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Shape and Texture based Image Segmentation using Image Database

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ABSTRACT

This paper presents the overview of the methodology employed in this research work for segmenting objects in the image sequences. Image segmentation is the technique of allocating a label to each pixel in an image such that pixels with the same label share some image characteristics like foreground and background of the image pixel. The result of image segmentation is a set of segments or regions that together represent the entire image. For each image pixel, a feature vector is computed as a sequence of area moments concerning certain characteristics such as color, texture, intensity, etc. From the literature survey, it has been observed that the performance of image segmentation methods is influenced by many factors such as intensity, shape, texture and image content. Hence, a single segmentation method cannot be applied to all types of images. At the same time, not all the methods perform well for one particular image. Efficient implementation, computational times are the critical aspects of defining the performance of these methods.

Keywords : Image segmentation, Enhanced Fractal Texture Analysis, Layout Descriptor

I. INTRODUCTION

Segmenting objects of dynamic shapes with different colors is still challenging to the computer vision of natural images. The difficulty is due to factors like slow computation, inaccuracy, and loss of information. In this investigation, a shape and texture based image segmentation which is obtained by the combination of Enhanced Fractal Texture Analysis (EFTA) with Layout Descriptor (LD) to overcome challenges of image sequences have been proposed. It is used to illustrate the boundary complexity of the segmented image. As a first step, the input data is pre-processed using Adaptive Switching Median Filter (ASMF) [1-4]. ASMF removes the noises and retains the fine details of the image efficiently. Subsequently, the strength of edges found by a noise-protected edge detector has been enhanced. Then, a morphological gradient approach, which is the combination of shape and texture gradient extraction for extracting the image features, has been applied. This step is performed directly on the colour image. The loss in colour characteristics is avoided which makes it better than the conventional grayscale conversion methods. Further, the shape feature is extracted from the pre-processed image based on the descriptors such as compactness, rectangularity, eccentricity and moment invariants.

II. DATA COLLECTION AND EVALUATION

The present study uses CV online image database for getting the information in the form of images. It is the openly available dataset, which is freely available online. CV online database is one the most extensive dataset containing different categories of images such as the face, Iris, fingerprints, eyes, hand action, and medical/biological images, etc., The availability of input from this database tends to be more feasible for making use of the data for the present research in image segmentation. These images were used only to ensure a varied data set. The image object detection and feature extraction performances are evaluated on this dataset. In this investigation, coloured images have been used instead of a gray-scale image. The collected data were tested making use of the segmentation approach. The simulation tool used in this research is Matlab 2016b. The semantic features of the input image sequences are accessed by segmenting the image and representing it as a model [6-7].

The performance of the proposed technique has been evaluated and compared with the traditional methods by measuring parameters like precision, recall, f-measure and average processing time. The accuracy achieved will be high when both values of precision and recall are high. In addition, F-Measure has been used for analyzing the accuracy of the particular system. F-measure or F-score or F1 can be inferred as a weighted average of recall and precision that computes the scores between 1 and 0 to show the best and worst consequence. These are explained in detail in evaluation metrics section.

III. SHAPE AND TEXTURE BASED IMAGE SEGMENTATION

Image Enhancement and Denoising

The image has been pre-processed using image enhancement algorithm, which is based on the combination of window gray stretching method and a power transform. This algorithm not only improves the image contrast but also has good adaptation and robustness to a different set of the image with different illumination conditions. In addition, an optimized compounding algorithm for image de-noising is designed, which combines the improved median filtering and mathematical morphology. Experiments show that this algorithm removes image noise and preserves image edges, thereby laying a good foundation for image object extraction and recognition [8] Hence, the optimized compounding algorithm has been used for in this research.

Object Extraction

For the extraction of an object from the image sequences, the present system employed the spatiotemporal based image features for identifying the object. It has been done via isolating the image pixels or segmenting the object parts from other parts of the image. Subsequently, the pixel distance information and size of the image particle, color information is assumed for detection and extraction of an object from the input image. At the same time, the edge information for the reconstruction of an object from the image has been concerned [9-10]. All these edge features offer more constraints about objects' shape than point features.

Texture Feature

In this research, the colour, shape and texture features have been extracted for the segmentation and object detection. The term colour is the visual characteristics of an object, which resulted from transmitted, or light emitted or reflected. In the view of mathematical representation, the term colour is an extension from scalar to vector signals. With the help of the image histogram, the colour features have been extracted. The term shape of an object referred to its physical profile or structure. In order to recognize, measurement of shapes, finding and matching shapes, the shape feature has been utilized. The few characteristics of shape features are orientation, moment and perimeter. With the help of material composition, content, spatial and colour properties, we determine the shape of an object. The term texture is termed as the repeated pattern of procedure or data of the structure along with the regular intervals.

Let X and Y represent the horizontal and vertical axis in 2-Dimension, a point (x,y) represents the gray level value in the image and is given as f(x,y).

The (p+q) th two dimensional moment is written as,

$$m_{pq} = \int_{xy \in c} \int x^p y^q f(x,y)dxdy \quad p,q=0,1,\ldots\ldots \qquad (1)$$

The p and q is the first and second order moments that utilized to estimates the covariance matrix and mean vector.

The (p+q) th two dimensional central moment is defined as follows

$$\mu_{pq} = \int_{xy \in c} \int (x-\bar{x})^p (y-\bar{y})^q f(x,y)dxdy \qquad (2)$$

Where,

$$\bar{x} = \frac{m_{10}}{m_{00}} = \frac{\int_{x,y \in c} \int x f(x,y)dxdy}{\int_{x,y \in c} \int f(x,y)dxdy} \qquad (3)$$

$$\bar{y} = \frac{m_{01}}{m_{00}} = \frac{\int_{xy \in c} \int y f(x,y)dxdy}{\int_{x,y \in c} \int f(x,y)dxdy} \qquad (4)$$

The (p+q) th two dimensional normalized central moment is defined as follows

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\frac{p+q+z}{2}}} \qquad (5)$$

Where, P, q- two dimensional vector

η - Efficiency

z- Average gray level

In our case the image is partitioned into foreground and background regions. Thus, given a feature G, for instance, the average gray level which maximizes the difference between two scalars u + and u − defined as follows:

$$u^+ = A^+ \int_{\omega} G^+(I(x))dx, \qquad (6)$$

$$u^- = A^- \int_{\Omega/\omega} G^-(I(x))dx. \qquad (7)$$

The superscripts + and − correspond to the feature values in ω ⊂ Ω and in Ω/ω, respectively.

The energy minimizing function defined as,

$$E(\theta_1, \varphi_i) = \min E(\theta, \varphi) \qquad (8)$$

Where θ is the initial level set and θ_1 is the final discovered level set on the image boundary. The other parameter φ is F: C → R^2 propels the contour towards the object region. The object region is defined by parameters φ_i and φ_e representing the interior and exterior of the contour respectively. The equation of the minimization function defined as:

$$E = a_1 \int_{\theta} ds + v \iint_{\theta i} \theta dxdy + a_2 \left(\frac{1}{2} \iint_{\theta_i} (F-\varphi_i)^2 dxdy + \frac{1}{2} \iint_{\theta_e} (F-\varphi_e)^2 dxdy \right) \qquad (9)$$

In this above equation, the initial term, points to the arc length $\arg_{\min(\theta,\varphi)} (a1 * len(\varphi))$, , which provides the evenness of φ during the curve growth with $len(\varphi)$ as contour boundary.

The distance minimization problem defined as

$$E(\theta, \varphi_i, \varphi_e) = a_1 \int_{\theta} |\nabla H(\varphi)| dxdy + a_2 \left(\frac{1}{2} \iint_{\theta_i} (F-\varphi_i)^2 H(\varphi) dxdy + \frac{1}{2} \iint_{\theta_e} F-\varphi_i)^2 (1-H(\varphi))dxdy \right) \qquad (10)$$

Here a1 and a2 are the initial two relations provide regularization for length and area of the contour image.

ϭ - Gaussian variance

ω - Frequency

H φ is Heaviside function and the level set in Eq (10) reaches a minimum value of $\varphi(x, y)$ iteratively with gradient decent model defined by:

$$\theta(dt) = -\delta(\theta)\left((F-\varphi_i)^2 - (F-\varphi_e)^2\right) - a_1\nabla.\frac{\nabla\theta}{|\nabla\theta|} \quad (11)$$

Here φ- phase shift

θ - filter angle

The delta function is $\delta(\theta)$ and Eq.(11) is updated iteratively as

$$\varphi_i = \frac{\int_o FH(\theta)ds}{\int_o H(\theta)ds} and \varphi_i = \frac{\int_o F(1-H\theta)ds}{\int_o (1-H\theta)ds} \quad (12)$$

The colored texture invariance prior is moved by the following energy function

$$E_{ct}(\varphi) = d^2(\varphi_o, \varphi_t) = \iiint (-H(\varphi_o) + H(F_{ctf}))^2 dc \quad (13)$$

Here F_{ctf} - linear combination of principle components for each dimension

The texture refers to the appearance and surface characteristics of object assume via density, size, arrangement, shape and fraction of its fundamental parts. The collection of these features analysis is known as texture feature extraction. Due to this functionality, it is common to the different image processing applications such as medical imaging, remote sensing and image retrieval process. The image feature extraction method not only takes into account the gradient features of an object's edge but also incorporates the layout descriptor method to describe texture features. This method is based on the texture features from a psychological perspective. It consists of six dimensions corresponding to the perception of texture features, including coarseness, contrast, directionality, line-likeness, regularity, and roughness. The three major applications related to the texture analysis is segmentation, extracting shape from texture and texture classification. The term segmentation creates the image partition into a set of disjoint regions based on texture properties. Hence, all regions are identical which relies on certain texture characteristics. The term texture classification offers the classified output whereas the texture region is recognized with the help of the texture class.

The shape of an object has been extracted by the gradient vector approach. In this approach, at first, the background has been extracted and then performs shape matching with the database image. This is done at each corner of the image. At the edge point, the edge detector produces the data about the magnitude of the gradient and the edge direction in the locality of the point. The edge point in the local neighbourhood that has similar gradient directions once deciding the edge points are linked together i.e. which lies on the same edge. Once the gradient points are not satisfied the primary constraint, the process gets stops and concluded at the end of the edge. Or else, if found the new edge point, the process will repeat. The calculation ends when all edge indicates have been connected one edge or if nothing else has been considered for connecting once. In this way, the essential procedure utilized by nearby edge linkers by following a succession of edge focuses and gives the shape

IV. SIMULATED RESULTS

On receiving the query image from the user, the colour, shape and its texture quality are totally removed and evaluated with the qualities of the images available in the database. The six-colour quality is tested with the similar six-colour quality in the colour table, likewise for the four-texture quality. Every quality is evaluated with the similar quality of the image available in the database, correspondingly. As depicted earlier, the colour and texture quality are tested and saved in the database, the quality of the query images is removed, and the quality of the query is tested with the database image. In the Fig. 3, the colour quality of image appears similar in mean feature extraction; however, it differs in the texture. Hence, the colour and texture quality are significant in recovering similar images.

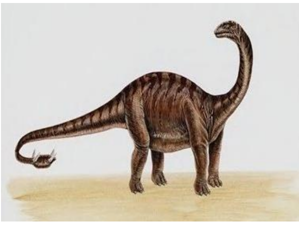

Fig. 1 Input Image

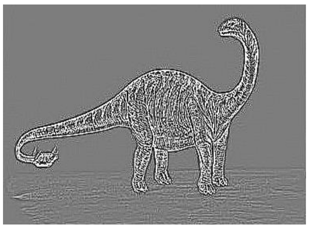

Fig. 2 Texture Extraction

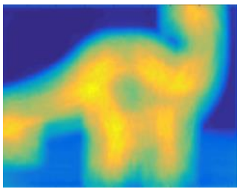

Fig. 3 Mean Feature Extraction Map

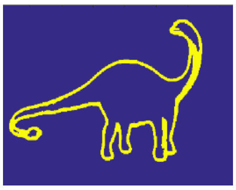

Fig. 4 Shape Extraction

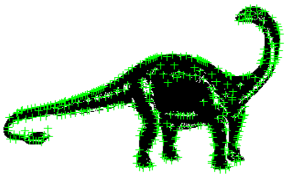

Fig 5 Layout Descriptor

Fig 6 Object Extraction

respectively. The Fig. 4 is the shape-extracted output. The extraction is done following the steps in the previous sub-sections. Layout descriptor is shown in the Fig. 5 it has been obtained basing on CLD. Finally, the required object is extracted as shown in Fig. 6. Subsequently, all the objects are classified earlier to the object tracking process, which denotes the tracking process identifies the object before what it being tracked. The simulated results of the extracted objects are presented in Fig. 6.

Table 1. Simulated results

Method	Precision	Recall	F-measure
Active contour	0.79	0.81	0.80
Marker based	0.66	0.84	0.71
Region based Geometric	0.50	0.77	0.57
EFTA-LD	0.90	0.91	0.95

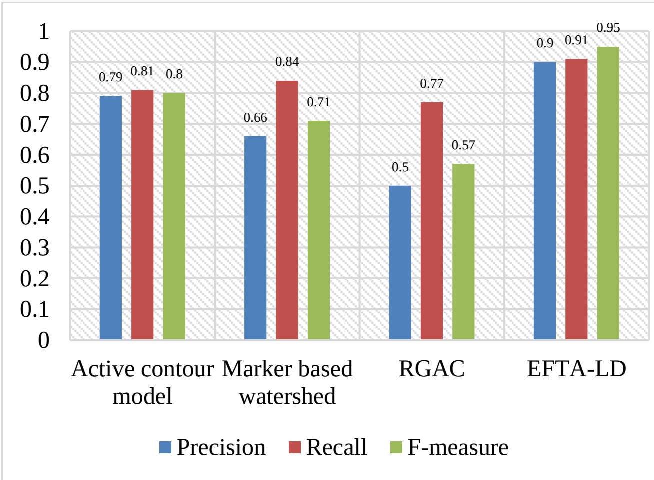

Fig. 7. Representation of parameters

In this study, fractal-based texture analysis has been used to measure the intensity variation of a surface that enumerates the properties like regularity and smoothness of the image. Further, image descriptors, which are similar to edge, texture and colour features and are less sensitive towards illuminating the colour changes towards tracking the object have been obtained. By the experimental procedure, the extracted features are depicted in Fig. 4, 5 and 7

The simulated results of statistical parameter measurement such as precision, recall and F-measure with average processing time in seconds are discussed in Table 1. The representation of parameters is given in the Fig. 7.

In addition, the obtained results were compared with previously available models such as active contour, marker-based watershed, and region-based geometric active and contour mode. Based on these comparative results, the proposed method shows better performance than the previous approaches based on the measure of F-measure (0.95), recall (0.91) and precision (0.90) values.

Table 2 Comparison of processing time(s)

Method	Average processing time (s)
Active contour model	15.7
Marker based watershed	0.15
Region based Geometric Active Contour(RGAC)	25.1
EFTA-LD	2.68

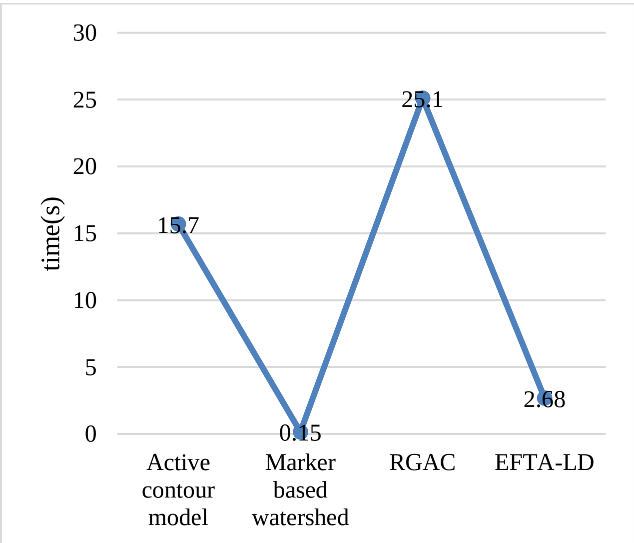

Fig. 8. Representation of processing time(s)

Table 2 and Fig. 8 shows the processing time comparison and representation of processing time respectively. The average processing time is only high when compared with the marker-based watershed model. On comparing with the other methods like active contour model and RGAC, EFTA-LD is the fastest one.

Table 3. Performance evaluation

Method	F1-score	Precision	Recall
Hit-or-miss	0.27	0.4	0.21
Stochastic approach(SA)	0.16	0.12	0.24
Morphological Transforms(MT)	0.89	0.3	0.32
Path-based morphological operators	0.5	0.56	0.54
RORPO	0.73	0.73	0.73
EFTA-LD	0.90	0.91	0.95

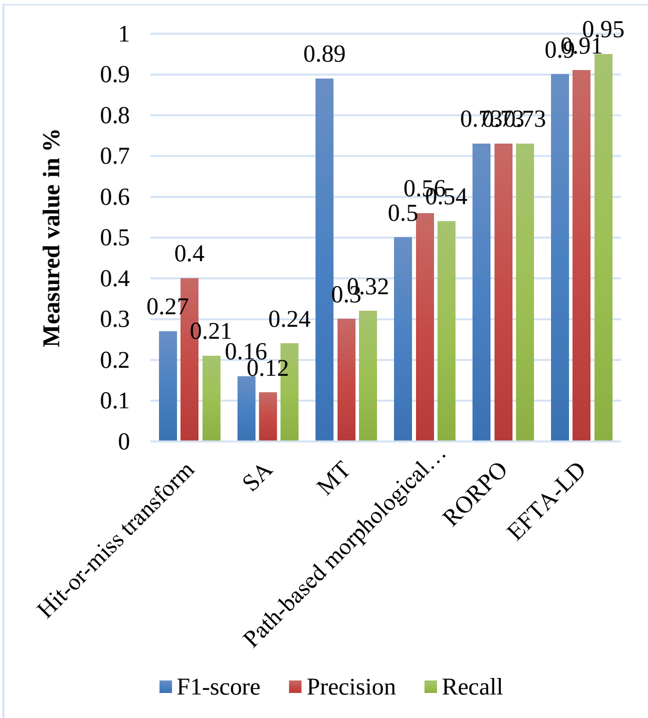

Fig. 9. Pictorial Representations of Precision, Recall, F-Measure

The performance evaluation of the proposed method has been done based on the precision, recall, F-measure. Further, the effectiveness of the proposed method has been validated and compared with the existing methods such as hit-or-miss transform, stochastic approach, morphological transforms, path-based morphological operators, Ranking the Orientation Responses of Path Operators (RORPO) in table 3 and Fig. 9. The experimental results of precision, recall, f-measure are discussed in table 2. From the obtained results, the framed method provides better results than the existing methods. The pictorial representation of precision, recall, and F-measure is shown in Fig. 9.

V. CONCLUSION

The proposed image segmentation algorithm is verified on a database of natural colour images for qualitative analysis. The proposed approach gives better experimental results even if the images are corrupted by impulse noises. In comparison to colour contrast and multi-scale morphological gradient, the edges in the colour composite gradient are strengthened, and the inner regions are smoothened. The segmented results of this gradient image have over segmentation problem. When applied a morphological gradient technique to marker-extracted image many smaller regions are removed and over segmentation problem has been reduced. In order to perform the shape, texture gradient removal in colour images, and diminish the problem of over-segmentation, a combined approach of fractal texture analysis with layout descriptor is proposed and carried out. The morphological gradient technique is the product of the colour contrast gradient and the multi-scale morphological intensity gradient. This algorithm can be applied to other applications, such as content-based image retrieval, CMIR etc., The morphological gradient contrast can also be applied to other segmentation algorithms.

In the morphological gradient approach, edge enhancement in the image using gradient computation is a significant step. This approach works well in all conditions like low or high contrast, noisy background and, uneven background. Moreover, while pre or post processing there is no need for considering the threshold value for separating foreground and background. Further, the gradient-based detection is used, and it detects the text including the false negatives since different constant thresholds are employed for detection. Later, the combination of edge information takes place including intensity and range. It limits the gradient to eradicate local minima, in turn, reducing the homogeneous regions. Hence the morphological gradient approach is a powerful technique for eliminating local minima.

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