COMPRESSION OF VIDEO RECORDING OF SLEEPING PATIENT

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ABSTRACT

Video data recording on PC hard disc without any data compression can have only one result. The capacity of hard disk will be exhausted very quickly although our hard disc have relatively enough space. Archiving of the recorded data without compression, after eight our sleeping monitoring for each patient, is impossible and then it is very important to find some appropriate method and algorithm for the video data compression.

1 THE REASON FOR IMAGE DATA COMPRESSION

Portable camera connected to PC through the USB port allows transmition of the image with graphic resolution 320×240 and 24b color deep. Size of one image is then

$$320 \cdot 240 \cdot 24 = 1843200\text{b} \doteq 1,85\text{MB}.$$

During the recording of 25 images per second is saved 46MB every second. Hard disc with capacity about 80GB allows to save only 30 minute length record. Using grayscale format for recording enable to save three times longer record then for the color format. But this is still not enough. Doctors require saving of EEG and recorded data eight hours long.

2 SPECIFIC IMAGE PROPERTIES

For effective processing of the image of a sleeping pacient in a sleeping laboratory is required the specific information about this image. This information is necessary for investigation of the optimal algorithm destination processing of this images with another polysomnographics data.

At first, the digital motion picture camera scan the color image and then the data are saving to a computer. This data have another property than video data assumed for a digital television.

One of the most important property is the fact that the video recording of the sleeping patient is generally a static image. This video recording does not contain any movement. The next important property is that the picture indeed does not have any color components. Although it is saved as the RGB color image.

The reason of absence of color components at video recording of sleeping patient is recording in a dark room. The digital motion picture camera work in scotopic vision mode.

The great problem for video record in scotopic vision mode is dark current. It is stochastic charge generation at the CCD chip. This noise generate weak movement in static video recording.

3 IMAGE COMPRESSION METHODS

There are many methods for the image compression. The most popular are methods which use the Discrete Cosine Transform (DCT) or Discrete Wavelet Transform (DWT). We choose DCT for the compression in our system.

3.1 TWO-DIMENSIONAL DISCRETE COSINE TRANSFORM

Two-dimensional discrete cosine transform come from two-dimensional Fourier transform, but don't include sine components. Mathematics formula of two-dimensional discrete cosine transformation is:

$$F(u,v) = C(u)C(v)\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\cos\frac{(2x+1)u\pi}{2M}\cos\frac{(2y+1)v\pi}{2N}, \tag{1}$$

where x,y are $0 \le x \le M-1$ and $0 \le y \le N-1$. Input two-dimensional signal is denoted as f and output signal as F. The variables M and N contain information about the size of input matrix of input signal f. Values of $C(u)$ and $C(v)$ are computed from following equations:

$$C(u) = \begin{cases} \frac{1}{\sqrt{M}}, & u = 0 \\ \sqrt{\frac{2}{M}}, & 1 \le u \le M-1 \end{cases} \qquad C(v) = \begin{cases} \frac{1}{\sqrt{N}}, & v = 0 \\ \sqrt{\frac{2}{N}}, & 1 \le v \le N-1 \end{cases}$$

As a standard for JPEG image compression and MJPEG (Motion JPEG) is usually used two-dimensional DCT. Image is divided to squares which consist of 8×8 image pixels and the DCT is applied to each square. The reason is first of all the speed of computation which is better then for the whole image.

The DCT for two dimensional signal 8×8 pixels is possible to write:

$$F(u,v) = \frac{1}{4}\cdot C(u)C(v)\sum_{x=0}^{7}\sum_{y=0}^{7} f(x,y)\cos\frac{(2x+1)u\pi}{16}\cos\frac{(2y+1)v\pi}{16}, \tag{2}$$

where x,y are $0 \le x \le 7$ and $0 \le y \le 7$. Value of $C(u)$ a $C(v)$ are defined as:

$$C(u) = C(v) = \begin{cases} \frac{1}{\sqrt{2}}, & u = v = 0, \\ 1, & \text{otherwise.} \end{cases}$$

3.2 INVERSE TWO-DIMENSIONAL DISCRETE COSINE TRANSFORM

For image reconstruction we need to use inverse two-dimensional discrete cosine transform (IDCT). The formula for computing of the two-dimensional IDCT is similar as for the two-dimensional DCT. Common formula is possible to write:

$$f(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} C(u)C(v)F(u,v)\cos\frac{(2x+1)u\pi}{2M}\cos\frac{(2y+1)v\pi}{2N}, \qquad (3)$$

where u,v are $0 \leq u \leq M-1$ and $0 \leq v \leq N-1$. M a N values contain information about number of rows and columns of F signal. Values of $C(u)$ a $C(v)$ are computed from following formulas:

$$C(u) = \begin{cases} \frac{1}{\sqrt{M}}, & u = 0 \\ \sqrt{\frac{2}{M}}, & 1 \leq u \leq M-1 \end{cases} \qquad C(v) = \begin{cases} \frac{1}{\sqrt{N}}, & v = 0 \\ \sqrt{\frac{2}{N}}, & 1 \leq v \leq N-1 \end{cases}$$

For two-dimensional IDCT computing for 8×8 pixel blocks is possible to used equation:

$$f(x,y) = \frac{1}{4}\sum_{u=0}^{7}\sum_{v=0}^{7} C(u)C(v)F(u,v)\cos\frac{(2x+1)u\pi}{16}\cos\frac{(2y+1)v\pi}{16}, \qquad (4)$$

where u,v are $0 \leq u \leq 7$ and $0 \leq v \leq 7$. Values of $C(u)$ and $C(v)$ are defined as:

$$C(u) = C(v) = \begin{cases} \frac{1}{\sqrt{2}}, & u = v = 0, \\ 1, & \text{otherwise.} \end{cases}$$

4 A IMAGE COMPRESSION

The image compression is possible to split into two parts – inter-frame compression and intra-frame compression. Inter-frame compression reduces a redundant information between the successive images and intra-frame compression reduce redundant information in a image.

For a data quantity minimisation are chosen some interesting rectangle parts from the image which showed sleeping patient. These parts often show a head with neck, hands with chest and one part usually showed legs of a sleeping patient (see Figure 1). The other parts of the figure around the marked body areas are uninteresting and there is no reason to record them.

4.1 INTER-FRAME COMPRESSION

Inter-frame compression reduces redundant information between the successive images. Patients usually sleep without any movements most of the recorded time. Therefore these images are not the same. The movement in the record (static recording) is given above all by the dark current. The dark current is the reason why two images, picked-up successive, are not the same although the scene is.

Solution of this problem is easy. The problem is solved by a clipping gate. The clipping gate classify level of dark current and tells what is a dark current and what is a variance between two images. Level of the clipping is set up before each recording, because every scene is different (camera position, luminary, etc.).

Figure 1: Image of a sleeping patient

4.2 INTRA-FRAME COMPRESSION

Intra-frame compression is based on JPEG standard which was modify for achieve better compression approach.

A image compression is a bit complicated problem. Our system uses three steps to solve it.

First every image is converted from the RGB color model to the grayscale model, because video recording on scotopic vision video mode haven't any information about the color. This means that the color information loss is absolutely unimportant.

Next formula shows the converting from RGB color model to grayscale image:

$$Y = 0,2989 \cdot R + 0,5870 \cdot G + 0,1140 \cdot B, \tag{5}$$

where Y is a brightness component of grayscale picture. R, G and B are color components of the original picture.

In the next step the image is (or denoted part of image) divided into little parts 8×8 pixels. Two-dimensional discrete cosine transformation is applied on it according the formula (2). After DCT was applied to a data block 8×8 pixels we obtain a data block DCT coefficients with the same size. So we have no compression. For the compression is necessary to have the same or very similar coefficients. This condition is not fulfilled after DCT implementation. But the similarity among DCT coefficients exists. The $F(0,0)$ coefficient have the maximum value in comparison with the other coefficients. The name of this coefficient is DC because it contains the mean value of the others coefficients. Simply said, the coefficients $F(0,0)$ contain the brightness value of all pixels in 8×8 parts. The name of the other coefficients is AC. They are very similar to each other and they have small values. The AC coefficients represent higher cosinus frequency – changing among neighbouring pixels in both tracks.

Third for the data reduction we need to use quantization. For quantization is used JPEG quantizing table for brightness because our picture is grayscale.

The quantization tables are designed in reference to a human eye characteristics. The human eyes don't feel higher steric frequency so good as low steric frequency. Therefore the quantization tables have lower values of coefficients on some position then the others. A lower element value $Q(u,v)$ in table means higher importance of $F(u,v)$ elements.

The quantization algorithm divides coefficients $F(u,v)$ by a quantization table $Q(u,v)$. Every element from $F(u,v)$ is divided by the corresponding element $Q(u,v)$ and every result is rounded. Then we receive table of quantized coefficients.

$$F^Q(u,v) = round\left(\frac{F(u,v)}{Q(u,v)}\right) \tag{6}$$

Reconstruction of the originals elements $F^*(u,v)$ is performed very easy. We multiply quantized coefficient by the same quantization table (**??**).

$$F^*(u,v) = F^Q(u,v) \cdot Q(u,v) \tag{7}$$

4.3 A STREAM CODING

One very important and large part is a stream coding. This coding finally produces a compressed data stream which is saved and archived.

A stream coding and compressing is quite simple to describe altough the algorithm realization is quite difficult. An algorithm monitors a video record and when it notice any movement in the market parts then it automatically starts the recording.

The coding algorithm saves periodically one image in before defined time interval. The images are saved like JPEG. The 8×8 DCT elements block (pixels block after two dimensional DCT and quantization) is saved zigzag from DC element. Row of identical numbers is presented as a number of values and a number of repetitions of the value. For coding is used Huffman code.

Every recorded movement in a figure is introduced by time information which is necessary for synchronization.

5 CONCLUSION REMARKS

Above described image compression was developed for special apparatus for recording of sleeping patient with EEG record because standard compress algorithms are focused only on the quality of the record. We prefer a big compress ratio. Then a juxtaposition with algorithms for digital television don't have meaning. Our compress algorithm is able to compress one hour video recording of a sleeping patient to a file which have approximately 74MB.

The problem is, that it is impossible to compress video data in real time on video recording. A computer, which record video data, is able only to monitor movement in the record, to convert it from RGB color model to grayscale and to save it. The compression is necessary to make after data recording.

REFERENCES

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