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Color-based object segmentation method using artificial neural network

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ABSTRACT

This paper presents a color-based technique for object segmentation in colored digital images. Principally, we make use of some color spaces to segment pixels as either objects of interest or non-objects using artificial neural networks (ANN). This study clearly shows how a novel method for fusion of the existing color spaces produces better results in practice than individual color spaces. The segmented objects include lips, faces, hands, fingers and tree leaves. Using several databases to represent these problems, the ANN was trained on the color of the pixel and its surrounding 8 neighbors to be an object or non-object; in the test mode the trained set was used to segment the 9 pixels in the test image into object or non-object. The feature vector was used for training and testing results from the fusion of different types of color information that came from different color models of the targeted pixel. Several experiments were conducted on different databases and objects to evaluate the proposed method; significant results were recorded, showing the power of expressiveness of color and some texture information to deal with the object segmentation problem.

1. Introduction

Image segmentation that is based on color information is a process that aims to subdivide images into their components, depending on the colors of objects searched for. Ideally, the process is based on partitioning an image into regions that exhibit similarity in color according to a priori defined criteria. Image segmentation in general is a crucial initial step in most automatic pictorial pattern recognition and scene analysis tasks. This paper attempts to demonstrate work on human lip, face, hand and finger segmentation, in addition to tree leaf segmentation, using color information. These 5 problems have attracted a great deal of researchers' attention, because they are related to a variety of important applications.

Lip segmentation is an automatic process used to localize and detect the lip and mouth area in digital images. It is an important area of research because it is a basic step in many applications, such as automatic lip-reading applications [1], speech recognition systems, which deal with the video signal as well as the audio [2], visual passwords systems [3], face recognition systems [4], facial expression recognition [5] and human–computer interfaces [6]. Also, lips alone can be used for personal authentication as a standalone biometric system [7]. There are many challenges yet to be overcome in the area of lip segmentation [8,9]. This is because there is low color contrast between the lip and face regions, diversity of lip shape

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and color across humans, as well as the presence of facial hair and poor lighting conditions, all of which hinder the success of algorithms for lip segmentation.

Face segmentation is an essential first step in face and facial recognition systems, in order to extract the face region from the background. It has a number of applications in areas such as content-based image retrieval [10,11], video coding [12], video conferencing [13,14], crowd surveillance [15], and intelligent human–computer interfaces [16]. However, it was just recently that the problem of face detection has attracted considerable attention from researchers. The human face is vital and has a high degree of variation in appearance, which makes face detection a serious and difficult problem in the computer vision area.

Recently, in the field of Hand and Finger Detection, there have been tremendous efforts of research into hand gesture recognition. In the past, gesture recognition systems attempted to identify gestures using tools such as glove-based devices that could measure the position and the movement of the hand and the fingers [17]. However, these devices are very expensive and not easy to use because of the number of cables connected between the gloves and the computer. This has motivated new research into using non-intrusive, vision-based approaches to recognizing gestures. On the commercial side, finger and hand gesture recognition is gaining much attention, which may be best illustrated by Sony's Eye Toy, an accessory for the company's PS 2 – a camera on the top identifies full body motions and reacts accordingly. However, hand gesture recognition has not yet reached the same level of robustness and reliability of other technologies [18–20]. Finger segmentation is a vital first step for fingerprint recognition methods used in identification/verification systems, as well as hand segmentation.

This paper attempts to make use of different color models to obtain the greatest amount of information, so as to categorize pixels as either object or non-object pixels. Many different color models and features have been used in the literature; however, this study clearly shows how a novel method for fusion of the existing color spaces with some texture information produces better results in practice than individual color spaces and single pixel segmentation. The proposed approach demonstrates that more accuracy can be attained in dealing with images of many different sizes, colors, expressions, orientations and complex situations.

The rest of this paper reviews some of the major work carried out previously, presents the proposed method, describes the databases used for evaluation, and discusses the experiments and the results of this study.

2. Literature review

Several approaches for segmenting objects in digital images can be found in the literature, such as: histogram methods [21], thresholding [22], edge-based segmentation [23], statistical and region growing techniques [24], clustering techniques [25], etc. The proposed work tackles 5 problems, including human lip, face, finger and hand segmentation, in addition to tree leaf segmentation, using color information. Therefore, it is appropriate to review some of the most important work that has been carried out on each problem separately, focusing in particular on those which used color information for segmentation.

2.1. Lip segmentation

Many approaches have proposed solutions to the problem of lip segmentation in colored images. For example, Bao and co-workers proposed a novel method that segmented images based on skin instead of lip color. Using a series of preprocessing techniques and exploiting the power of the artificial neural network (ANN), they were able to significantly reduce runtime while still achieving good results (85.5%) [26]. Their method, however, was not effective for images where people had beards or were wearing sunglasses.

Yilmaz increased the accuracy of lip segmentation using lip boundary information, from which algebraic features can be extracted. He employed several color spaces such as RGB, $R/(R+G)$, Hue and (rg), and calculated the segmentation errors. The reported results were in the range of 76–87% of mean precision and recall depending on the method used [2].

Badura and Mokrys [27] proposed using HSV space histograms and achieved a satisfactory detection rate that made use of RGB, similar to Yilmaz's work and YCbCr, similar to Shemshaki's and Amjadifard's work, in addition to two transforms, pseudo HUE and LUX. Capilar and co-workers built a skin and lip pixel database [28]. They concluded that the color spaces were inefficient, but the transforms yielded adequate results. Lack of a publicly available database, however, makes the results unverifiable.

Recently, Sangve and Mule not only used color spaces for lip segmentation like the aforementioned researchers, but also began person recognition based on the lips [7]. They did this by combining the region of interest (ROI) with the appearance-based model (ABM), active shape model (ASM), and point distribution model (PDM). Additionally groundbreaking was the work of Spyridonos and co-workers. They employed a fuzzy C-means (FCM) clustering algorithm to identify the lip border, also making use of the YIQ color space [29]. Their results showed the method's cost-effectiveness and accuracy.

Using the difference in color between the lips and the face, Hassanat and Jassim used the K-mean clustering algorithm on the *Cb* and *Cr* components of the YCbCr color space to find at least any part of the lip as an initial step. Then they used other information such as *r, g, b*, warped hue, in addition to some special information, to create two feature vectors: one representing the lip and the other representing the face. Euclidian distance was used as a similarity measure between each