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Combined Source and Channel Coding System Using Different Importance of Multi-Media Information

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Abstract — **In this paper, we propose a combined source and channel coding system for multimedia information sources, which outputs different kinds of information on a frame by frame basis. We use a source encoder which has several probability tables for each medium and a channel encoder which has several convolutional codes for unequal error protection. Computer simulation shows the performance of our system.**

I. Introduction

Recently, the importance of multimedia communication, which has information sources like image, voice and text, is increasing. However for multimedia communication, we need a high bit rate channel. It is hard to send raw data without compression. Also, intelligent communication systems, which can efficiently correct channel errors by taking into account the information contents and achieve highly reliable communication for human receivers, are popular. In this field, intelligent error controlling schemes are considered to protect information effectively from channel errors [1]-[2]. In this paper, we consider that media have different importance, which correspond to different quality requirements. For example, in a TV conference, we send images and text. It is hard to understand if the text has errors, however an image can be allowed to have more errors than text. In this case, we consider that text is more important than images. We propose a combined source and channel coding system considering what was mentioned above.

II. Proposed System

We consider a communication system for multi-media information with combined source and channel encoder and decoder and AWGN channel. We consider that as follows.

A. Multi-Media Information Source

We define a multimedia information source as one with the following properties:

- consists of different kinds of media.
- each medium has different importance.
- each output consists of a frame selected from the information sources by a multiplexer.
- at the receiver, the frames are separated into different media by a demultiplexer.

The multiplexer divides each frame into l symbols like Fig.1. We call l the frame length. We only know the number of media, the frame length and the probability of use of each medium.

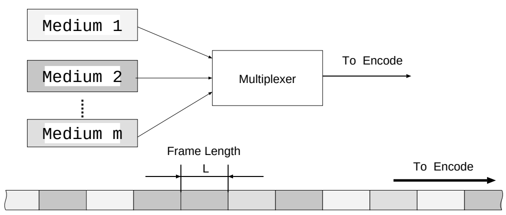

Figure 1: Multi-Media Information Source Image

B. Proposed Coding System

Fig.2 represents configuration of our combined source and channel coding system. We use a source encoder which has several probability tables corresponding to individual media and a channel encoder which has several convolutional codes for unequal error protection corresponding to individual media. A pair consisting of a probability table and a convolutional code can be determined according to the importance of each medium. Therefore, we assume that individual media have different importance and probability tables. The individual media should be protected by convolutional codes with different error-correcting capabilities corresponding to the importance in relation to the importance of the medium. we don't need to transmit any supplemental information about which table and convolutional code were used in the source and channel encoders. In the decoder, an appropriate probability table for source decoding can be selected by using results of channel decoding, because the convolutional code that was used in the encoder can be estimated in Viterbi decoding. Moreover, errors of selecting the convolutional encoder during channel decoding can be detected if we check whether the decoded information frame has the appropriate length or not. By using these interactive processes between source and channel encoding and decoding, we can achieve both efficient

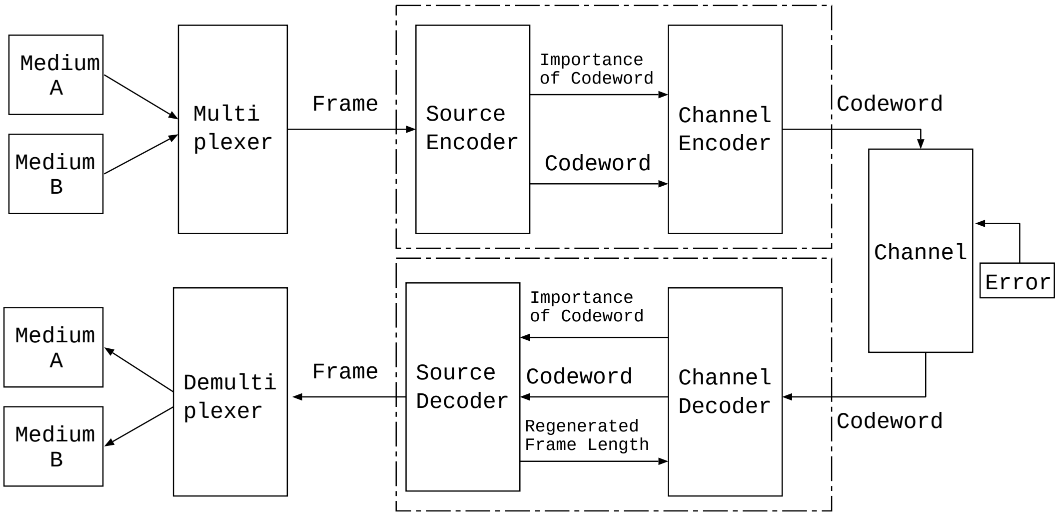

Figure 2: Proposed Combined Source and Channel Coding System

information compression and reliable error protection for multimedia information.

C. Coding Algorithms

C.1. Encoding Algorithms

In Fig.3, our encoding algorithm is given. At first we encode a frame from the multiplexer in the source encoder. We do not know which medium the frame came from. We use all probability tables for encoding and decide which medium it came from by comparing the compression rate after encoding. The probability table which achieves the best compression rate is chosen for the frame.

In the channel encoder, we use the convolutional encoder which corresponds to the importance of the medium.

C.2. Decoding Algorithms

In Fig.3, our encoding algorithm is also given. On the receiver side, we use a Viterbi decoder as the channel decoder. By using the Viterbi algorithm with several trellis diagrams, we can estimate the maximum likelihood path by comparing each path metric and then which convolutional code was used on the encoder side. Then information about the importance of the medium can be sent to the source decoder. In the source decoder, the codewords which are estimated by the Viterbi decoder are used to decode the frame. After the frame is output, we can get information about errors by checking the frame length. If there were errors in the codewords, the frame will not have the appropriate length. Then we decode again as another medium's sequences.

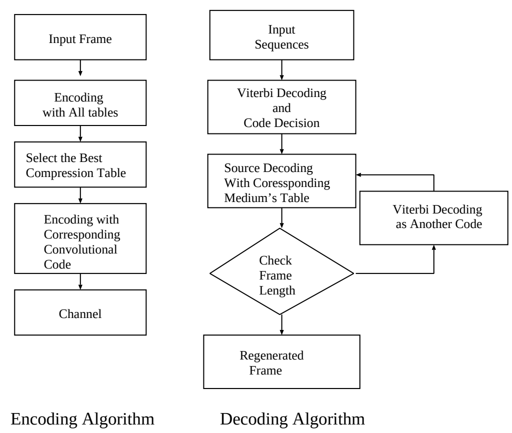

Figure 3: Proposed Encoding and Decoding Algorithm

III. Advantage of our systems

If we treat these multimedia information sources as one information source, that is a mixed information source, then this entropy is given by

$$\begin{aligned} H_{Multi} &= -P_{Multi} \log_2 P_{Multi}(\mathbf{X}) \\ &= -\{\sum_M S_m P_m(\mathbf{X})\}\{\log_2 \sum_M S_m P_m(\mathbf{X})\} \quad (1) \end{aligned}$$

where M is the number of media, S_m is the probability of media appearance P_m is the probability of symbol occurence.

For the multimedia information sources, we propose a universal coding scheme that selects several probability tables frame by frame. At first, we determine which medium the input frame comes from. Then we compress it with the table for that medium. Therefore, we can achieve highly efficient lossless compression for multimedia information sources. However, in this scheme we should transmit information about which probability table was used for the decoder to regenerate the correct frame. Then the redundancy of codebooks increases by $-\frac{1}{l}\sum_M S_m \log_2 S_m$ bits per symbol.

For the proposed scheme, the entropy of the multimedia information sources is the following,

$$H_{Each} = -\sum_M \{(S_m P_m(\mathbf{X}) \log_2 P_m(\mathbf{X})\} - \frac{1}{l}\sum_M S_m \log_2 S_m \quad (2)$$

For channel coding we use unequal error protection using several convolutional codes. We select convolutional codes with different error correcting performance in relation to the importance of the media. A more important medium uses a channel code with larger error-correcting capability. We transmit only codewords with no information about the encoder. By using combined source and channel coding, we can remove the redundancy of the source coding by $-\frac{1}{l}\sum_M S_m \log_2 S_m$ bits per symbol.

At the receiver side the convolutional codes are decoded by the Viterbi algorithm. We use a decoder which can decode all convolutional codes with only one Viterbi decoder. However this scheme has the problem of encoder detection error. Because if a channel decoder could not estimate the correct code, we may decode using the wrong decoder.

Since the information translates between the source decoder and the channel decoder, the decorder part can correct the media determination errors. Because if we decoded the data using the wrong medium's table in the source decoder, the regenerated frame length will not be the same as the correct frame length. Then we can tell that this code is not correct or is another medium's sequence.

IV. System Performance

In this section, we use a computer simulation to show the error rate performance of the proposed scheme.

Two kinds of media, image and text are used. Each media has a different importance: high and low.

A. Encoder

An LZW encoder which has two codebooks for each medium is employed as the source encoder. The codebook size is 2^{13} each and LUR scheme (Least Use Remove) is used for codebook replacement. Each codebook is cleared every 10000 symbols.

As the channel encoder, two convolutional coders which have different code rates are used. A high level encoder and a low level encoder have a code rate of $\frac{1}{3}$ and $\frac{2}{3}$ respectively. Also, the constraint length is 2 in each convolutional coder.

Table 1: Spec of Systems

LZW Encoder	Codebook Size	Number of Codebooks
System 1	2^{14}	1
System 2 Proposed	2^{13}	2
Convolutional Code	**Code Rate**	**Constraint Length**
High Level	1/3	2
Low Level	2/3	2
One Level	1/2	2

B. Decoder

At the receiver side the convolutional codes are decoded by the Viterbi algorithm. We use a decoder which can decode all convolutional codes with only one Viterbi decoder. The source decoder is an LZW decoder which has two codebooks for each medium.

C. Comparison

We can compare the error rate, considering the importance of each source, against the following and Table 1:

- Using one table for source coding and one convolutional code for channel coding. For to make even the overall bit rate, convolutional code which has code rate $\frac{1}{2}$.[System 1]
- Using multiple universal coding for source coding and a high and a low level convolutional codes for channel coding. However, without information between the source and the channel coder. [System 2]

In this simulation, we use images and japanese text as the multimedia information sources and these appears with the same probability, $\frac{1}{2}$.

Fig.4 shows a bitrate after source coding. Our scheme achieves the best performance.

In Fig.5, we show the overall bit rate after channel encoding. The overall bit rates are almost same. However in Fig.6 and Fig.7, our combined source and channel coding system has better performance than without combined system.

V. Conclusion

In this paper, we proposed a combined source and channel coding system that corresponds to a universal encoder and several convolutional codes. Our proposed system is effective for Multi-Media information sources which have different importance, because our proposed system can protect the important medium more than a conventional system. Also, we showed the advantage of combined source and channel coding against

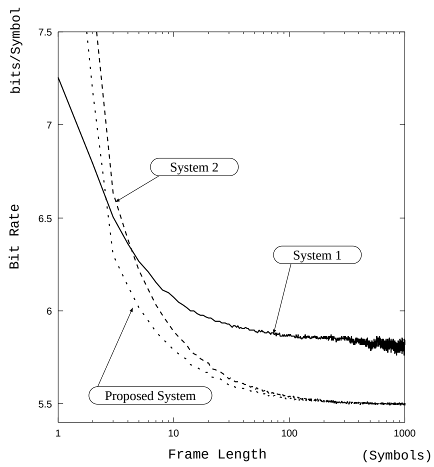

Figure 4: Compression Bit Rate

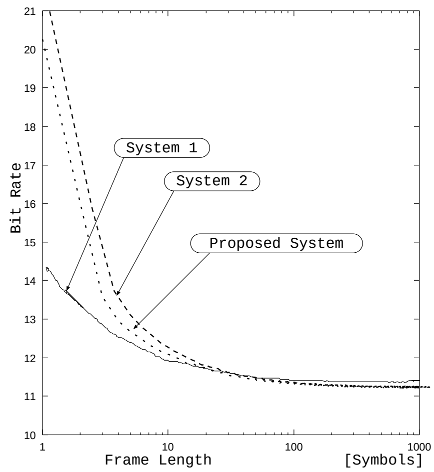

Figure 5: Overall Bit Rate

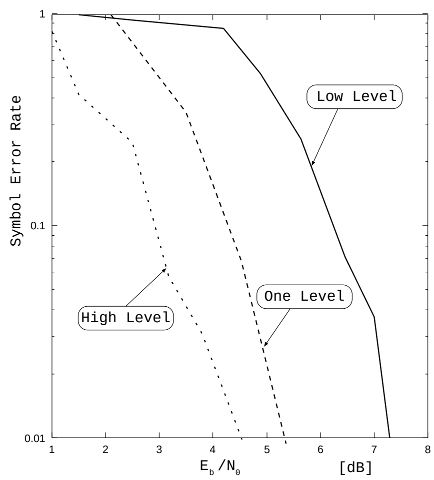

Figure 6: Symbol Error Rate for the Proposed System

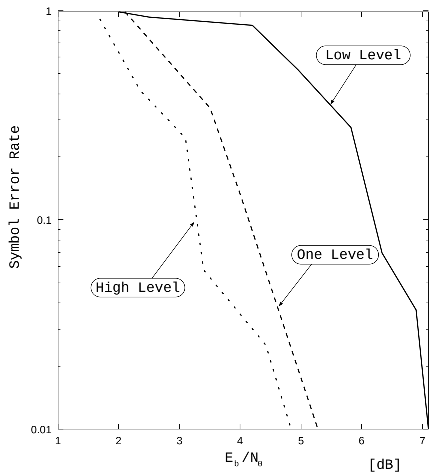

Figure 7: Symbol Error Rate for the Comparison System[System2]

a system without combining in terms of bit rate and symbol error rate. Computer simulation shows good performance against other schemes.

We should consider the importance among each medium and the way to have many levels of importance. Also, we consider the parallel channel and coding schemes using correlation among media in future work.

References

[1] T. Sasaki, R.Kohno, H. Imai,"An Error-Controlling Scheme Based on Different Importance of Segments of a Natural Language," IEICE Trans. Fund. Vol. E75-A, No.9, 1992.

[2] N. Suzuki, T. Sasaki, R.Kohno, H. Imai,"An Error-Controlling Scheme according to Different Importance of Segments of Model-based Coded Facial Image," IEEE International Symposium of Intelligent Signal Processing and Communication System(ISPACS '93), 1993.

[3] S. Fujioka, R. Kohno, "LZW Coding Scheme Using Multiple Dictionaries for Compression of Multimedia Information," Technical Report of IEICE , IT95-3, pp.13–18, 1995.

[4] M. Matsunaga, D. Asano, R. Kohno, "A Study on Unequal Error Protection Using Several Convolutional Code," Technical Report of IEICE , IT95-75, pp. 37–42, 1995.

[5] J. W. Modestino, D. G. Daut, "Combined Source-Channel Coding of Images," IEEE Trans. on Com., vol. COM-27, No.11, pp.1644–1659, September 1979.

[6] D. K. Asano, R. Kohno,"A TCM-based Unequal Error Protection Scheme for Intelligent Communication," Technical Report of IEICE , IT96-21, pp. 67–72, 1996.