Image Processing of Large-Scale Pollution on Water

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Abstract. In order to improve the monitoring of water surface environment, the image processing of large-scale water pollution is proposed. First, UAV was used to take aerial photos of the area to be cleaned on the water, and the obtained image was preprocessed with saturation enhancement, etc. Then the image was segmented into image segmentation or edge detection to distinguish the foreground from the background. This experiment used three widely used segmentation methods to process the selected aerial image. The three methods are: threshold segmentation, region-based segmentation and morphological gradient detection.

1. Introduction

In recent years, China has been attaching great importance to the water quality of rivers, lakes and seas, and strengthening the control of water pollution. However, if garbage cleaning vessels aimlessly search for garbage on the surface of the water, they will definitely increase the cost of manpower, money and fuel waste. If the approximate location of pollutants in this area can be known in advance before water surface cleaning, energy saving and cleaning efficiency can be achieved to a certain extent. However, our country has more than 24800 lakes alone, and the area of natural lakes in more than 1 square kilometers more than 2800, if artificial to detect pollutants position will be very costly power consumption, the proposed using the aerial drones for clean water, then put the figure obtained by aerial target recognition, after pollutants location for path planning. Image processing is required to distinguish the foreground from the background before target identification of a picture of medium or large contamination above water.

2. Principle analysis of each step

2.1 Saturation rise

After the drone system takes a picture of the water to be cleaned, it sends the image to a processor for processing. Saturation enhancement means increasing the color saturation in the HSL colour pattern. First, it is necessary to convert the RGB spatial image into HSL spatial image, assuming that “max.color” and “min.color” respectively represent the maximum and minimum value of RGB components in the RGB space. Use the following transformation formulas:

\[
H = \begin{cases} 
0^\circ & \text{max. color = min. color} \\
60^\circ \times \frac{G-B}{\text{max.color-min.color} + 0^\circ} & \text{max.color} = R \ G \geq B \\
60^\circ \times \frac{G-B}{\text{max.color-min.color} + 360^\circ} & \text{max.color} = R \ G < B \\
60^\circ \times \frac{B-R}{\text{max.color-min.color}} + 120^\circ & \text{max.color} = G \\
60^\circ \times \frac{B-R}{\text{max.color-min.color}} + 240^\circ & \text{max.color} = B 
\end{cases}
\]
\[ L = \frac{1}{2} (\text{max. color} + \text{min. color}) \] (2)

\[ S = \begin{cases} 
\frac{\text{max. color} - \text{min. color}}{\text{max. color} + \text{min. color}} & L < \frac{1}{2} \\
\frac{\text{max. color} - \text{min. color}}{2} & L > \frac{1}{2} \\
0 & \text{max. color} = \text{min. color}
\end{cases} \] (3)

Set the saturation increment to inc, ranging from -1 to 1, and calculate the adjustment factor applicable to RGB space for saturation adjustment. Here, we only consider the case of inc > 0, and select the adjustment basis according to the value of the sum of inc and S. When the sum value is greater than 1, the complement of s is taken as the adjustment basis (the larger the complement of s, the larger the adjustment). When the sum is less than 1, take “I” as the adjustment basis (the bigger “I” is, the bigger the adjustment). Finally, the RGB adjusted by saturation is verified. The value less than 0 is set as 0, and the value greater than 0 is set as 1.

2.2 Colour space reduction

Since the color of the top view of water garbage will be a little messy, it will take a lot of calculation to directly process the color information, so it is more convenient to extract and process the garbage area in the later stage by reducing the color components that are not significant to the extraction target. The principle of color space reduction is not complicated. The initial idea is to directly subtract, such as dividing the RGB value of each pixel in the existing color RGB space by an input value, so as to obtain a smaller number of colors. For example, if the color range is 0-5, the new value will be 0; if the color range is 6-10, the new value will be 6. However, it is worth noting that the color of the garbage area is not so regular to follow, so the scope of each reduction should not be too wide in the process of reduction, otherwise it is easy to cause image distortion and reduce the accuracy of image processing. Due to the mixed colors, dark and light, it is recommended to set the range as 4.

2.3 Image segmentation

The significance of sub-image segmentation is to distinguish the surface object from the surface background. At present, the traditional sub-image segmentation methods include threshold segmentation, region segmentation, edge segmentation and histogram segmentation.

2.3.1 Threshold segmentation. The key point of threshold segmentation is to determine the threshold. The mathematical significance of the threshold is shown in the Figure 1. The method of selecting threshold can consider the otsu method which theoretically has the lowest probability of misclassification, namely the maximum inter-class variance method. This method divides all pixels in the image into two categories: less than the threshold value and more than or equal to the threshold value. So the key is the selection of threshold. The principle is that for image K, mark M as the segmentation threshold between the object area and the background, the proportion of the number of points in the object area in the whole image is e0, and the average gray level is i0. The proportion of background points in the whole image is e1, and the average gray scale is i1. Traverse M from the minimum gray value imin to the maximum gray value imax, and calculate the variance value as follows:

\[ \delta = e_0 * e_1 * (i_0 - i_1) * (i_0 - i_1) \] (4)

When \( \delta \) is at its maximum, M is the optimal threshold. After the threshold is determined, the threshold value is compared with the gray value of the pixel point one by one, and the final result is directly the image area of the water object we need.
2.3.2 Region segmentation. Region segmentation can be based on region growth. Region growth is the process of aggregating pixels or subregions into larger regions according to predefined criteria. The key to this method is to select the right seeds and growth criteria. The algorithm considers the region growth method based on the similarity of image gray value. The design idea of the algorithm is to first create a blank image (full black) and define the maximum gray value distance variable as \( r_{\text{max dist}} \). When the absolute value of the difference between the gray value of the pixel to be added and the average gray value of all the pixel points in the segmented region is less than or equal to \( r_{\text{max dist}} \), the point is added to the segmented region, and otherwise, the core region stops growing. In the process of region growth, it is necessary to know the number of pixel points to be analyzed (that is, pixel coordinates), as well as their corresponding gray value. The rules of growth are divided into four domain relations and eight domain relations. An example of region growth is shown in the Figure 2.

The steps of the region growth algorithm for the eight domains are as follows:

- Scan the image sequentially to find the first pixel \((x_0, y_0)\) that does not belong as the seed.
- Find the seed pixel eight field pixel point, and judge whether it meets the growth rules, meet the seed will be divided into a region, and pressed into the stack.
- When the stack is not empty, take out the stack top elements from the stack and repeat the step, on the contrary, return the step.
- Repeat the above steps until each pixel is assigned.

\[
\begin{array}{cccc}
5 & 5 & 8 & 6 \\
4 & 8 & 9 & 7 \\
2 & 8 & 8 & 3 \\
3 & 7 & 3 & 3 \\
\end{array}
\quad
\begin{array}{cccc}
5 & 5 & 8 & 6 \\
4 & 8 & 9 & 7 \\
2 & 8 & 8 & 3 \\
3 & 7 & 3 & 3 \\
\end{array}
\]

Figure 2. An example of growth from 9.

2.3.3 Edge segmentation. Edge segmentation can consider morphological gradient detection to draw the contour range of the object region. In image processing, the difference between the expanded image and the corroded image is defined as morphological gradient in order to highlight the sharp transition region of gray scale in the image. The mathematical relationship is as follows:

\[
Dst = \text{morph\_grad}(src, element) \tag{5}
\]

\[
Dst = \text{dilate}(src, element) - \text{erode}(src, element) \tag{6}
\]

In the gradient operator, the etching operation is used to filter out the bright details smaller than the structural elements in the image while keeping the overall gray level and the large bright area of the image basically unaffected. In the final output image, the maximum variation of grayscale intensity in the domain defined by corresponding structural elements instead of local transition region is grayscale value, so the image is equivalent to the gradient of a function. At the end of the day, morphological
gradient detection ultimately describes the edge of gray, highlighting the periphery of the highlight area.

3. Results
The experimental original diagram and the results obtained by using three segmentation methods are shown in Figure 3.

![Figure 3. Original diagram and result images. (left one: the original image; left two: the image of morphological gradient; right one: the image of Otsu algorithm; right two: the image of Region growing)](image)

4. Discussion
The comparison of the three figures shows that the most intuitive feeling is that the segmentation method based on region growth has the least uneven degree of light, which is mainly because the selection of seeds is determined according to similarity. The other two methods have obvious areas of light. However, for the top view of the water, it is inevitable to have uneven illumination. To minimize this effect, consider filtering the image before the colour space reduction operation. It has also been found that morphological gradient detection can really well express the details of colour changes. However, it is still recommended to use the segmentation method based on region growth for such maps that are susceptible to light distribution. And for this kind of material colour relatively rich image, using threshold segmentation method is not good.

5. Conclusions
In this experiment, three kinds of traditional image processing were carried out on the aerial images of water surface with large pollutants. The results are different and have their own advantages and disadvantages. Considering that the aerial images of water surface are seriously affected by light, the recommended method is image segmentation based on area growth method. In fact, this experiment is only a single study of the edge features of the surface map containing pollutants. As most of the pollutants have irregular shapes, it is also a way to study their color features.

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