ABSTRACT

Background/Objectives
In this paper, we propose a new method to convert image data into HSV color space data separated into three color channels in order to implement merged edge detection techniques after a noise removal in the S channel.

Methods/Statistical analysis: The proposed algorithm was used with Gaussian blur pre-processing to reduce the noise in the image, unlike how a Sobel operator is commonly applied to a grayscale image after 3-channel color space separation on the image where the edge is detected. After the color space has been converted to the HSV color space according to binary human vision from a conventional RGB color space, each of the channels (H, S, V) is separated using the Sobel Operator. Findings: The results for each channel are compared, and then the surrounding pixel and comparison operations are executed to remove contour noise occurring in the S Channel. Improvements/Applications: In this manner, the noise removal filter is applied, and finally, the S and V channels are combined applying a filter to the end result and showing that the edges have been effectively detected.

KEYWORDS: Gaussian Blur, Edge Detection, RGB to HSV Conversion & Removal Noise filter

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1. INTRODUCTION

Data Edge detection is an important technique that has been implemented in a wide variety of imaging applications, and a basic step in such image processing techniques is to detect the boundary of an object at different points in the extracted image or to identify text\(^1\). Different operators are useful during edge detection, including a Canny operator, Sobel operator, and Prewitt Operator\(^2,3\). Of these, the Sobel operator has the advantage that it can be robust against noise in all directions of the edge extraction. Nevertheless, it generates a gray scale image for detection for which more than 90% of color loss occurs instead of carrying out edge detection in color space\(^4,5\).

In this paper, we conduct edge detection in color space to improve upon the limitations of edge detection in grayscale\(^6\). The R, G, B color space is a widely used color space, but it is not suitable for in certain cases because people are very sensitive to changes in brightness. Therefore, the R, G, B color space provides information that does not correspond to the sensitivity of the human eye\(^7\). In this paper, each color is divided after converting the original image into the HSV color space to include brightness information, and the Sobel operation is conducted for each of the H, S, V channels. The noise removal filter is used on the edge of the S channel according to the contour back conditions by comparing the center pixel to those in four directions (up, down, left, right). Finally, we propose an algorithm to merge the image contour of the V-channel in order to obtain a more
2. RELATED RESEARCH

2.1. Gaussian Blur

Noise removal is an important step for image processing\textsuperscript{8,9,10}, and the Gaussian blur technique uses a Gaussian function as a large-blurring algorithm to soften the image. The mask calculated from the Gaussian function convolution processes a set of surrounding pixels for each pixel to save a new pixel value. The Process of Gaussian blur is as follows. For a pixel in the image \((x,y)\), \(\delta\) (sigma) is the standard deviation and \(G(x, y)\) is the value of the applied pixel as the Gaussian blur.

\[
G(x, y) = \frac{1}{2\pi \sigma^2} e^{-\frac{x^2 + y^2}{2\sigma^2}}
\]  

(1)

The size of the Gaussian blur mask is 1,3,5,... and can be set to an odd number such. We thus use the 3 X 3 mask value for the mask matrix as follows.

\[
G(x, y) = \begin{bmatrix}
\frac{1}{16} & \frac{1}{8} & \frac{1}{16} \\
\frac{1}{8} & \frac{1}{4} & \frac{1}{8} \\
\frac{1}{16} & \frac{1}{8} & \frac{1}{16}
\end{bmatrix}
\]  

(2)

When comparing an original image with one processed with a Gaussian blur (Figure 1), the noise suppression can be seen to soften the cross-sectional area of the binary image.

![Figure 1: (a) Original Image (b) Result Image of Sobel Operator](image)

2.2. RGB and HSV Color Space

The RGB color space consists of the red, green, and blue primary colors. When each color is added to the mixture, the brightness increases. However, RGB color information does not provide saturation and brightness\textsuperscript{11}, and the HSV color space indicates the color brightness (H), saturation (S), and degree of light and dark for a particular color (V)\textsuperscript{12}. The RGB image information does not properly indicate the change in brightness in the image in a manner that corresponds to human vision. Thus, contour detection in a color image is carried out after color space conversion to HSV\textsuperscript{13}. The conversion to the
Improved Edge Detection in HSV Color Space

HSV color space from the RGB color space is as follows. The procedure is as follows.

\[
H = \cos^{-1}\left(\frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right)
\]  

(3)

\[
S = 1 - \frac{3}{(R+G+B)} \cdot \text{MIN}(R, G, B)
\]  

(4)

\[
V = \frac{1}{3} (R + G + B)
\]  

(5)

2.3. Sobel Operator

The boundary of the object in the image, or the edge, is detected according to the presence of an object using various edge detection methods, including the Prewitt, Canny, Sobel, and Roberts techniques. The Sobel operator is a method that extracts the line of an edge with strong noise, and it is an exemplary method that uses the first derivative value to extract an edge in any direction applying a horizontal mask and vertical mask. Since the image data is arranged in constant intervals without a mathematical differential operation, it is calculated by obtaining the difference between the adjacent pixels. The Sobel horizontal mask and the vertical mask operator are as follows.

\[
\begin{array}{ccc}
-1 & 0 & 1 \\
-2 & 0 & 2 \\
-1 & 0 & 1
\end{array}
\]  

(6)

\[
\begin{array}{ccc}
1 & 2 & 1 \\
0 & 0 & 0 \\
-1 & -2 & -1
\end{array}
\]  

(7)

Figure 2: (a) Original Image (b) Resulting Image with the Sobel Operator

3. PROPOSED WORK

In this paper, a Gaussian filter is applied after converting an image into the HSV color space from the RGB color space where H, S, and V comprise each channel. After that, the Sobel operator is performed in each channel to detect the edges. Before merging each detected image, a 3x3 mask is applied to the S channel to remove unwanted texture, and then the S channel is merged with V to show the final results.
3.1. Converted to HSV Color Space in the RGB Color Space after Using Edge Detection Sobel Operator

The image is converted to the HSV color space from the RGB color space, and the HSV channels are divided to then produce the respective edges after applying a Sobel operator. Finally, the edges detected from the S and V channels are merged into one image. Figure 4 shows a comparison of the results of the Sobel operator for the RGB color space and HSV color space. The results shows that in the RGB color space, noise in the data results in edges and blocks not being detected, but the HSV color space can detect edges and blocks like of the noise.

3.2. Using the Edge Detection Sobel Operator in the H,S,V Channel

To obtain an outline for each component, the information is first divided into each of H, S, and V channels. The H channel has a problem in that edges turn into blocks. In the S channel, there also has a problem in the texture for the edges of the object.

The above results show that only the S channel should be used without H and V channels.
3.3. Noise Removal Filter

Since the S channel indicates the color saturation, the Sobel operation can also be used to detect the edges and texture due to certain characteristics. A 3x3 filter is used to remove the unnecessary textures, and Figure 6 shows the filter operation.

\[
C_{(x,y)} = \begin{cases} 
C_{(x+1,y)} > \theta 
& \text{if} \ C_{(x,y-1)} > \theta \\
C_{(x,y+1)} > \theta 
& \text{if} \ C_{(x-1,y)} > \theta \\
0 
& \text{else}
\end{cases}
\]  \hspace{1cm} (8)

The resulting mask is in one of four of the vertical and horizontal directions relative to the center pixel, and it is even greater than the threshold (\(\theta\)) value of the C pixel, which shows an original value or values of zero.

Since the filter is applied to all values for all pixels in the image, the filter for the contour in the V-channel (\(\alpha\)) is as follows.

\[
\alpha = \sum_{r=1}^{r} \sum_{c=1}^{c} C_{(x,y)}
\]  \hspace{1cm} (9)

Thus, the noise removal filter, removes unnecessary textures. Figure 7 shows the resulting image after applying the noise removal filter in the V channel.

![Figure 6: Remove Noise Filter](image)

![Figure 7: (A) Result Image of Sobel in V Channel (B) Result Image of V Channel Using Proposed Filter](image)

Figure 8 shows the process to find the optimal threshold for the filter, and it was measured at 50 units. The results show that when the threshold is too low, there is less texture removal. If you go to a value of 100 or more for the threshold, the contour is deleted in addition to the unwanted texture.
4. EXPERIMENTAL RESULTS

This study uses OpenCV in Visual Studio 2013 on a Windows 7 environment. The following images show (a) the original image, (b) RGB color space to gray scale conversion with the results of a Sobel operator, (c) RGB color space after conversion to the HSV space and then applying a Sobel operator, (d) the proposed method ($\theta = 50$).

Figure 9 shows the images resulting from an experimental run, showing that for a simple image, the result provided by the proposed method (d) has detected more edges than that in the RGB color space (b).

Figure 10 shows that the (c) more edges and textures are detected for many unnecessary objects in the RGB color space converted into HSV, relative to that of a conventional RGB color space (b), but the proposed method (d) shows results with clearer edges and removal of unwanted textures.
Figure 11: Edge Detection Result of Toys Image (A) Original Image (B) Gray Scale using Sobel Operator (C) after the Split RGB using Sobel Operator (D) Proposed Method (θ=50)

Figure 11 shows many kinds of toys, and only a part of each toy is detected with a conventional RGB method, but the proposed method shows the removal of unnecessary textures and detects the edges of the toys.

Figure 12: Edge Detection Result of Flower Image (A) Original Image (B) Gray Scale using Sobel Operator (C) After the Split RGB using Sobel Operator (D) Proposed Method (θ=50)

Figure 12 shows the results of edge detection in an image of a flower. In a conventional RGB color space, detection is weak in the central part of the flower (b). On the other hand, the proposed algorithm (d) accurately detects the edges and removes unwanted textures.

5. CONCLUSIONS

This paper proposes a method for edge detection using the Sobel operator by first carrying out a conversion to the HSV color space to produce single H, S, V channels in order to improve upon the shortcomings of the loss of color in the RGB color space, which does not correspond with the sensitivity of the human eye. The results are first compared for each of the H, S, V channels, and H is shown to produce unnecessary blocking edge detection. The S channel can be used to remove the texture of the object using the proposed filter, so the S channel results are used after that. This process detects more edges than a single channel. Future research based on this algorithm is proposed to study its use in image processing techniques, such as object recognition and character recognition.

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REFERENCES


