AN ADAPTIVE NETWORK CONTROL SCHEME FOR REGION-BASED HYBRID CODING ALGORITHM*

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ABSTRACT

Based on the packet loss rate and the frame loss rate experiment in the practical Internet environment, a novel adaptive network control scheme is proposed for region-based hybrid coding algorithm. In comparison with the source/channel coding [1], this adaptive network control scheme is presented to reduce 50% frame loss rate during the Internet weak day use condition and 58% frame loss rate during the Internet peak day use condition.

1. INTRODUCTION

In the video conference system, the compressed multimedia data is transmitted to receiver by network. The network need to guarantee the real time transmission, low delay, and low packet loss rate. In the past researches, there are the source/channel coding [1] and automatic repeat request (ARQ) [2] mechanism to solve the packet loss problem. In this paper, a novel adaptive network control scheme is applied to the region-based hybrid coding algorithm [3] for solving the packet loss problem of the multimedia compressed data.

2. REGION-BASED HYBRID CODING ALGORITHM

There are two important properties in the video conference system. In first, camera is fixed in video conference application. Secondly, a participant appears in front of an unchanged background, and moves almost slowly. The information of the background can be removed for reducing the computation loading and the network congestion.

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The following example explains the region-based hybrid coding algorithm. A circle object moves in consecutive frames from lower left to upper right as shown in Fig. 1 (a) and Fig 1 (b). The difference of two frames is shown in Fig. 1 (c). It is obvious that the changed region is the two circle objects. It is only necessary to encode the two objects.

The region-based hybrid coding algorithm is shown in Fig. 2. In the coding algorithm, the *I* frame is *Intra_Frame(n)* and the *P* frame is *Frame(n) - Predict_Frame(n-1)* as shown in Fig. 3. The *I* frame coding algorithm and *P* frame coding algorithm are described in the following:

2.1 I frame Coding Algorithm

The *I* frame is encoded as still image. The following is the *I* frame coding algorithm:

Step 1: *I* frame is divided into many 8x8 blocks.

Step 2: For each block in *I* frame, do the following processing:

```
{ do_8x8_DCT;
  quantization;
  run length coding;
  VLC;
  add to transmission buffer container; }
```

2.2 P frame Coding Algorithm

Step 1: *P* frame is divided into many 8x8 blocks.

Step 2: Calculate MAE (Mean Absolute Error) for per block.

Step 3: For each block in *P* frame, do the following processing:

```
{ if (MAE > threshold)
  { do_8x8_DCT;
```

```

quantization;
run length coding;
VLC;
add to transmission buffer container;}}

```

The *MAE* (Mean Absolute Error) and *threshold* are used to identify the changed blocks in *P* frame.

3. ADAPTIVE NETWORK CONTROL SCHEME

The design of the adaptive network control scheme is based on the packet loss rate of the *UDP* protocol experiment and the frame loss simulation of the region-based coding algorithm on Internet. The two experiments are described in the following:

3.1 The Loss Rate of the UDP Protocol Experiment:

This experiment is performed at peak use of network and heavy load of cicsun06 (load=1.2) as shown in Fig.4. The *TD* is time division (ms) between the two successive packet transmissions. There are two results shown in this figure. In first, the larger packet size will have higher probability of packet loss at the same time division. Secondly, the longer time division will have lower packet loss rate at the same packet size.

3.2 The Frame Loss Simulation of the Region-based Coding Algorithm

Without retransmission of the lost frame, the Fig. 5 represents that the packet arrival process is highly correlated with the successive packet drops. When there are more than three successive frames loss, the *PSNR* value of the frame will decline quickly and video quality will be poor.

3.3 Adaptive Network Control Scheme Using First Order Markov Model

According the above two experiments result, a novel adaptive network control scheme is proposed for the region-based hybrid coding algorithm. In this scheme, the successive packet loss condition can be detected and the frame loss rate can controlled with the adjustment of the frame transmission threshold.

The packet loss condition can be detected with the transmission status between the transmitter and the receiver. After receiver gets a video packet, it sends a grant to transmitter immediately. So, the packet loss condition can be counted and the first order Markov model is used to simulate the behavior of the network as shown in Fig. 6. In this model, there are two states and four parameters described as following:

PS: the state of a successful packet.

PL: the state of a loss packet.

PSS: the probability of a successful packet following a successful packet.

PSL: the probability of a successful packet following a loss packet.

PLS: the probability of a loss packet following a successful packet.

PLL: the probability of a loss packet following a loss packet.

The two equations can be got as following:

$$PSS + PSL = 1$$

$$PLL + PLS = 1$$

Based on the above model, a novel network control scheme is designed to adapt the video transmission. This scheme degrades or upgrades the server transmission rate depending on feedback message from receiver on the control channel.

When the *PSL* and the *PLL* are small, it is hard to become the *PL* status from the *PS* status, but easy to become the *PS* status from the *PL* status. The two conditions ($PSL > cpsl$) or ($PLL > cpll$) are used as criteria. The *cpsl* and *cpll* criteria parameters are the probability of the packet loss and used to detect the satus of the packet loss. The *cpsl* and *cpll* criteria parameters are adjusted according the necessity of the users.

If the packet loss rare is high, the *threshold* of the region-based hybrid coding algorithm is increased to reduce the data rate of the

changed blocks in the P frame. When network is in weak use, the *threshold* is decreased to get high video quality. The adaptive network control scheme is described as following:

```

if (( PSL > cpsl ) or ( PLL > cpll))
{
    if (threshold < 800)
        threshold += 50;
    else
    {
        if (framerate > 1)
            framerate = frame - 1;}}
else
{
    if (threshold > 100)
        threshold -= 50;
    else
    {if (framerate < 10)
        framerate = frame + 1;}}

```

The *threshold* is bounded between 150 and 800. If the *threshold* is equal to 800 and packet loss rate is still high, the *framerate* will be reduced to low down the packet loss rate. The transmitter adjusts *PSS* and *PLL* according to statistical data from receiver. Based on the practical Internet experiment, the network condition can be represented by sampling data each 10 seconds.

4. EXPERIMENTAL RESULTS

The adaptive network control scheme is tested on the 120 seconds salesman sequence. The spatial resolution is 320x240 for 8-bits gray level. The Internet transmission experiments are carried out between the video5 workstation and the cicsun06 workstation as shown in Table. 1. and in Fig. 7.

As shown in Fig. 8., the different statistical time is used to understand network condition by applying the adaptive control scheme. When the 10 seconds are chosen as the statistical time, the packet loss rate is the lowest.

Table. 2. shows the comparison of frame loss rate for various scheme. Testing time is at 08:00am during periods of weak day use. Table. 3. represents the frame loss rate during network peak day use. Because the network control scheme can adjust coding strategy according network condition, the frame loss rate is lower than source/channel coding in [1]. In comparison with the source/channel coding in [1], this adaptive network control scheme is presented to reduce 50% frame loss rate during the Internet weak day use condition and 58% frame loss rate during the Internet peak day use condition.

5. CONCLUSIONS

A novel adaptive network control scheme for region-based hybrid coding algorithm is proposed in the above sections. The first order Markov model is used to control the network behavior. It is to meet the bandwidth of the network by minimizing data rates of transmitter. From the results of the real Internet experiments, this adaptive network control scheme is superior to the source/channel coding.

REFERENCE

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Figure 1. Example of region base hybrid coding.

Figure 2. Block diagram of region base hybrid coding system.

Figure 3. Frame type

Figure 4. Packet loss rate for various packet size

Figure 5. Frame loss simulation result of Region-base hybrid coding (Threshold=600). There are two successive frame loss at frame number 22 and 23. There are three successive frame loss at frame number 32, 33 and 34. There are four successive frame loss at frame number 42, 43, 44, and 45. There are five successive frame loss at frame number 52, 53, 54, 55, and 56.

Figure 6. The state diagram of packet transmission in the network.

Figure 7. Testing environment

Table 1. Host computers used in our experiment.

hostname + domainname	IP Address	Function
video5.ee.ntu.edu.tw	140.112.20.225	receiver
video.ee.ntu.edu.tw	140.112.18.134	router
ntu-ee-router.ee.ntu.edu.tw	140.112.18.254	router
	140.112.41.254	router
ntu-router.ntu.edu.tw	140.112.1.254	router
	134.208.227.111	router
	134.208.225.110	router
NCHC-FDDI-NCTU.edu.tw	134.208.150.113	router
NCTU-T1-CIC.nctu.edu.tw	140.126.245.253	router
inbox.gw.cic.edu.tw	140.126.24.31	router
	140.126.26.2	router
cicsun06.cic.edu.tw	140.126.25.6	transmitter

Figure 8. Statistical Time(sec) vs Loss Ratio (cpsl = 0.1; cpil = 0.1).

Table 2. The frame loss comparison for various scheme. Network is in weak use. (cpsl = 0.1; cpil = 0.2)

Mechanism	Proposed	No network control	Source/Channel Coding [1]
Frame loss rate	3%	5%	6%

Table 3. The frame loss comparison for various scheme. Network is in peak use. (cpsl = 0.13; cpil = 0.2)

Mechanism	Proposed	No network control	Source/Channel Coding [1]
Frame loss rate	8.9%	16.67%	21%