The Policy for Real-Time Storage in a Nonlinear Editing System

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Abstract In a nonlinear editing system, real-time storage of video requires: firstly, utilizing the storage speed as much as we can. Secondly, using the fragment in a disk. The common random access and sequent access can not satisfy the above requirements. We present the policy of block access in this paper. It can greatly decrease the fragment with improving the speed of access.

Keyword: Nonlinear Edit Video Edit Video Storage Block Storage

1 Introduction

Video and audio signals have been recorded on the magnetic tape sequentially in the past, hence a relation of linear chain list exists between the signals. This editing for the video and audio signals was called "linear editing". Linear editing has a number of disadvantages, such as complicated mechanical structure, signal loses, and difficult modification on editing result. Nonlinear editing has been defined as the systems by using hard disk or CD-ROM as recording media. Where, it is not necessary to record on sequence when working, and it can be retrieved by jump and not be effected by the order when editing. Compared to the linear editing system, nonlinear editing system has some superior performance as follows: flexibility of editing and modifying, scatheless to the signals edited by several times, and plenty of inditing method. By virtue of these superiorities, the development of nonlinear editing system has brought about the evolution by leaps and bounds for the broadcast and television.

The storage capacity and the read/write speed of storage are the key issues which must be taken into account in the nonlinear editing system. Compared to the read/write speed of storage, the storage capacity has greatly been increased recently. The capacity of single hard disk has increased from 1G three years ago to more than 10G nowadays, moreover there are no sign that the development tendency will slowdown. Furthermore, the Compact-Disk-based DVD technology has gained big evolution. For the sake of improving the read/write speed of storage, such as high speed hard disk interface of SCSI-2、Ultra Wide SCSI and AV high speed hard disk has been used successively. But due that reading and writing of hard disk refers to mechanical operation, the sector-searching speed on hard disk has always not been improved rapidly. After developing for one decade, the rotation speed of hard disk has been increased from 3600 rotation/minute to 1080 rotation/minute and the sector-searching time of HD has decreased from 15ms to 8ms. It is obviously that this developing speed does not match the other computer technologies. The striped technology of HD can give some helps of raising the read/write speed of HD, and but has not been applied widely because of its high price. Refer to this reason, the policy for real-time storage has become very important. A good policy for storage can decrease searching times of data on HD, thereby we can avoid operating on HD in the mechanical mode and raise the read/write speed of HD.

Video compression is another means to solve the problem of real-time storage for video. A stream of digital video of ITU R601 4:2:2 is about 21MB/S, and with sampling by 4:2:4 is 32MB/S. Such as amount of data stream seems obviously too wide for any operating platform. On the other hand, there are great deal of spatial and temporal redundancy in video data, thus we need video compression technology. But other than common video application, nonlinear editing system requires high quality of video. After many years of searching and developing, the compression algorithm of motion JPEG which is a hybrid coding between lossy and lossless compression has gain supports from the majority of manufacturers and become the de-facto industry standard. In order to meet the requirement of video quality, the lossy compression with high SNR will be adopted, and so much as the lossless compression. The ratio of compression is traditionally 1.5 to 3 times. But, the efficient storage policy is still needed for the compressed video data to store to HD in real time.

The sequence access method, which each frame data will be stored in sectors and connected to each other forth and back, can bring down the moving delay of the HD head efficiently. This is because that after the fore-frame data has been read, and without the moving of HD head the next-frame data can be read at once. But, the main problem which has been evoked from the sequence access method applied in the nonlinear editing system is that the great amount of HD fragment generated from editing process can not be utilized. The policy of block access presented in this paper can greatly utilize the fragments on the basis of satisfying real-time access.

2 real-time storage model

As we know, hard disk is composed of a number of cylinders. In figure 1, the read-write arm of HD should be located on the corresponding cylinder while accessing the HD, and we define the average time needed for this process as T_s. Fixed at the cylinder, the read-write arm starts rotating and finding out the related sectors, and the average time needed for this process denoted as T_r. After just two steps, the data will be read and transferred to sectors(memory) from memory(sectors), and this transmission speed is denoted as D_t.

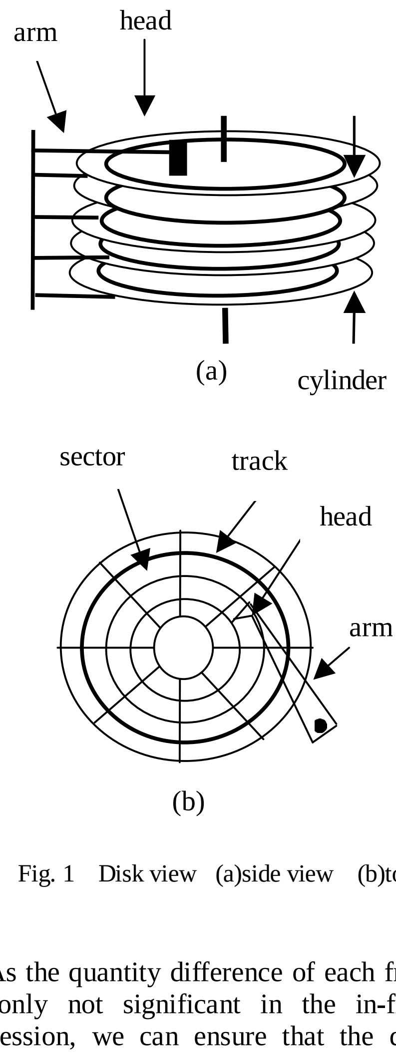

Fig. 1 Disk view (a)side view (b)top view

As the quantity difference of each frame data is commonly not significant in the in-frame video compression, we can ensure that the data outputs smoothly after smooth process operated by some buffers.

Any frame of video was put on a HD location which must meet the real time performance, i.e. the reading time Ti_{read} is not greater than the playback time Ti_{play}. In a general way,

$$T_i^{read} = n * (T_s + T_r) + \frac{f}{D_t} \quad \cdots\cdots 1)$$

$$T_i^{play} = \frac{1}{R} \quad \cdots\cdots 2)$$

Where, n indicates the searching times needed for accessing one video frame data from sectors. We assume that the raw data stream of video is 32MB/s, compressed of it is 16MB/s, and the frame rate(R) is 30frame/second. According to this assumption, the average quantity of each frame data is easily calculated as f=0.53MB.

Table One

Average time of track locating（T_s）	7 millisecond
Speed of rotate	10800 rotate/min
Rate of Data transmission（D_t）	40MB/sec
Size of sector	512bytes
Sectors/track	63
Number of head（heads/cylinder）	255

In light of the random access policy, it's necessary to locate the HD heads while accessing the sectors. The times of locating is n=f/(255*512)=4. Thus, the reading time of one frame data of video T_{read}=64ms illustrated in table 1 is computed by the equation (1). In order to satisfy the real time performance, T_{read} must be less than or equal to $\frac{1}{R}$, but $\frac{1}{R}$ =33.3, so the above-described real time features can not be achieved.

The reason of occurrence of above-described situation is because that no reasonable access policy was applied. Due to each times of accessing of one frame data needs to locate the situation of read-write arm, the efficiency of HD accessing speed is very low. If continuous access policy was applied, the efficiency of HD accessing speed should be boosted greatly.

2 Sequential Storage

Def. one continuous storage

"Continuous storage" will store each frame data in HD by the following means: the frame i+1 adjacent to frame i tightly, and if the present cylinder is insufficient to store a frame data, the frame i+1 would be shifted to the first sector of another cylinder. The frame i+2 adjacent to frame i+1 tightly, so do the others.

According to the continuous storage policy, only the first frame needs to locate the read-write arm. The each one of other frames adjacent to the fore frame tightly, so it can be read directly and continuously. Assuming that each one of cylinders can store the data of K frames continuously, then following inequality exists:

$$T_s + T_r + \frac{K \cdot f}{D_t} \le \frac{K}{R} \qquad \text{.......3)}$$

From (3), the inequality referring to K can be obtained:

$$K \ge \frac{R \cdot D_t \cdot (T_r + T_s)}{D_t - f \cdot R} \qquad \text{.......4)}$$

In the way of continuous storage, the minimum K_{min} of video frame stored on each one of cylinders can be gained from (4):

$$K_{min} \left\lceil \frac{R \cdot D_t \cdot (T_r + T_s)}{D_t - f \cdot R} \right\rceil \qquad \text{......5)}$$

If each one of HD cylinders is greater than $K_{min} \cdot f$, the real time access can be realized by using the continuous storage policy. Adopting the hard disk with parameter as shown in table one, where $K_{min} - 1$, as it were, if the capacity of each cylinder is greater than f=0.53MB, the real time access on this disk can be acquired by using the continuous storage policy. As the quantity of each one of HD cylinder in table 1 is 8.2MB, it can satisfy the above-described requirements.

The continuous storage has the advantages of simple control and the high using efficiency of HD speed, however, there are two disadvantages:

1) The fragments of hard disk can not be used. It isn't difficult to know from the definition of continuous storage that the cylinders which can be applied to store the AV frame sequentially must be blank, i.e. none of data has yet been stored in it. The cylinders which has been occupied by the non-realtime such as text can not be used to store video data.

2) Making against the video editing. Video editing will generate a large number of HD fragments, in particular, the deleting operation of video frame will lead to free sectors. Whereas there will be no way for continuous storage policy to utilize the free sectors. Next, we will propose one type of block access policy.

4 Block Access

Def. two Block access

Given any one of cylinders, which has N continuous free areas of n frames of video, then the cylinders can be used to store video data. The continuous free areas that can contain n frames are called as small block, and N small blocks form a big block. Depicted in figure 2, the cylinder has 2 mall blocks, and each block can store 3 frames. For any small blocks, there existed the following inequality of similar continuous storage policy:

$$T_s + T_r + \frac{n \cdot f}{D_t} \le \frac{n}{R} \qquad \text{.......6)}$$

It is obtained by (6):

$$n \ge \frac{R \cdot D_t \cdot (T_r + T_s)}{D_t - f \cdot R} \qquad \text{.......7)}$$

Let $n = \left\lceil \frac{R \cdot D_t \cdot (T_r + T_s)}{D_t - f \cdot R} \right\rceil$

We suppose that each big block is composed of N small blocks, and in the same cylinder, reading each small block requires re-seeking the location of the first data sector of next small block, thus the inequality (8) is obtained:

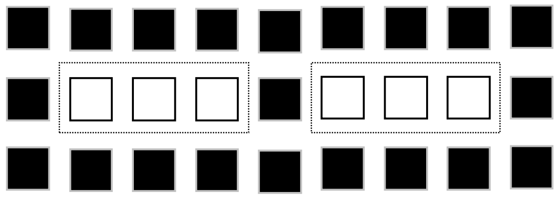

Fig. 2 The Small and Large Blocks

Note: i ndicate used sector.

indicate free sector, the small block is in the dotted line.

$$T_s + \sum_{i=1}^{N} (T_r + \frac{n \cdot f}{D_t}) \le \frac{N \cdot n}{R} \qquad \text{.......8)}$$

And the following (9) is obtained by (8):

$$N \ge \frac{R \cdot D_t \cdot T_s}{D_t \cdot n - R \cdot n \cdot f - R \cdot D_t \cdot T_r} \qquad \text{....9)}$$

(9) illustrates that: in order to satisfy real-time access, the number of small blocks needed for each one of cylinders is N_{min},

Let

$$N_{min} \left\lceil \frac{R \cdot D_t \cdot T_s}{D_t \cdot n - R \cdot n \cdot f - R \cdot D_t \cdot T_r} \right\rceil ,$$

For the hard disk parameters shown in table one,

$n=1$, $N_{min}=1$ can be acquired. This result indicates that: for any one of HD cylinders assumed to have N of free areas which size is $n \cdot f$, if $N \geq N_{min}$, the cylinder can be applied to store video data, and the number of frames which may be used to storing video is $N \cdot n$.

Clearly, block storage can utilize HD fragments efficiently and will not affect the real-time performance, which is very important to the video editing or the hybrid storage of negative real-time data and video data.

5 Conclusion

As the nonlinear editing system has the stronger functions than the conventional linear editing system, it has made a big evolution in this year. It is known that the exclusive editing device has been substituted with all-purpose equipment based on general PC gradually. It requires higher performance to the storage policy. On the analysis of sequential and random access, this paper proposed the block storage policy that can give aids to actual applications.

Reference

(1) Yale N. Patt, The I/O Subsystem: A Candidate for Improvement, March 1994, computer.

(2) Chris Ruemmler, An Introduction to Disk Drive Modeling, March 1994, computer.