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Based on 4 d matrix of discrete cosine transform remote education video compression technology research

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ABSTRACT

Distance education is a new teaching technology strictly, the development of this technology to the development of education provides more power, and in the process of the technical implementation faces the problems of slow video transmission and archive material, if it is able to seek an effective algorithm for video compression coding, can mitigate the problem to a certain extent. In this paper, aim at the characteristic of video image sequence is studied, using the discrete cosine transform of four-dimensional matrix algorithm for video image file compression coding, in the process of research this paper in view of the definition of the four-dimensional matrix and the algorithms are expounded, and then discusses the four dimensional matrix math algorithm of the cosine transform and involved in the process of video coding compression algorithm, the use of video coding compression algorithm described in this paper in DSP evaluation data. Data shows that: based on 4 d matrix of discrete cosine transform video compression algorithm has obvious superiority than the rest of the algorithm, algorithm for video coding theory to provide technical support for the implementation of remote education.

KEYWORDS

Four dimensional matrix; Cosine transformation; Coding and decoding; DSP simulation data.

INTRODUCTION

Modern distance education is based on digital satellite transmission and computer network, use a variety of media resources and means to form to adapt to the students' individualized learning is the combination of xinhua form of education, ministry of education has will develop modern distance education as a means of constructing the system of 21st century life-long learning, as do good education under the condition of the shortage of education resources in our country's strategic measures to strengthen the construction, distance education, with its wide audience, low cost, and is not affected by the teachers and schools educational infrastructure conditions, easy to carry out high level teaching, the teaching quality is relatively easy to guarantee the characteristics such as widely promoted by the education[1]. With the development of the Internet, the network remote education has penetrated into all fields, provides learners with many convenient conditions of learning, in order to be able to make the network remote education to serve the people better, remote education, the author of this paper to study the video compression encoding and decoding, in order to through the research for the remote education video to contribute to the improvement of transmission speed and storage materials to reduce.

Video file there are two basic standard for evaluating the merits of the compression algorithm is the compression ratio, the other one is the peak signal to noise ratio, with the development of digital video files, the compression algorithm for continuous development, and towards more quickly and take up the space is smaller in the direction of development, remote education, the author of this paper video file compression encoding and decoding process are studied, using the four-dimensional matrix is discrete cosine transform and fan algorithm to deal with the change, in order to explore more convenient compression coding method.

Study of distance education and video compression of the efforts of many people, it is these people trying to make the development of distance education to more quickly, make video compression algorithm is more convenient to adapt to the network transmission and archive. For remote education research are: dalian university chang-qing ji in the remote education mode based on mobile and computation research, in-depth discussion of the nature and main application of mobile learning and cloud services, combining the actual situation of the remote teaching, puts forward to the next generation network technology such as mobile computing, cloud computing is introduced into the remote education in the construction of teaching resources, to set up the new teaching mode of mobile cloud computing, and actively explore the mobile learning in distance education personnel, integration, network mode of[2]; South China normal university network education institute of lu and Yan in the remote education video conference application case study "in the video conference system are analyzed in the academic education and non-academic training application effects of the difference, put forward the video conference system on application, its USES the model of" classroom "[3]. For the research of video compression has: sherry Chen went of information engineering college of communication university of China in the distributed video coding, this paper introduces the theoretical basis and application of distributed video coding method, this paper briefly introduces the current research direction and research achievements in the field of distributed video coding[4]. China shipbuilding industry corporation, jiangsu institute of automation of xu, etc in the wavelet transform in the application of the radar video compression for engineering applications in radar and difficulty in real-time transmission of video data, analyzed the radar video data redundancy of information related to the signal characteristics, puts forward a radar video data compression algorithm based on wavelet transform, the algorithm to the actual collection of a certain type of radar video data compression and decompression process, the results show that the algorithm has higher compression ratio and good signal quality, has certain using value[5]. Jilin university communications and information systems professional zhi-jie zhao in his master's thesis of the video compression algorithm for matrix of parallel DSP system research "in the analysis of the importance of video image processing, and the existing image coding techniques were described in brief, on the basis of full study of image coding technology advantages and disadvantages, combined with the characteristics of video images, many for the concept of matrix theory is given, and the specific three-dimensional matrix theory is given and the related definitions and properties of the four-dimensional matrix theory, and on the basis of research on the discrete cosine transform, presents a three dimensional discrete cosine transform nuclear matrix four-dimensional matrix definition of discrete cosine transform, and the core algorithm of video image processing, through simulation on DSP system, get more credible experimental results[6]; Deng Shiyang of taiyuan university of science and technology and so on in the residual distributed video compression perception by integrating DVC and CS respective features to build simple video coding framework, and USES the residual technology to improve system performance, finally puts forward a residual distributed video compression algorithms, perception of key frames with the traditional frame encoding, decoding, and the non-critical frames, encoding to use a random model based on residual joint sparse observations, decoding end use edge information reconstruction algorithm is optimized and improved gradient projection reconstruction, experimental results show that the recovery quality RDCVS algorithm than the reference scheme improved the 2-3 db[7];

In this paper, on the basis of predecessors' research, in view of the remote education in video compression coding and decoding process are studied, using the four-dimensional matrix is discrete cosine transform and inverse transform algorithm to DSP system simulation, compared with other algorithms of the simulation results obtained in this paper the advantages of research methods.

FOUR DIMENSIONAL MATRIX THEORETICAL BASIS

Four dimensional matrix definition

Definition 1. $I \times J \times K \times L$ pieces of real number a_{ijkl} compose I pieces of horizontal lines, J pieces of vertical columns, K pieces of vertical sequences and L pieces of deep hypercube form data ranking, the data ranking is called $I \times J \times K \times L$ order four dimensional matrix, as formula (1)show:

$$\mathbf{A}_{\mathbf{I\times J\times K\times L}} = \lfloor \mathbf{a}_{\mathbf{i\times j\times k\times l}} \rfloor_{\mathbf{I\times J\times K\times L}}, (\mathbf{1 \le i \le I, 1 \le j \le J, 1 \le k \le K, 1 \le l \le L}) \quad \mathbf{(1)}$$

In formula (1), a_{ijkl} represents four dimensional matrix $A_{I\times J\times K\times L}$ element.

Definition 2. Any four dimensional matrix $A_{I\times J\times K\times L}$ can use some horizontal lines, vertical lines, ordinates and depth lines to classify into small size four dimensional matrix, and the small four dimensional matrix after classification is called that $A_{U\times V\times W\times S}$ is four dimensional matrix $A_{I\times J\times K\times L}$ sub matrix, from which :$U < I, V < J, W < K, S < L$.

Four dimensional matrix operational criterion

If two four dimensional matrixes of the same order: $A_{I\times J\times K\times L} = \lfloor a_{i\times j\times k\times l} \rfloor_{I\times J\times K\times L}$ and $B_{I\times J\times K\times L} = \lfloor b_{i\times j\times k\times l} \rfloor_{I\times J\times K\times L}$ corresponding elements are all the same, then call two four dimensional matrixes are equal.

If two four dimensional matrixes of the same order: $A_{I\times J\times K\times L} = \lfloor a_{i\times j\times k\times l} \rfloor_{I\times J\times K\times L}$ and $B_{I\times J\times K\times L} = \lfloor b_{i\times j\times k\times l} \rfloor_{I\times J\times K\times L}$ sum is : $C_{I\times J\times K\times L} = \lfloor c_{i\times j\times k\times l} \rfloor_{I\times J\times K\times L}$, then same order matrixes corresponding elements have formula (2) showed relations:

$$\mathbf{C}_{\mathbf{I\times J\times K\times L}} = \lfloor \mathbf{c}_{\mathbf{ijkl}} \rfloor_{\mathbf{I\times J\times K\times L}} = \lfloor \mathbf{a}_{\mathbf{ijkl}} + \mathbf{b}_{\mathbf{ijkl}} \rfloor_{\mathbf{I\times J\times K\times L}} \quad \mathbf{(2)}$$

In formula (2)showed four dimensional matrix addition meets associative law and commutative law.

Multiplication of two four dimensional matrixes of same order have six kinds that are respectively line-column multiplication, line-ordinate multiplication, line-height multiplication, column-ordinate multiplication, column-height multiplication and ordinate-height multiplication, two same order matrixes $A_{I_1\times J_1\times K_1\times L_1}=\lfloor a_{ijkl}\rfloor_{I\times J\times K\times L}$, $B_{I_2\times J_2\times K_2\times L_2}=\lfloor b_{ijkl}\rfloor_{I\times J\times K\times L}$ product expression is as formula (3)show:

$$\left(\mathbf{A}_{I_1\times J_1\times K_1\times L_1}\cdot \mathbf{B}_{I_2\times J_2\times K_2\times L_2}\right)=\lfloor \mathbf{C}_{ijkl}\rfloor_{I_3\times J_3\times K_3\times L_3} \tag{3}$$

As formula (3) show, line-column multiplication conditions are as formula (4)show:

$$\begin{cases} c_{ijkl}=\sum_{e=1}^{j} a_{iekl}\cdot b_{ejkl},(i=1,2,\cdots,I_3;j=1,2,\cdots,J_3;k=1,2,\cdots,K_3;l=1,2,\cdots,L_3) \\ K_3=K_2=K_1,L_3=L_2=L_1,I_2=J_1,I_3=I_1,J_3=J_2 \end{cases} \tag{4}$$

Conditions that line-ordinate multiplication should meet is as formula (5)show:

$$\begin{cases} c_{ijkl}=\sum_{e=1}^{k} a_{ijel}\cdot b_{ejkl},(i=1,2,\cdots,I_3;j=1,2,\cdots,J_3;k=1,2,\cdots,K_3;l=1,2,\cdots,L_3) \\ J_3=J_2=J_1,L_3=L_2=L_1,I_2=K_1,I_3=I_1,K_3=K_2 \end{cases} \tag{5}$$

Conditions that line-height multiplication is as formula (6)show:

$$\begin{cases} c_{ijkl}=\sum_{e=1}^{l} a_{ijke}\cdot b_{ejkl},(i=1,2,\cdots,I_3;j=1,2,\cdots,J_3;k=1,2,\cdots,K_3;l=1,2,\cdots,L_3) \\ J_3=J_2=J_1,K_3=K_2=K_1,I_2=L_1,L_3=L_2,I_3=I_1 \end{cases} \tag{6}$$

Conditions that column-ordinate multiplication is as formula (7)show:

$$\begin{cases} c_{ijkl}=\sum_{e=1}^{k} a_{ijel}\cdot b_{iekl},(i=1,2,\cdots,I_3;j=1,2,\cdots,J_3;k=1,2,\cdots,K_3;l=1,2,\cdots,L_3) \\ I_3=I_2=I_1,L_3=L_2=L_1,J_2=K_1,J_3=J_1,K_3=K_2 \end{cases} \tag{7}$$

Conditions that column-height multiplication is as formula (8)show:

$$\begin{cases} c_{ijkl}=\sum_{e=1}^{l} a_{ikke}\cdot b_{iekl},(i=1,2,\cdots,I_3;j=1,2,\cdots,J_3;k=1,2,\cdots,K_3;l=1,2,\cdots,L_3) \\ I_3=I_2=I_1,K_3=K_2=K_1,J_2=L_1,J_3=J_1,L_3=L_2 \end{cases} \tag{8}$$

Conditions that ordinate-height multiplication is as formula (9)show:

$$\begin{cases} c_{ijkl}=\sum_{e=1}^{l} a_{ijke}\cdot b_{ijel},(i=1,2,\cdots,I_3;j=1,2,\cdots,J_3;k=1,2,\cdots,K_3;l=1,2,\cdots,L_3) \\ I_3=I_2=I_1,J_3=J_2=J_1,K_2=L_1,K_3=K_1,L_3=L_2 \end{cases} \tag{9}$$

Four dimensional matrix $A_{I\times J\times K\times L}$ transposition computing has six types that are respectively line-column transposition that is interchanging I,J, line-ordinate transposition that is interchanging I,K, line-depth transposition that is interchanging I,L, column-ordinate transposition that is interchanging J,K, column-depth transposition that is interchanging J,L, ordinate-depth transposition that is interchanging L,K.

FOUR DIMENSIONAL MATRIX DISCRETE COSINE TRANSFORMATION-BASED VIDE CODING

Discrete cosine transformation was proposed by N.Ahmed and others as earliest, it was widely used in image compression coding field, from which international standard JPEG, MPEG coding also adopted two dimensional discrete cosine transformation technique, in image documents, it included lots of low frequency information, while discrete cosine transformation had approximately optimal decorrelation functions on signals with Gauss-markov-1 statistical features. In order to better represent video image correlations in airspace, time domain as well as R, G, B three frames, promoted three dimensional discrete cosine transformation to four dimensional matrix, it could get better effects. In the following, it makes theoretical statements on one dimensional cosine discrete transformation, four dimensional cosine discrete transformations, in the hope of provide more reasonable and better theoretical basis for video coding.

One dimensional cosine discrete transformation

If one dimensional discrete sequence $f(x)$, from which $x=0,1,2,\cdots,N-1$, take $-\frac{1}{2}$ as break, it can form into $-N\rightarrow -1$ sequence and combine with original sequence into $2N$ even function sequence, then transform kernel is as formula (10)show:

$$\exp\left[-j\frac{2\pi\left(x+\frac{1}{2}\right)u}{2N}\right]=\exp\left[-\frac{j\pi(2x+1)u}{2N}\right] \qquad (10)$$

Then discrete variable turns into $-N,-N+1,\cdots,-1,0,1,\cdots,N-1$, according to Fourier transformation attributes, imaginary number as zero don't need to calculate, formula (10) only leaves $\cos\left[\frac{\pi(2x+1)u}{2N}\right]$, therefore cosine positive transformation is as formula (11)show:

$$F(u)=c(u)\sqrt{\frac{2}{N}}\sum_{x=0}^{N-1}f(x)\cos\left[\frac{\pi(2x+1)u}{2N}\right] \qquad (11)$$

In formula (11), $c(u)$ range is when $u=0$, $c(u)=\frac{\sqrt{2}}{2}$, when $u=1,2,\cdots,N-1$, $c(u)=1$, formula (11)corresponding inverse transformation is as formula (12)show:

$$f(x)=\sqrt{\frac{2}{N}}\sum_{x=0}^{N-1}c(u)F(u)\cos\left[\frac{\pi(2x+1)u}{2N}\right] \qquad (12)$$

Four dimensional cosine discrete transformation

Four dimensional discrete cosine transformation is as formula (13)show:

$$[c_{uvws}]_L = \begin{cases} \sqrt{\frac{2}{N}}\cos\frac{i\pi(2j+1)}{2N} & i \neq 0 \\ \frac{1}{\sqrt{N}} & i = 0 \end{cases} \tag{13}$$

In formula (13), when $L=1$, it has $i=u, j=v$; when $L=2$, it has $i=u, j=w$; when $L=3$, it has $i=u, j=s$; when $L=4$, it has $i=v, j=w$; when $L=5$, it has $i=v, j=s$; when $L=6$, it has $i=w, j=s$; if set A and B to be four dimensional matrix, then four dimensional matrix discrete cosine transformation is as formula (14)show:

$$\begin{aligned} B &= \left(C_6\left(C_1AC_1^{T1}\right)_1C_6^{T6}\right)_6 = \left(C_1\left(C_6AC_6^{T6}\right)_6C_1^{T1}\right)_1 \\ &= \left(C_5\left(C_2AC_2^{T2}\right)_2C_5^{T5}\right)_5 = \left(C_2\left(C_5AC_5^{T5}\right)_5C_2^{T2}\right)_2 \\ &= \left(C_3\left(C_4AC_4^{T4}\right)_4C_3^{T3}\right)_3 = \left(C_4\left(C_3AC_3^{T3}\right)_3C_4^{T4}\right)_4 \end{aligned} \tag{14}$$

Correspond to formula (15) four dimensional matrix discrete cosine inverse transformation is as formula (15)show :

$$\begin{aligned} A &= \left(C_6^{T6}\left(C_1^{T1}AC_1\right)_1C_6\right)_6 = \left(C_1^{T1}\left(C_6^{T6}AC_6\right)_6C_1\right)_1 \\ &= \left(C_5^{T5}\left(C_2^{T2}AC_2\right)_2C_5\right)_5 = \left(C_2^{T2}\left(C_5^{T5}AC_5\right)_5C_2\right)_2 \\ &= \left(C_3^{T3}\left(C_4^{T4}AC_4\right)_4C_3\right)_3 = \left(C_4^{T4}\left(C_3^{T3}AC_3\right)_3C_4\right)_4 \end{aligned} \tag{15}$$

Video image four dimensional sub matrix segmentation and video coding system

A color image normally is composed of same size R, G, B gray level images, and video image constitutes are multiple continuous static color images, so it can use four dimensional matrix model to express video image, four dimensional matrix discrete cosine transformation-based video compression algorithm can do without adopting motion compensation techniques among intra-frame coding.

During utilizing two dimensions to express image space location, color image three color components can be used as one dimension, and another dimension is used to express time coordinate axis, then express video image relations among airspace, time domain and each color components as a unified mathematical model, the method makes full use of video image airspace, time domain and color components correlations. And four dimensional matrix discrete cosine change-based video coding needs firstly to make four dimensional submatrix segmentation on image sequence, in segmentation process, considering computing complexity, blocking effects and system time delay and other factors, it can adopt $4\times4\times3\times3$ submatrix segmentation scheme, take 3 frames as one group and regard every group 3 frames as a four dimensional image matrix, while to every frame image, take 4×4 block, let it to form into several $4\times4\times3\times3$ video submatrixes, and then separately carry out four dimensional matrix discrete cosine transformation on every submatrix.

Apply four dimensional matrix models to express video images, segment image sequence into thought video submatrix, system is fully symmetric in coding end and decoding end, due to it doesn't involve motion estimation and motion compensation, let computing complexity to be slightly reduced, structure is also relative easy to implement, four dimensional matrix discrete cosine transformation video decoding system chart is as Figure 1 show.

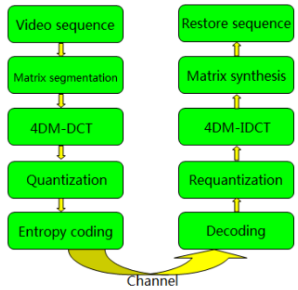

Figure 1 : Video decoding and coding system chart

As Figure 1 show, firstly group continuous video sequences, let them to fulfill video sequence four dimensional matrix model expression, then make four dimensional matrix discrete cosine transformation on every $4\times4\times3\times3$ four dimensional submatrix, obtained four dimensional coefficient matrix implements effective decorrelation on airspace, time domain and color space in 4DM-DCT transformation link, due to 4DM-DCT coefficient correlation is lower and causes most of energy concentrating on fewer low frequency coefficient, most of coefficient is zero or gets closer to zero, especially for each color component transformation coefficient, they are almost zero, the features provide higher possibility to get high compression ratio. Quantization link effect is on the premise of ensuring certain images qualities, removing such information that has smaller effects on visual effects, so quantization link is also introducing method of errors, quantization in the paper is vector quantization. After fulfilling vector quantization on transformation coefficient, it needs to make run coding and entropy coding on quantization coefficient, use run coding to let quantization coefficient distribution to be more regular, in order to further arrive at the purpose of compressing data, make entropy coding on run coding codon, the paper adopts Huffman coding. Decoding process is reverse process of coding.

SIMULATION DATA ANALYSIS

Data evaluation criterion

Apply the paper stated four dimensional matrix discrete cosine transformation-based video compression algorithm, implement coding experiment in DSP simulation system, for experiment data evaluation quantities, it has compression ratio and peak signal to noise ratio, compression ratio formula is as formula (16) show:

$$C_r = \frac{preByte}{pasByte} \tag{16}$$

In formula (16), C_r represents compression ratio, $preByte$ represents original image bit number, $pasByte$ represents bit number after compressing and coding. Objective quality evaluation standard peak signal to noise ratio computational formula is as formula (17)show:

$$PSNR(dB) = 10Lg\left(\frac{255^2}{\sigma_e^2}\right) \tag{17}$$

In formula (17), PSNR represents peak signal to noise ratio, σ_e^2 represents original image sequence pixel value and reconstruction image pixel value differences' mean square error.

Evaluation standard data comparing

TABLE 1 : Different compression methods' evaluation standard data comparison table

Experiment image sequence	Compression method	Compression ratio	Average signal to noise ratio
Image sequence 1	3DM-DCT	64	40.95
		256	35.70
	MC/2D-DCT	287	35.50
Image sequence2	3DM-DCT	64	38.19
		256	34.35
	MC/2D-DCT	139	32.60
Image sequence1	4DM-DCT	72	39.44
		288	36.75
	MC/2D-DCT	287	35.50
Image sequence3	4DM-DCT	72	33.20
		288	32.77
	MC/2D-DCT	168	33.30

TABLE 2 : Coding and decoding process time-consuming comparison table

Compression process	Decoding each link	Running time coordinate	Total time-consuming
3D-DCT coding process	Submatrix segmentation and cosine positive transformation	4.02ms	4.58ms
	Vector quantization and entropy coding	4.58ms	
3DM-IDCT decoding process	Decoding and inverse quantization	3.13ms	4.19ms
	Cosine inverse transformation and submatrix synthesis	4.19ms	
4DM-DCT coding process	Submatrix segmentation and cosine forward transformation	2.67ms	2.67ms
	Vector quantization and entropy coding	1.52ms	
4DM-IDCT decoding process	Decoding and inverse quantization	1.00ms	2.72ms
	Cosine inverse transformation and submatrix synthesis	2.72ms	

Data in TABLE 1 and TABLE 2 shows that under high compression ratio four dimensional matrix discrete cosine transformation-based video coding has higher average signal to noise ratio, time-consuming is obvious fewer than that of video coding based on three dimensional matrix discrete cosine transformation.

CONCLUSION

1) through theoretical elaboration and the simulation data show based on 4 d matrix of discrete cosine transform video compression algorithm in performance and operation obviously better than that of the mentioned three dimensional transform compression algorithm;

2) In order to realize the remote video education is easy to transport demand, based on 4 d matrix of discrete cosine transform is video compression method can provide more convenient theoretical basis for this demand;

3) this article focuses on the four dimensional matrix operation method and the system structure of video encoding and decoding, by representing the number of learning algorithms, simulation on DSP, and the evaluation standard is obtained data, through the data shows the four-dimensional matrix of discrete cosine transform in video compression have superiority.

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