Application research of denoising and super pixel algorithm in image processing

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Abstract. With the popularization and development of science and technology, mobile phone, tablet and computer has become the necessities of people, whether work or life, the emergence of science and technology, development and rich brought a whole new world for human civilization, including electronic information in time and space communication provides convenient conditions for people, especially the image processing technology, in the life is very broad. At present, smart phones have become extremely common, and users have a huge demand for images. Every link is inseparable from the formation, acquisition, transmission and acceptance of images. However, in every link, images will be more or less polluted by noise, resulting in users’ inability to obtain the desired image effect. However, if the noise is directly optimized or removed, the accuracy of the image will be affected. Therefore, the advanced noise removal technology plays a crucial role in the efficient use of the image. Image superpixel is to gather pixels with similar attributes into a region to represent the image instead of pixels, so as to reduce the order of magnitude of the image atomic structure and further reduce the complexity of the subsequent image processing algorithm, which provides the possibility for the real-time performance of the image processing algorithm.

1. Introduction
Vision is one of the most important ways for human beings to obtain information. It contains more than 70% of all information obtained by human beings. Images are more vivid than words and are the basis of vision. After receiving the image data, the human brain processes, processes and analyzes the data to extract the information it needs. The process of extracting information from an image is actually complicated because the human brain is so exquisitely constructed. With the progress of science and technology and the development of society, human beings have invented computers to help accomplish some tasks. Digital image processing is the process that the computer tries to simulate the human brain to obtain the required information from the
image data. In a broad sense, digital image processing includes all image manipulation techniques, which can also be collectively referred to as image engineering [1.2].

Image denoising and super pixel generation are basic problems in the field of image processing, but they are also very important tasks. The purpose of image denoising is to remove noise interference, improve the visual effect of the image, make the image can accurately transmit information and meet the needs of subsequent image processing applications, such as segmentation and super pixel generation, so as to ensure its accuracy. The goal of image superpixel generation is to aggregate pixels into several regions that do not overlap each other and can maintain the original structural characteristics of the image, so as to replace pixel points as the basic atoms to represent the image and reduce the time complexity of subsequent image processing tasks. After de-noising operation and generation of super pixels, the image processing and analysis tasks can not only be protected from noise, but also reduce the complexity of the algorithm, and is conducive to improving the effect of the algorithm. According to figure 1.1 in front of the sample and analysis it can be seen that the existence of the noise generated directly affects the super pixel accuracy, in order to accurate segmentation of noise images, on the one hand to deal with the noise of image, on the other hand can combine image denoising algorithm study design has the noise pixel generation algorithm. Although there are many related literatures on image denoising and super pixel generation, there are still some problems in the algorithm, and the effect still needs to be further improved, more exploration and discovery are needed.

2. Image denoising

2.1. Overview of image denoising

In the process of image acquisition and transmission, it will be affected by equipment and external factors, and noise will be introduced to pollute the image signal. Denoising is a classical and basic problem in image processing and analysis. Common image noises include salt and pepper Noise and Gaussian Noise (AWGN) of Additive White. This paper focuses on salt and pepper noise. Salt-pepper noise, also known as impulse noise, reduces the image quality by randomly changing the color or brightness value of pixels in the image to the maximum or minimum. It is assumed that the level of pepper and salt noise is \( s, s \in [0,1] \), pixel \( x \), the probability of \( 1-s \) remains unchanged with its true color value \( I(x) \), and the probability of \( s/2 \) each becomes the maximum value \( d_{max} \) or the minimum value \( d_{min} \), and its mathematical expression is as follows[3]:

\[
I(x) = \begin{cases} 
  d_{min}, & s/2 \\
  d_{max}, & s/2 \\
  I(x), & (1-s)
\end{cases}
\]  

(1)

To generalize the image denoising model, it can be expressed as

\[
G = I + N
\]  

(2)

Where \( I \) is the clean image matrix without noise, \( N \) is the noise matrix, and \( G \) is the image matrix with noise observed. The purpose of image denoising is to remove the noise \( N \) from the noisy image \( G \) and obtain the denoised image \( I \) to make \( I \) most similar to the real image \( I \).
2.2. denoising algorithm
Existing image denoising algorithms can be generally divided into two categories, spatial domain method and transform domain method, according to the different basic objects. Image denoising algorithm in spatial domain is to process pixel points directly and separate the real signal from noise. Contrast, transform domain algorithm is to use some method of transform signal transformation to another domain, such as the frequency domain, and then according to the different characteristics of signal and noise in the transform domain to transform domain coefficient, finally, inverse transform to the image spatial domain, and the image denoising after, achieve the goal of denoising. Commonly used transforms include Fourier transform, wavelet transform, etc. [4]

2.3. Common test data of denoising algorithm
Whether the image processing algorithm is designed successfully or not usually needs to be tested by many experiments. Only through comprehensive analysis of the experimental results can a reasonable and credible conclusion be obtained. In the process of algorithm testing, open data sets are generally adopted. Common image denoising test images are shown in figure 2 and figure 3.

2.4. Evaluation criteria of denoising algorithm
The evaluation methods of denoising algorithm can be divided into subjective method and objective
method. The subjective evaluation method is to perceive the visual effect of the results processed by the algorithm with human eyes, and measure whether the algorithm meets the expectation, removes the noise, causes the blur and so on. Obviously, the subjective evaluation of the results is closely related to the evaluator himself, and the evaluation conclusions obtained by different observers may vary greatly. Therefore, purely subjective evaluation can not be qualitative for algorithm performance[5].

In order to evaluate the denoising algorithm objectively, scholars put forward some quantitative criteria in an attempt to accurately describe the perception effect of vision on image results. Evaluation indexes of common denoising algorithms include Peak signal-to-noise Ratio (PSNR) and Structure Similarity Index Measurement SSIM [6].

3. Image super-pixel generation algorithm

One of the most difficult tasks in the field of image processing is image segmentation. So-called image segmentation is to given an input image, on the basis of all color, gray scale, shape and texture feature information is divided into a number of mutually disjoint and can cover the entire image area, and makes all pixels in each small region with same or similar characteristics, and in any two have the obvious difference between different areas. One of the most important steps from image processing to image analysis is image segmentation. Image over-segmentation is a kind of image segmentation technology. The difference lies in that the image over-segmentation is to divide an input image into more non-overlapping areas of smaller size, and each small area is called super pixel. In other words, the process of image super pixel generation is to combine adjacent pixels together to form a region according to the characteristic information such as grayscale, texture, color and shape, so as to make the features of pixels within the region consistent and the pixels contained in any two different regions have obvious differences. If the input image is set as I and the number of pixels it contains is N, then the hyper-pixel generated by over-segmentation can be expressed as:

\[ I = \{ S_j \mid S_j \cap S_i = \emptyset, i \neq j \}, (i, j = 1, 2, \ldots, K) \]  

Where K is the number of superpixels, \( S_j \) and \( S_i \) represent the Jth and ith superpixels respectively. One of the most important properties of an ideal hyperpixel segmentation is that it fits well into the image edges.

4. Common test database for super pixel generation algorithm

Research and design of a new algorithm, always through the test before its performance, to determine whether the algorithm is available, effective. For image Segmentation algorithm, this paper used in The test database is also commonly used data sets is by The United States, Berkeley public image Segmentation of The computer vision and Benchmark data sets (The Berkeley Segmentation Dataset and Benchmark, BSD) The test data set is The Berkeley computer vision for image Segmentation and edge detection of The institute to provide The testing image set and its Benchmark. It contains a total of 500 natural images, of which the test set contains 20. , 200 images are contained in training set, and 100 images are contained in val set.

Figure 4 shows an example of an image in BSD. There are two sizes of images in the data set, the first one as shown in the first line of figure 4 with a size of 481 x 321, and the second one as shown in the second line of figure 4 with a size of 321 x 4810.

In order to provide a reliable comparison benchmark for algorithm comparison, each image in the database is manually marked by five different individuals on the boundary, and the results are averaged as the boundary benchmark for algorithm evaluation. At the same time, the database also provides a color segmentation benchmark. Each region is displayed with a color. The segmentation benchmark of the image in figure 4 is shown in figure 5. For the boundary, binary images are used to display the database. White pixels represent the marked boundary, and the boundary reference of the image in FIG. 4 is shown in FIG. 6.
5. Evaluation criteria of super pixel generation algorithm

Image is the main form of visual presentation, so for almost all image processing algorithms, visual effect as a subjective evaluation standard has very important significance. For the same image, different individuals will have different visual perception effects, so the visual evaluation mechanism has strong subjectivity, which generally requires more tests to obtain relatively reliable evaluation results. Therefore, vision can be used as a reference for the evaluation of image processing algorithm results, but it is not all. An objective evaluation standard is needed to give a quantitative evaluation result for the algorithm. In order to objectively evaluate the image superpixel generation algorithm, scholars have proposed several quantitative criteria to accurately describe the visual perception of image results. The
commonly used image pixel generation algorithm of evaluation criteria are: Boundary Recall rate (a Boundary Recall BR), Under Segmentation rate (Under Segmentation Error USE) Segmentation Accuracy (Achievable Segmentation Accuracy, ASA) and Compactness (Compactness COM).

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6. Conclusion
In the aspect of image denoising, the characteristics of each method are analyzed from local method and non-local method. The non-local similarity denoising method is relatively effective, but similar block matching is needed, and the computational complexity of this process is relatively high. In the aspect of super pixel generation, several commonly used image segmentation test data sets are also introduced. One of the most important properties of superpixels is to fit the image boundary as well as the compactness of superpixels. However, the opposition between the two makes it necessary to find a balance between them. For the input image and video signal, the noise must be removed before accurate super pixel generation and subsequent image processing.

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