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Comparison Study of Object Extraction Based on Color Space Using Active Contour and Morphology Methods

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Abstract

Object extraction is imperative as it permits the separation and identification of precise objects within an image, empowering more accurate analysis, recognition, and decision-making in numerous applications like robotics, surveillance, and medical imaging. In this study, a proposed comparison study has been introduced between two object-extraction methods, active contour and dilation of morphology operation based on RGB or YCbCr color spaces components when processed by a Wiener filter to reduce noise. Then, some measures are used to evaluate the performance of each proposed technique.

Keywords: active contour, morphology, dilation, color space

1. Introduction

Dividing an image into relevant sections with comparable characteristics and attributes is called a segmentation of an image. The goal of segmentation is simplification or the meaningful and readily analyzed representation of an image. The initial stage of image analysis is the process of segmentation. image segmentation's primary objective is to split an image into several sections or segments with comparable characteristics [1]. A crucial part of various visual considerate schemes is image segmentation. It divides images (or video frames) into different sections or objects. Applications such as autonomous vehicles (e.g., passable surface and pedestrian recognition), video surveillance, and medical image analysis (e.g., tumor border extraction and measurement of tissue quantities) all heavily rely on segmentation [2]. There are several methods for segmenting images into smaller parts. Every method has unique characteristics [1]. Layer-based and block-based segmentation are the two main categories recognized in image segmenting. The tactics in the second categorization are separated into three groups: hybrid approaches, edge-based or boundary-based procedures, and region-based strategies. The categories are based on two attributes: discontinuity and similarity [3].

In this area many works are introduced, in [4] a method for segmenting images to recognize pothole areas on roads was produced, including six steps: smoothing, computing gradient values, automatically defining minimum flood values, merging catchment basins, eliminating residual catchment lines, and forming watershed curves. The work has appeared to show the procedure is efficient in minimizing the problem of over-segmentation.

In [5] The work offers a brain tumor segmentation system that comprises three main steps: pre-processing, image thresholding, and segmentation. The article precisely studies the efficiency of brain tumor segmentation by comparing the Level Set Method (LSM) and Chan-Vese (C-V) techniques.

Where in [3] the paper presents a process of segmentation utilizing a template of features based on watershed or morphology processes. The template conveys pixels' intensities and contents of texture, standard deviation filtering has been utilized. The image quality has been enhanced by employing a wiener filter and histogram equalization methods. The hybridized operation has been achieved with an edge detector operator for segmentation enhancement.

An ordering of the coordinate scheme and subspace bounded by the system, in a way that every color has been categorized by a single point termed color system, color space, or color model [6]. It is considered an abstract mathematical model in which the description of the means colors is characterized as numerical tuples (such as triplets in RGB or quadruples in CMYK). There are numerous color spaces, in which everyone with distinct characteristics, benefits, restrictions, and specific applications [7].

In [8] The authors proposed a color image segmentation method by converting RGB images into HSV format, applying Otsu's multi-thresholding on V(value) channel, segmenting the resulting image with K-Means clustering, merging over-segmented regions, performing background subtraction, and morphological processing.

Where the authors in [9] presented a suggested algorithm for implementing the segmentation process of an area of human skin using color images that input employing a watershed method with a modified morphological reconstruction as an open-closed marker.

In [10] This research compares L*A*B* and HSV color spaces for color image segmentation using mse and psnr parameters, revealing that HSV color space outperforms L*A*B*.

In [11] hybrid features from two diverse apparatuses of two distinct color spaces L*a*b* and RGB have been utilized based on the k-means approach to achieve image segment. Sobel operator with its gradient intensity of an image and texture characterization from the Gabor filter are combined in the mask segmentation.

In [12], the work tries to realize the model of the segmentation of an image utilizing the process of region growing to implement the segmentation on Landsat (land satellite) images to recognize land cover variations.

The challenge is to identify the image object precisely. The proposed study explains the effect of color space components with the object extraction method. RGB channels and YCbCr components are considered when applying active contour or dilation operation. The remaining paper sections are organized as a methodology in section 2, experimental result and analysis in section 3 followed by a conclusion in section 4

2. Methodology

A proposed comparison study has been introduced in this work between two object-extracted methods, active contour and dilation of morphology operation based on RGB or YCbCr color spaces components when processed by a Wiener filter for noise reduction. the main stages of this proposed method and the details of these stages are illustrated in Figure 1:

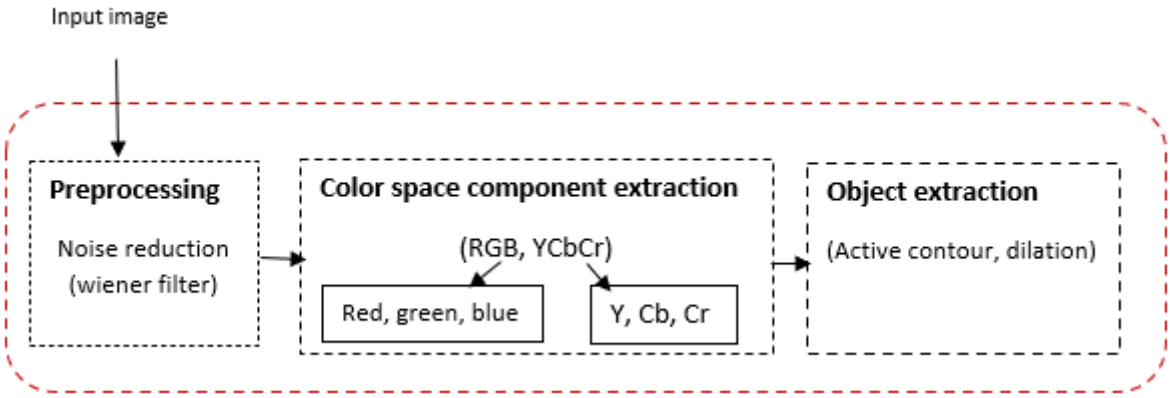


Figure 1. Stages of the proposed method

2.1 preprocessing

The preprocessing step is considered an actual step in the image analysis process, in this work conversation to grayscale image and noise reduction using a wiener filter are applied as preprocessing steps, The Wiener filter is a broadly utilized procedure in image processing for noise decrease and enhancement, reflecting blurring and eradicating noise. However, it is a shift-invariant, linear filter method that is able to degrade high-frequency components, making it unsuitable for images with edges due to blurry edges [13].

2.2 color spaces components extraction

The input-tested images were employed in two color spaces, RGB and YCbCr, where in RGB color space its components are extracted which are red, green, and blue. Also, in the YCbCr color space the Y, Cb, and Cr components are extracted. Digital video and photography systems employ the YCBCR color space approach. Luminance in images is the brightness component, while chrominance represents color information in signals, focusing on red and blue channels. Human vision is more sensitive to luminance. The YCbCr color space separates these components, capturing brightness and color variations for efficient image representation [14].

2.3 object extracted

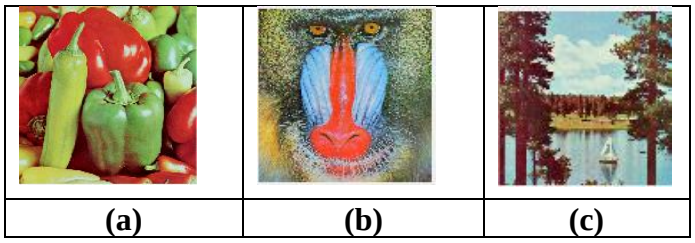
Active contour or dilation morphology operations are considered in this stage on the extracted components that yielded from the previous stage for implementing the extraction operation of input image objects when applying each component of each color space to active contour procedure or dilation morphological operation. Active contour models are a state-of-the-art style used in image segmentation, and they are considered into two types: parametric active contour and geometric active contour models [15, 16]. The chief goal of these models is to perceive and extract the boundary of an object within an image. The fundamental perception for computing encompasses representing a curve as the minimizer of a functional. These functional combine numerous energy terms to stabilize the shape consistency and the contours demarcated by the image's gradient [17]. A binary image is considered in this segmentation process as an initial mask. It gives the active contour a first estimate of the area to be divided, enabling iterative boundary refinement.

Mathematical morphology is a theoretical basis for studying geometric structures. It is an extensively utilized scheme in image processing for extracting features that assist in designating shapes, such as boundaries and skeletons. The main morphological operations include erosion, dilation, opening, and closing [18]. This second proposed approach applied with structure element 3×3 for region segmentation with dilation on each component of each color space.

3. Experimental results and analysis

3.1 Read input images

In this study, well-known standard images of pepper, baboon, and lake with sizes (512×512 pixels) for each were utilized to examine the experimental results for performance evaluation, as explained in Figure 2, which shows the tested input images in Figure 2(a) to 2(c).



(a) **(b)** **(c)**

Figure 2. Input images, (a) pepper, (b) baboon, (c) lake

3.2 Noise reduction

To eliminate noise in this step wiener filter is employed, and its calculations are demonstrated in the following equations [19]. Table 1 explains the evaluation of this step in PSNR, and SNR measures.

$$\mu = \frac{1}{mn}\sum_{i}^{m}\sum_{j}^{n} a_{i,j} \tag{1}$$

$$\sigma^2(A) = \frac{1}{mn}\sum_{i}^{m}\sum_{j}^{n} a_{i,j}^2 - \mu^2(A) \tag{2}$$

Forming Wiener filter equation from combining Mean Equation and Variance equation together

$$W_{i,j} = \mu(A) + \frac{\sigma^2(A) - v^2}{\sigma^2}\left(a_{i,j} - \mu(A)\right) \tag{3}$$

Where μ is local mean, σ^2 variance around each pixel, v^2 is the noise variance, $W_{i,j}$ is Wiener.

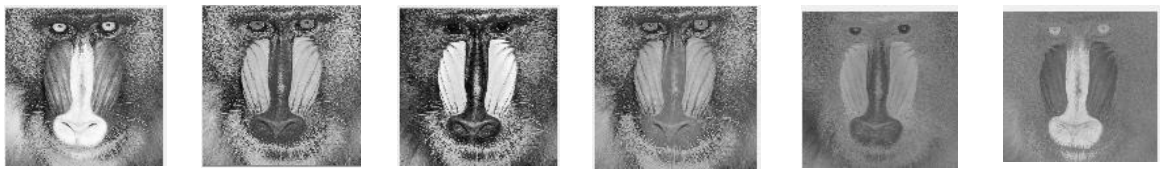
Table 1. Noise removal assessment

Image	Pepper	Baboon	lake
PSNR	32.8648	31.1779	31.3940
SNR	27.5025	26.3320	26.0407

3.3 Color space components extraction

Table 2 explains the RGB and YCbCr color spaces with their components. The first three columns illustrate the RGB color space components (Red, Green, and Blue), and the last three columns show the YCbCr color space (Y,Cb,Cr) for the tested input images (Pepper, Baboon, Lake). Each color space component is based on extracting the object from each input image when applying the active contour technique or morphology operations with a dilation operation.

Table 2. Input images in the color space component

images	RGB color space			YCbCr color space		
	Red	**green**	**blue**	**Y**	**Cb**	**Cr**
Pepper						
Baboon						
lake						

Tables 3,4 and 5 explain the performance analysis when applying the active contour technique and the effect number of iterations based on each color space component and evaluated using entropy measure as released in (4) [20], also as seen in Table 6 with dilation operation the performance has been evaluated. From these tables analysis, the performance evaluation is dependent on the image nature with its colors that affect image analysis. The pepper and Baboon images perform better with the active contour process than the dilation operation with YCbCr color space with an entropy value. At the same time, the lake image achieved more performance by applying dilation on the YCbCr color space. As a result, YCbCr color space achieved better performance than the RGB components with any of the proposed methods of segmented utilized. The color space affects image analysis when extracting its components. Entropy is a metric that quantifies the degree of disorder or uncertainty present in an image [21]. The objective of segmentation is to separate the image into more uniform or meaningful parts, each of which should have more consistent features, a lower entropy value implies a uniform region. The number of iterations showed its effect on the accuracy of the extracted image object, in which the performance is improved when the iteration numbers are increased in the active contour image.

$$entropy = -\sum_{i=0}^{L-1} p(x_i) log_2 p(x_i) \qquad (4)$$

where xi represents the intensity of the pixels, $p(x_i)$ is the probability distribution function (PDF) of the intensity levels in the window, and L refers to the intensity level number that exists in the window.

Table 3. Object extraction evaluation using entropy measure with active contour iter. N =100

	RGB color space			YCbCr color space		
image	red	green	blue	Y	Cb	Cr
Pepper	0.9999	0.9979	0.9924	0.9999	0.9937	0.9822
Baboon	0.9960	0.9998	0.9302	1.0000	0.9754	0.6010
Lake	0.9959	1.0000	0.9932	0.9999	0.9969	0.9987

Table 4. Object extraction evaluation using entropy measure with active contour iter. N=200

	RGB color space			YCbCr color space		
image	red	green	blue	Y	Cb	Cr
Pepper	0.9996	0.9973	0.9908	1.0000	0.9900	0.9710
Baboon	0.9927	0.9999	0.9191	0.9999	0.9825	0.5855
Lake	0.9950	1.0000	0.9933	0.9999	0.9965	0.9987

Table 5. Object extraction evaluation using entropy measure with active contour iter. N=300

	RGB color space			YCbCr color space		
image	red	green	blue	Y	Cb	Cr
Pepper	0.9994	0.9969	0.9890	1.0000	0.9883	**0.9646**
Baboon	0.9905	0.9999	0.9142	0.9999	0.9837	**0.5804**
Lake	0.9946	1.0000	0.9933	0.9999	**0.9959**	0.9987

Table 6. Object extraction evaluation using entropy measure with dilation operation

	RGB color space			YCbCr color space		
image	red	green	blue	Y	Cb	Cr
Pepper	0.9814	0.9905	0.9931	0.9976	**0.9493**	0.9599
Baboon	0.9980	0.9799	0.9611	0.9618	0.9494	**0.6030**
Lake	0.9996	0.9964	0.9989	0.9980	**0.9907**	0.9933

4. Conclusion

comparison study has been introduced between two object-extracted methods, active contour and dilation of morphology operation based on RGB or YCbCr color spaces components when processed by a wiener filter for noise reduction. Then some measure is used to evaluate the performance of each proposed technique. The RGB-based segmentation performs well and effectively, however, because

the Y channel represents luminance, YCbCr-based segmentation performs better in terms of intensity separation and it is less susceptible to color shifts and more resilient to changes in illumination. Also, morphology with dilation does well in segmentation, when segmentation deals with different lighting circumstances, the active contour will be more focused on brightness changes, which might be helpful. In conclusion, the performance with any color space depends on the nature of the image.

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