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STUDYING HOW TO USE WAVELET TRANSFORMS IN DIGITAL MEDIA IMAGE PROCESSING

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Abstract:

In an era dominated by informatization, the abundance of information is ever-increasing. Images, serving as a fundamental medium for human perception and information dissemination, play a vital role in conveying and interpreting information. The development of digital image processing, the computerized manipulation of images, has a rich history dating back to the 1920s when digital compression technology was employed to transmit photos across continents. Digital image processing technology offers a means to enhance our understanding of the world objectively and accurately. While the human visual system is remarkably adept at extracting information, it is limited by its ability to perceive and interpret visual data. Image enhancement technology rectifies this limitation by rendering previously blurred or obscured images into sharp clarity. This field has garnered significant research, with promising results affirming the feasibility of related endeavors.

Recognizing the pivotal role of image processing technology, researchers have embarked on extensive investigations, yielding fruitful outcomes. However, the current trend in research leans towards delving deeper into the complexities of image processing technology. Yet, the application of image processing is a holistic endeavor, necessitating both depth and systematic considerations. Consequently, an integrated model encompassing various aspects of image application stands to bolster the utilization of image processing technology. Wavelet transform, a versatile technique, has found successful applications across a spectrum of image processing domains. This paper, therefore, introduces a unified model based on wavelet transform. Through simulations involving filtering, watermarking, encryption, decryption, and image compression, this model demonstrates commendable efficacy, highlighting its potential for practical implementation.

Introduction:

With the increase of computer processing power, people use computer processing objects to slowly shift from characters to images. According to statistics, today's in- formation, especially Internet information, transmits and stores more than 80% of the information. Compared with the information of the character type, the image in-formation is much more complicated, so it is more complicated to process the characters on the computer than the image processing.

Therefore, in order to make the use of image information safer and more convenient, it is particularly important to carry out related application research on image digital media. Digital media image processing technology mainly includes denoising,en- cryption,compression, storage, and many other aspects.

The purpose of image denoising is to remove the noise of the natural frequency in the image to achieve the characteristics of highlighting the meaning of the image itself. Because of the image acquisition, processing, etc., they will damage the original signal of the image. Noise is an important factor that interferes with the clarity of an image.

This source of noise is varied and is mainly derived from the transmission process and the quantization process. According to the relationship between noise and signal, noise can be divided into additive noise, multiplicative noise, and quantization noise. In image noise removal, commonly used methods include a mean filter method, an adaptive Wiener filter method, a median filter, and a wave-let transform method.

For example, in the literature this method is used for image denoising, and good denoising results are obtained. Median filtering is a commonly used nonlinear smoothing filter that is very effective in filtering out the salt and pepper noise of an image. The median filter can both remove noise and protect the edges of the image for a satisfactory recovery. In the actual operation process, the statistical characteristics of the image are not needed, which brings a lot of convenience.

Image encryption is another important application area of digital image processing technology, mainly including two aspects: digital watermarking and image encryption. Digital watermarking technology directly embeds some identification information (that is, digital watermark) into digital carriers (including multimedia, documents, soft- ware, etc.), but does not affect the use value of the original carrier, and is not easily perceived or noticed by a human perception system (such as a visual or auditory system).

Through the information hidden in the carrier, it is possible to confirm the content creator, the purchaser, transmit the secret information, or determine whether the carrier has been tampered with. Digital watermarking is an important research direction of information hiding technology.

For example, the literature is the result of studying the image digital watermarking method. In terms of digital watermarking, some researchers have tried to use wavelet method to study. For example, AH Paquet and others used wavelet packet to carry out digital watermark personal authentication in 2003, and successfully introduced wavelet theory into digital water- mark research, which opened up a new idea for image- based digital watermarking technology. In order to achieve digital image secrecy, in practice, the two-dimensional image is generally converted into one-dimensional data, and then encrypted by a conventional encryption algorithm. Unlike ordinary text information, images and videos are temporal, spatial, visually perceptible, and lossy compression is also possible. These features make it possible to design more efficient and secure encryption algorithms for images. For example, Z Wen and others use the key value to generate real-value chaotic sequences, and then use the image scrambling method in the space to encrypt the image. The experimental results show that the technology is effective and safe. YY Wanget al. proposed a new optical image encryption method using binary Fourier transform computer generated hologram

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(CGH) and pixel scrambling technology. In this method, the order of pixel scrambling and the encrypted image are used as keys for decrypting the original image. Zhang X Yet al. combined the mathematical principle of two-dimensional cellular automata (CA) with image encryption technology and proposed a new image encryption algorithm. The image encryption algorithm is convenient to implement, has good security, large key amount, goodavalanche effect, high degree of confusion, diffusion characteristics, simple operation, low computational complexity, and high speed.

In order to realize the transmission of image information quickly, image compression is also a research direction of image application technology. The information age has brought about an "information explosion" that has led to an increase in the amount of data, so that data needs to be effectively compressed regardless of transmission or storage. For example, in remote sensing technology, space probes use compression coding technology to send huge amounts of information back to the ground. Image compression is the application of data compression technology on digital images. The purpose of image com- pression is to reduce redundant information in image data and store and transmit data in a more efficient format. Through the unremitting efforts of researchers, image compression technology is now maturing. For example, Lewis A S hierarchically encodes the transformed co- efficients, and designs a new image compression method based on the local estimation noise sensitivity of the human visual system (HVS). The algorithm can be easily mapped to 2-D orthogonal wavelet.

Devore A introduced a novel theory to analyze image compression methods based on wave- let decomposition compression. Buccigrossi R W developed a probabilistic model of natural images based on empirical observations of statistical data in thewavelet transform domain. The wavelet coefficient pairs of the basis functions corresponding to adjacent spatial locations, directions, and scales are found to be non- Gaussian in their edges and joint statistical properties.

They proposed a Markov model that uses linear predictors to interpret these dependencies, where amplitude is combined with multiplicative and additive uncer- tainty and indicates that it can interpret statistical data for various images, including photographic images, graphic images, and medical images. In order to directly prove the efficacy of the model, an image encoder called Embedded Prediction Wavelet Image Coder (EPWIC) was con- structed in their research. The subband coefficients use a non-adaptive arithmetic coder to encode a bit plane at a time. The encoder uses the conditional probability calculated from the model to sort the bit plane using a greedy algorithm. The algorithm considers the MSE re- duction for each coded bit. The decoder uses a statis- tical model to predict coefficient values based on the bits it has received.

Method:

1. Image binarization processing method

The gray value of the point of the image ranges from 0 to 255. In the image processing, in order to facilitate the further processing of the image, the frame of the image is first highlighted by the method of binarization. The so-called binarization is to map the point gray value of the image from the value

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space of 0–255 to the value of 0 or 255. In the process of binarization, threshold selection is a key step.The threshold used in this paper is the maximum between-class variance method (OTSU). The so-called maximum inter-class variance method means that for an image, when the segmentation threshold of the current scene and the background is *t*, the pre-at- traction image ratio is w0, the mean value is u0, the background point is the image ratio w1, and the mean value is u1. Then the mean of the entire image is:

2. **Wavelet transform method**

Wavelet transform (WT) is a research result of the development of Fourier transform technology, and the Fourier transform is only transformed into different fre- quencies. The wavelet transform not only has the local characteristics of the Fourier transform but also contains the transform frequency result. The advantage of not changing with the size of the

Spatial domain approach:

A typical watermarking algo- rithm in this type of algorithm embeds information into the least significant bits (LSB) of randomly selected image points, which ensures that the embedded watermark is in- visible. However, due to the use of pixel bits whose images are not important, the robustness of the algorithm is poor, and the watermark information is easily destroyed by filtering, image quantization, and geometric deformation operations. Another common method is to use the statis- tical characteristics of the pixels to embed the information in the luminance values of the pixels.

The method of transforming the domain: first calculate the discrete cosine transform (DCT) of the image, and then superimpose the watermark on the

window. Therefore, com- pared with the Fourier transform, the wavelet transform is more in line with the time-frequency transform. The biggest characteristic of the wavelet transform is that itcan better represent the local features of certain features with frequency, and the scale of the wavelet transform can be different. The low-frequency and high-frequency division of the signal makes the feature more focused.This paper mainly uses wavelet transform to analyze the image in different frequency bands to achieve the effect of frequency analysis. The

Method of wavelet transform can be expressed as follows:

According to different methods of use, digital watermark ing technology can be divided into the following types:

front *k* coefficient with the largest amplitude in the DCT domain (excluding the DC component), usually the low-frequency component of the image. If the first *k* largest components of the DCT coefficients are represented as $D =i = 1, ..., \mathrm{k}$, and the watermark is a random real sequence $W =, i = 1, ..., k$ obeying the Gaussian distribution, then the watermark embedding algorithm is di = di(1 + awi), where the constant a is a scale factor that controls the strength of the watermark addition. The watermark image I is then obtained by inverse transforming with a new coefficient. The decoding function calculates the discrete cosine transform of the original image I and the watermark image I^*, respectively, and extracts the embedded watermark W^*, and then performs correlation test to determine the presenceor absence of the watermark.

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Compressed domain algorithm:

The compressed domain digital watermarking system based on JPEG and MPEG standards not only saves a lot of complete decoding and re-encoding process but also has great practical value in digital TV broadcasting and video on demand (VOD). Cor- number of decomposition layers, and K can be represented by H, V, and D, respectively, representing the horizontal, vertical, and diagonal subgraphs. Because the sub-picture distortion of the low frequency is large, the picture embedded in the watermark is removed from the picture outside the low.

According to whether TD and w_i are the same, the calculation of the quantized wavelet coefficient $D(i, j)'$ can be as follows:

However, the filtered image does not change significantly compared to the original image. The normalized mean square error before and after filtering is calculated, and the M value before and after filtering is 0.0071. The wavelet transform is well protected to protect the image details, and the noise data is better removed (the white noise is 20%).

As shown in Fig. 2, the watermark encryption process based on wavelet transform can be seen from the figure. Watermarking the image by wavelet transform does not affect the structure of the original image. The noise is 40% of the salt and pepper noise. For the original image and the noise map, the wavelet transform method canextract the watermark well.

According to the method described in this paper, the image correlation coefficient and peak-to-noise ratio of the original image after watermarking are calculated. The correlation coefficient between the original image and the watermark is 0.9871 (the first column and the third column in the first row in the figure). The water- mark does not destroy the structure of the original image. The signal-to-noise ratio of the original picture is 33.5 dB, and the signal-to-noise ratio of the water-jet printing is 31.58SdB, which proves that the wavelet trans- form can achieve watermark hiding well. From the second row of watermarking results, the watermark extracted from the image after noise and denoising, and the original watermark correlation coefficient are (0.9745, 0.9652).

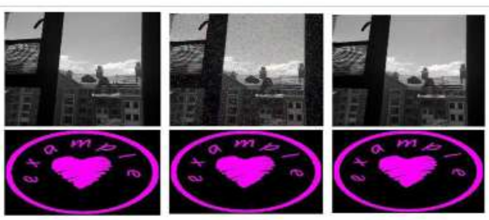
Results 3: image encryption based on wavelet transform

In image transmission, the most common way to protect image content is to encrypt the image. Figure 3 shows the process of encrypting and decrypting an image using wavelet transform. It can be seen from the figure that after the image is encrypted, there is no correlation with the original image at all, but the decrypted image of the encrypted image reproduces the original image.

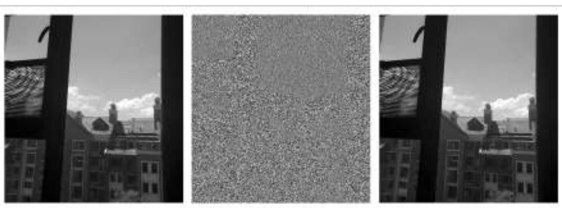
The information entropy of Fig. 3 is calculated. The results show that the information entropy of the original image is 3.05, the information entropy of the decrypted graph is 3.07, and the information entropy of the encrypted graph is 7.88. It can be seen from the resultsof information entropy that before and after encryption. The image information entropy is basically unchanged, but the information entropy of the encrypted image data can be compressed because of the redundancy in the data.

The redundancy of image data mainly manifests as spatial redundancy caused by correlation between adjacent pixels in an image; time redundancy due to correlation between different frames in an image sequence; spectral redundancy due to correlation of different color planes or spectral bands. The purpose of data compression is to reduce the number of bits re- quired to represent the data by removing these data redundancy. Since the amount of image data is huge, it is very difficult to store, transfer, and process, so the compression of image data is very important.

Figure 4 shows the result of two compressions of the original image. It can be seen from the figure that although the image is compressed, the main frame of the image does not change, but the image sharpness is significantly reduced. The Table 1 shows the compressed image properties



Results 2: digital watermark encryption based on wavelet transform



It can be seen from the results in Table 1 that after multiple compressions, the size of the image is significantly reduced and the image is getting smaller and smaller. The original image needs 2,764,800 bytes, which is reduced to 703,009 after a compression, which is reduced by 74.5%. After the second compression, only 182,161 is left, which is 74.1% lower. It can be seen that the wavelet transform can achieve image compression well.

Result 4: image compression

Conclusion:

With the development of informatization, today's era isan era full of information. As the visual basis of human perception of the world, image is an important means for humans to obtain information, express information,and transmit information. Digital image processing, that is, processing images with a computer, has a long history of development. Digital image processing technology originated in the 1920s, when a photo was transmitted from London, England to New York, via a submarine cable, using digital compression technology. First of all, digital image processing technology can help people understand the world more objectively and accurately. The human visual system can help humans get more than 3/4 of the information from the outside world, and images and graphics are the carriers of all visual information, despite the identification of the human eye. It is very powerful and can recognize thousands of colors, but

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in many cases, the image is blurred or even invisible to the human eye. Image enhancement technology can make the blurred or even invisible image clear and bright. There are also some relevant research results on this aspect of research, which proves that relevant re-search is feasible.

It is precisely because of the importance of image processing technology that many researchers have begun re- search on image processing technology and achieved fruitful results. However, with the deepening of image processing technology research, today's research has a tendency to develop in depth, and this depth is an in- depth aspect of image processing technology. However, the application of image processing technology is a system engineering. In addition to the deep requirements, there are also systematic requirements. Therefore, if the unified model research on multiple aspects of image application will undoubtedly promote the application of image processing technology. Wavelet transform has been successfully applied in many fields of image processing technology. Therefore, this paper uses wavelet transform as a method to establish a unified model based on wavelet transform. Simulation research is carried out by filtering, watermark hiding, encryption and decryption, and image compression of image processing technology. The results show that the model has achieved good results.

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