are learned with different BPNs but with the same topology. After learning, these BPNs form a BPN ensemble that can be applied to predict the completion time of a new job. Pedrycz and Rai [3], introduced the concept of collaborative fuzzy clustering—a conceptual and algorithmic machinery for the collective discovery of a common relationships within a finite family of data residing at individual data sites. Sjahputera and Keller [4] proposed a scene matching approach based on spatial relationships among objects in the images and Possibilistic C means to determine if two images acquired under different viewing conditions capture the same scene. Doncescu et al. [5] incorporated spatial information into the fuzzy clustering for robust segmentation. Khotanlou et al. [6] used fuzzy classification for the detection of brain tumor in 3D magnetic resonance images. Laaksonen et al. [7] used Self-Organizing Map for

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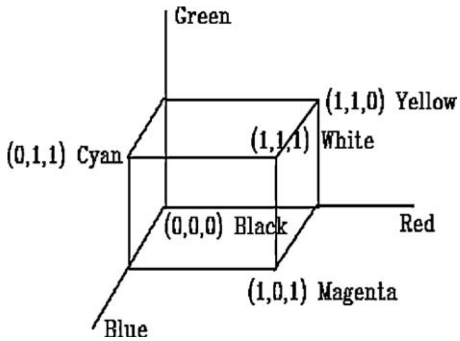

Fig. 1. RGB colour model.

determining prototypical segments in the images of the 101 object categories database. Chang and Teng [8] applied Self-Organizing Map for medical image segmentation.

This paper explains the task of classifying each pixel in an image into one of a discrete level of colour classes by using three main soft computing techniques, namely Fuzzy C means, Possibilistic Fuzzy C means and competitive neural network. The results obtained are compared on the quality measures, namely PSNR and compression ratio. The results are found to be more accurate and reliable in case of the competitive neural network than the fuzzy clustering techniques.

The rest of the paper is organized as follows. Image segmentation is described in Section 2. In Section 3 clustering techniques used in this design is explained. In Section 4 self-estimation algorithm for number of clusters is dealt. In Section 5 the important quality measurement techniques like PSNR, error image and compression ratio are discussed. Section 6 results and findings are given. The results are discussed in Section 7. In Section 8 concluding remarks and future scopes are given.

2. Image segmentation

Extracting information from an image is referred to as Image Analysis. Image segmentation is the foundation step in most automatic pictorial pattern recognition and scene analysis problems.

It is one of the most difficult tasks in image processing. Image segmentation is the process of dividing a digital image into multiple regions or clusters, where, each region is made up of sets of pixels. Image segmentation simplifies and changes the representation of an image, i.e. it transfers the image into something that is more meaningful and easier to analyse. Image segmentation is mainly used for locating objects of interest and boundaries like lines, curves in an image. The pixels of a colour image are represented as vectors. Each pixel is represented by a triplet containing red, green, blue spectral values at that position. The RGB colour model is shown in Fig. 1. This is based on Cartesian coordinate system. A colour expressed by an RGB vector is said to be a colour represented in RGB space.

RGB colour representation is one of the numbers of colour models available for representing the colour pixels. RGB colour model is chosen for image segmentation due to its simplicity and the fast processing speed. Image segmentation refers to the process of grouping the image into connected regions where pixels of a region share a common property. For colour images the common property is usually considered is the RGB (red:green:blue) colour ratio. This ratio must be reasonably constant over the connected region.

As the colour ratio does not have smoothly varying values when the pixel intensity is low, the colour image segmentation based on colour ratio requires that the intensity of the image must be above a threshold value. So instead of segmentation based on colour ratio other techniques have been evolved. The requirements of good colour image segmentation are as follows. A single region in a segmented image should not contain significantly different colours and a connected region containing same colour should not have more than one label. All significant pixels should belong to the same labeled region. The intensity of a region should be reasonably uniform. Several image segmentation techniques have been suggested for gray scale images and colour images. In this paper we suggest the neural network approach for colour images.

3. Clustering techniques

Clustering is the task of partitioning the data points into homogeneous classes or clusters so that items in the same class are as similar as possible and items in different classes are as dissimilar as possible. Clustering can also be thought of as a form of data compression, where a large number of samples are converted into a small number of representative prototypes or clusters. Depending on the data and the application, different types of similarity measures may be used to identify classes, where the similarity measure controls how the clusters are formed. Some examples of values that can be used as similarity measures include distance, connectivity, and intensity.

3.1. Fuzzy clustering

In non-fuzzy or hard clustering, data is divided into crisp clusters, where each data point belongs to exactly one cluster. In fuzzy clustering, the data points can belong to more than one cluster [9], and associated with each of the points are membership grades that indicate the degree to which the data points belong to the different clusters. Fuzzy clustering belongs to the group of soft computing techniques (which include neural nets, fuzzy systems, and genetic algorithms).

In real applications there is very often no sharp boundary between clusters so that fuzzy clustering is often better suited for the data. Membership degrees between zero and one are used in fuzzy clustering [10] instead of crisp assignments of the data to clusters. The resulting data partition improves data understanding and reveals its internal structure. Partition clustering algorithms divide up a data set into clusters or classes, where similar data objects are assigned to the same cluster whereas dissimilar data objects should belong to different clusters.

Areas of application of fuzzy cluster analysis include data analysis, pattern recognition, and image segmentation. The detection of special geometrical shapes like circles, rectangles, hyperbolas and ellipses can be achieved by so-called shell clustering algorithms [11]. In FCM and PFCM Euclidean distance is used for calculating the distance between cluster centers whereas shell clustering algorithms use other distance measures.

3.2. Fuzzy C means

The most prominent of the fuzzy clustering algorithms is the FCM or Fuzzy C means algorithm. The Fuzzy C means algorithm was proposed as an improvement of the classic Hard C-Means clustering algorithm The FCM algorithm receives the data or the sample space as an $n \times m$ matrix where n is the number of data and m is the number of parameters. The number of clusters c, the assumption partition matrix U, the convergence value E all must be given to the algorithm. The assumption partition matrix has c number of rows and n number of columns and contains values from 0 to 1. The sum of every column has to be 1. The first step is to calculate the cluster centers. This is a matrix v of dimension c rows with m columns. The second step is to calculate the distance matrix D. The distance matrix constitutes the Euclidean distance between every pixel and every cluster center. This is a matrix with c rows