

The Application of Image Compression Technology in Library

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Abstract—With the rapid development of information technology, more and more digital and electronic literature resources, including image compression technology, are widely used. This paper compares several kinds of image compression technology commonly used in library and finds that JPEG2000 as digital image storage format is more suitable for library image processing and storage.

Keywords—Image compression technology; Library

I. INTRODUCTION

It is well-known that one of the library's basic functions is to collect and store the literature information and books. The degree of electronic resources in the library is improved, and more and more paper books are digital and electronic at the present stage. The image compression technology has been widely applied in the storage and transmission process of digital resources. The compression of image data into library electronic books for storage is an important research topic. Specifically, the purpose of data compression is to reduce the redundant information in the original data so as to store and transmit the data by a more compact and more efficient method. In the digital resources of libraries, the electronic books are in the form of full-text scanned image. However, the scanned version of electronic book images as common data may experience distortion or information loss in the processing and storage process. Based on this, how to effectively store the scanned electronic books without distortion is an important research topic. We know that compressed images can be reconstructed. If the reconstructed image is completely identical to the original image, the compression is deemed as lossless compression. If partial information of the original image is lost in the reconstructed image, the compression is deemed as lossy compression [1].

In the actual application, image compression has four advantages as follows.

Firstly, image compression has higher economic value, and it can save a lot of storage space in the aspect of data storage. It also saves a lot of transmission bandwidth and time.

Secondly, the data volume to be processed is greatly reduced due to the reduction of stored information, thus the processing efficiency of images can be greatly improved.

What's more, the massive original data will greatly increase the probability of errors in the transmission process,

thus the image compression will greatly improve the correctness and stability of data transmission.

To a certain extent, image compression is beneficial to information privacy because the data will be coded in the compression process.

In order to solve the storage problem of digital image resources in the library, this article briefly introduces the theoretical basis of image compression. Then it delivers an analysis of commonly used image compression technologies at the present stage. Finally it presents the JPEG2000 format as the solution to the long-term storage of digital image resources.

II. THEORETICAL BASIS (WHY IMAGES CAN BE COMPRESSED)

The purpose of image compression is to express the original image with less information, i.e. to reduce the redundant information in the original image.

Data are used for representing information. If a certain quantity of information is represented in different data sizes by different methods, for the method in which more data sizes are used, some data certainly represents useless information or repeated information, known as data redundancy. Therefore, the redundant information in the image is the theoretical basis for the image compression. Specifically, the data in the original image include three kinds of redundant information: spatial redundancy, coding redundancy and visual redundancy [2]. We can realize the purpose of data compression by compressing one or more redundant information.

A. Spatial Redundancy

In one image, the adjacent pixels are not completely independent in a statistical sense. In other words, the value of one pixel has a strong correlation with that of surrounding pixels. If its carried information is relatively less or can be predicted based on the value of surrounding pixels, the visual contribution of these pixels is redundant. For example, we can store the value difference between adjacent pixels, rather than the original value, and the image stored in such form can be reconstructed without loss and the storage space can also be greatly reduced.

Literature identification number: A

B. Coding Redundancy

If the gray level of pixel value in an image is coded with coding symbols more than it really needs, the coding redundancy is included. We can effectively reduce the number of bits used for representing the gray level by different coding technologies based on the difference in the probability of different gray values. Therefore, the variable length coding can effectively utilize the statistical property of pixel values in the original image, and the original data can be represented with shorter characters and often reversible, and the common coding methods include Huffman coding, arithmetic coding, run coding, etc.

C. Visual Redundancy

Numerous experiments on the human visual system indicate that the sensitivities of eyes to all visual information are different. There are great differences in the relative importance of various information in the normal visual processing, thus some information is relatively unimportant to the visual cognition and deemed as the visual redundant information. The removal of the redundant information will not obviously reduce the image quality, but it can result in a certain quantity of information loss, and the process is generally called the quantification.

III. HOW TO CARRY OUT THE IMAGE COMPRESSION

For one 1920*1080 color image (including three color channels red, green and blue, each color occupies 8 bits, a total of 24 bits). The original image can be stored with about 5M (1920*1080*24) bytes, and it is very expensive in the storage and transmission of digital image resources. Therefore, the compression is necessary in order to reduce the image data. The image compression can be classified into lossless compression or lossy compression, depending on the information loss in the process of compression and decompression. For the lossless compression, because all the information of original image should be stored, its compression degree will be greatly limited (generally 3 to 4 multiples), but its reconstructed image is completely identical to the original data. For the lossy compression, 50 multiples or higher compression ratio can still be reached on the basis of maintaining the vast majority of visual information of the original image. For the storage of image resources, we can select the high compression ratio or high quality, based on the importance degree of image contents. For example, the precious historical video images, medical or legal images can be stored in the form of lossless compression.

A. Evaluation Index

The evaluation index of compression technology can contain three parts.

Firstly, the compression ratio, i.e. the size ratio of the original image to the compressed image.

Secondly, the quality of reproduction, the degree of deviation between the reconstructed image and original image:

(1)Root-mean-square error: root-mean-square error between the original image and reconstructed image

(2)Root-mean-square signal to noise ratio: root-mean-square ratio between the original image and noise signal

(3)Finally, the speed of compression and decompression reflects the operating efficiency of algorithm.

IV. LOSSLESS IMAGE COMPRESSION

In the practical application, the application scope of lossless compression [3] is relatively wide. For example, for the archiving of commercial files, the lossy compression cannot be accepted for legal reasons. For the storage of satellite images, the data loss is undesired due to its use mode and expenses incurred of data. For the medical image information, the information loss will affect the correctness of diagnosis. Therefore, the lossless compression technology is essential for the storage of digital image resources. For the redundant information in the original image, the lossless compression is mainly used for reducing the spatial redundancy and coding redundancy.

In the field of information science, the image compression process is also called the coding process [4], and the image reconstruction (decompression) process is also called the decoding process. Therefore, different compression technologies are also called different coding methods.

In order to reduce the coding redundancy in the original image, we can adopt different variable length coding method, such as Hoffman coding and arithmetic coding. The variable length coding will assign the shortest code word to the pixel value with the highest probability, thus greatly reducing the coding redundancy.

In order to reduce the spatial redundancy in the original image, we can adopt LZW coding, bit-plane coding and lossless predictive coding. LZW coding will establish a gray level table specific to the repeated gray level in the original data, and then replace the original data by the index representing the repeated gray level in the gray level table to eliminate spatial redundancy. The bit-plane coding will decompose one image into a series of binary images, and then compress these binary images. The lossless predictive coding can eliminate the spatial redundancy in the coding of pixels by extracting the new information contained in each pixel, because it is only needed to store the difference between the current value and the predicated value of pixel, the data space required for the image storage will be greatly reduced.

V. LOSSY IMAGE COMPRESSION

The losing compression can obtain the high compression ratio by sacrificing the correctness of reconstructed image, including the lossy predictive coding and transform coding [4].

The lossy predictive coding as one spatial method can directly operate the pixels in the image space. It predicts the current pixel value by the known pixel value, and codes the difference between the predicted value and actual value, including the differential pulse modulation prediction and self-adaptive differential pulse modulation prediction.

The transform coding as one frequency-domain method is one coding method based on the image transform. Specifically,

the transform coding maps the image into a group of transform coefficients by the reversible linear transform (such as Fourier transform, discrete cosine transform and wavelet transform), and then conducts the quantization and coding of these coefficients. Most coefficient values obtained from the image transform are very small, so it can be quantized roughly or ignored.

VI. LATEST IMAGE COMPRESSION TECHNOLOGY

The deep learning technology in the artificial intelligence (AI) field has obtained the substantial development in recent years [5], and it also has a profound influence on the researches relating to the computer vision. For the digital image, the most common coder is the neural network [6]. The automatic coder composed of the convolutional neural network and recurrent neural network has the outstanding performance in the feature expression of digital image, dimensionality reduction and generative model. Therefore, the neural network can generate a more flexible and efficient coder compared to the traditional image compression method, thus it can obtain better compression effect and more compact data representation in the digital image.

In recent years, the image compression methods based on the deep learning technology have obtained significant development. Firstly, in order to solve the training problem of neural network, [7] and [8] present a differentiable function to approximately calculate the information entropy and quantized value, thus realizing the end-to-end training and gradient spread of network. While [9] and [10] utilize the recurrent neural network of LSTM and binary neural layer to replace the quantization and coding process of data. [11] further improves the compression effect by compressing the energy density of data's characteristic pattern.

The traditional image compression method (such as JPEG) greatly depends on the prior knowledge of human and the manually designed coder / decoder utilizes the fixed transform matrix, therefore there are many restrictions, and meanwhile there is not enough flexibility and generalization ability. In contrast, the image compression method based on the deep learning can obtain better compression effect due to the stronger data coding ability and higher model complexity of neural network. Secondly, the image compression method based on the deep learning is strongly related to the data. Thus specific to the smaller data set, the method based on the deep learning can obtain a coder which is more targeted, so as to acquire more proper compression algorithm. While specific to the larger data set, the method can obtain stronger generalization ability due to a variety of training data. Finally, specific to the brand-new digital image resources (such as the virtual reality image shot by Virtual Reality, and 360° panoramic image), the method based on the deep learning can adapt new content and data type [11] more quickly.

VII. IMAGE COMPRESSION SCHEME

(1) Compared to the traditional image compression methods, the image compression method based on the deep learning can obtain the higher compression ratio and better image quality, but the method has some obvious defects and should not be used. Firstly, the image compression method based on the deep learning cannot realize the lossless compression, and the defect is unacceptable for the storage of many precious digital image resources. Secondly, the method requires a lot of training data and frequent training process in order to obtain the expected compression effect. Therefore, the compression and decompression processes of digital resources are relatively complex.

(2) JPEG is the abbreviation of Joint Photographic Experts Group, a committee engaged in the formulation of still image standards under the international standard organization. It formulated a set of international still image compression standard, i.e. ISO. 10918-1, i.e. JPEG. JPEG standard is selected as the international standard in 1992, and mainly applied in the image compression, and video frame compression coding technologies, and its core algorithm is based on changes in DCT. As the most common image storage and transmission format in the network and daily life at the present stage, it has obvious defects in the long-term storage of digital image resources [15]. Firstly, JPEG as one lossy data compression method cannot completely restore the original image, and therefore it has unacceptable weakness in the storage of precious digital images. Secondly, JPEG will attenuate the high-frequency component in the coding process to a certain extent, and therefore the image will appear serious mosaic distortion. Finally, because it utilizes the block coding method with the focus on the discrete cosine transform (DCT), there is still a space to further improve its compression ratio. These defects of JPEG become increasingly unable to satisfy more and more requirements for the multi-media image information, particularly, the proportion of electronic collection in each library is gradually increased, the reading and utilization of electronic books are also more and more acceptable by the vast majority of readers, and meanwhile the requirements for the quality of electronic books of readers are increasingly higher.

(3) Based on the above considerations, we put forward JPEG2000 as the storage format of digital images [16]. JPEG2000 Standard is the still image and video compression standard based on Discrete Wavelet Transform (DWT) published by JPEG (Joint Photographic Experts Group) in January 2001. JPEG2000 Standard gets rid of the traditional standard based on Discrete Cosine Transform (DCT). It uses the DWT-based still image compression standard, and it has the time-domain and frequency-domain "variable focal distance" property, symmetric compression and decompression, easy frame edition, three compression modes i.e. the lossless compression, lossy compression and ROI compression, strong fault-tolerant ability, high compression ratio and other features. [12]

Compared to JPEG, JPEG2000 uses the DWT-based multi-resolution coding method, and it has the following advantages [13-15]:

Firstly, JPEG only supports the lossy compression, while JPEG2000 can support the lossy and lossless compressions, and it can store the image information without the loss of original information, with the focus on the smaller image size. Therefore, it has huge advantages in the storage of precious digital images, particularly the digital storage of ancient books and good editions.

Secondly, JPEG2000 can support the progressive compression and storage, and the progressive transmission function can be realized by the spatial position and image component except the image precision and resolution, a total of four dimensions. Namely, the image contour is firstly transmitted and stored, then the details are gradually filled to constantly improve the image quality to make the image gradually become clear from fuzzy, in such case, the limited bandwidth can be fully applied and saved.

Additionally, JPEG2000 can designate the compression quality of different regions, define the important image region as ROI, and adjust the quality of the decoded image in the space domain. We can select the compression ratios for different regions based on our reading need and storage requirements, namely, we can remain more details in the important region, and we can increase the compression ratio of other regions.

Finally, JPEG2000 uses new data coding method, i.e. discrete wavelet transform, it has super compression property from high to low bit rate, and the distortion is shown in the form of image "slowness". Therefore, it can obtain the higher compression ratio and image quality, and its compression ratio can be increased by 30% compared to JPEG.

(4) Defects of JPEG2000: Firstly, the coding computation of JPEG2000 is obviously more complex than JPEG, its software realization is certainly difficult. In fact, although the coding efficiency of JPEG2000 is higher than JPEG, its increased calculating and processing capacity correspondingly exceeds the capacity increased by the coding efficiency. In such a case, it is a new challenge for the library technicians to meet the various conditions and requirements by a single method.

Secondly, the lossless image compression performance of JPEG2000 is relatively poor compared to JPEG-LS, and the JPEG-LS algorithm is relatively simple, and the near-lossless compression mode is more attractive at higher bit rate and in the application that the maximum margin of error specified in the article is needed. While JPEG2000 is greatly improved in the aspect of irreversible compression performance, it supports the highly scalable code stream, it embeds the lossy and lossless representation in the same stream, and it has the scalable resolution, random spatial access, compressed-domain shearing and many other properties absent in JPEG-LS [18].

VIII. CONCLUSION

In conclusion, the JPEG2000 stated in the article has higher compression ratio and image quality, and it shows obvious advantages in the scalable and editable capacity compared to the commonly used JPEG at the present stage. Compared to the image compression technology based on the deep learning, it can support the lossless and lossy compression modes, and its data processing and efficiency are even better. Therefore, JPEG2000 is put forward as the technical scheme for the processing and long-term storage of digital image resources.

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