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Coding Techniques for Intelligent Communication over a Satellite Link

衛星通信路上における知的通信のための符号化技術

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Abstract

In this paper, intelligent communication techniques are proposed for use over a satellite link. Specifically, an intelligent error control coding technique is proposed that takes into account the importance of the information. The proposed technique is shown to protect the important information more than an equal error protection scheme. A combined source and channel coding system is also proposed. This scheme improves the performance of an entire system by detected channel decoding errors during the source decoding stage. Finally, satellite transmission experiments using text and images are proposed to test the proposed intelligent communication techniques.

I Introduction

Conventional communication techniques treat information as bits. This works well for many types of information, but is not necessarily the most efficient for communication between human beings. In contrast, intelligent communication techniques extract the meaning of the information. These two approaches are shown in figure 1.

In intelligent communication systems, extracting the information can serve two purposes. One is to reduce the amount of information that must be transmitted, i.e., compression, and the other is to more efficiently protect the information from channel noise, i.e., error control coding. These two objectives may be treated separately or together.

In previous work [1] [2], intelligent compression was considered. In this paper, we look at intelligent coding techniques. In particular, we consider techniques for satellite communication channels.

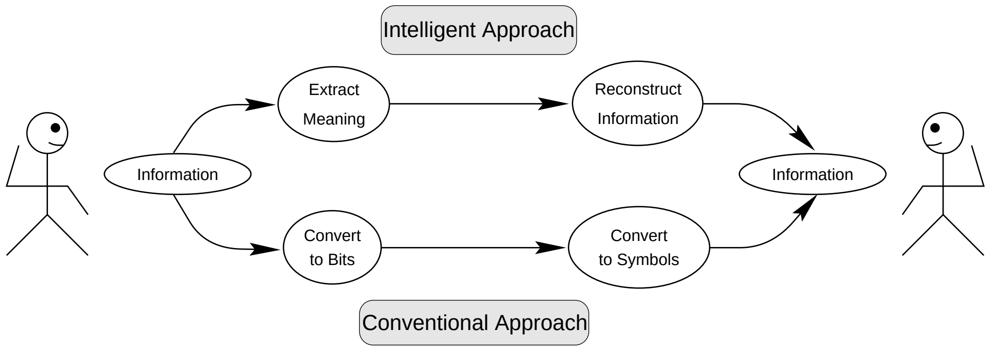

Figure 1: Conventional vs. intelligent communication.

In intelligent communication systems, not all the information is necessary to understand the message. On a character level, if some of the letters are missing or incorrect, the word can still be recognized by a human receiver. On a word level, not all the words are necessary to understand the sentence. In figure 2, we show a sample sentence with the importance of the letters shown as high ('H') or low ('L'). Even if the low importance letters are transmitted incorrectly, the original sentence can be reconstructed by using a dictionary and grammar rules. We can see that in these communication scenarios, information of varying importance naturally occurs.

The	quick	brown	fox	jumped	over	the	lazy	dog.
LLL	HLLHH	HHLLH	HLH	HLHHLL	HHLL	LLL	HLLH	HLH
---	q--ck	br--n	f-x	j-mp--	ov--	---	l--y	d-g.

Figure 2: A sample sentence with importance of the letters labelled 'H' or 'L'.

II Intelligent Channel Coding

To take advantage of the irregular nature of the importance of the information, we proposed unequal error protection (UEP) codes [3] [4] [5] [6]. For two importance levels, the system model is shown in figure 3.

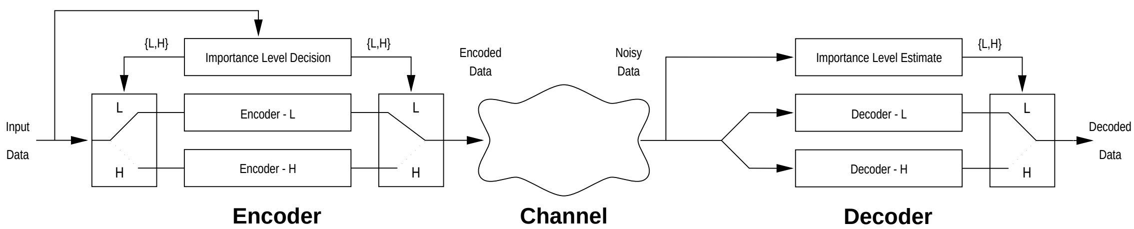

Figure 3: The UEP system model.

In these UEP codes, the error protection capability of the code is changed depending on the importance of the information. This is done by using a different code for each level of importance. Since we use convolutional codes in this work, the bits are divided into frames. The importance level is the same for all bits in a frame.

To decode the data, the received bits are decoded with all decoders in parallel. The bits from the decoder that results in the smallest metric are chosen as the estimates of the original information. Since we do not add extra information as to which encoder was used to encode the data, it is necessary to somehow distinguish between coded bits from each encoder.

Using just convolutional codes, it is difficult to distinguish between bits from each encoder, because the transmitted bits are either “0” or “1” irrespective of the encoder. To create differences among the outputs of each encoder, Trellis Coded Modulation (TCM) is used. Each encoder uses a different signal constellation, so that the receiver can distinguish between bits from each encoder.

The performance of this system is shown in figure 4 for two signal constellation types. From this figure, we can see that the important bits (marked with an ‘H’) are protected more than the less important bits (marked with an ‘L’). For comparison, an uncoded system and an equal error protection system (Coded QPSK) are shown. The error rate of the important bits in the unequal error protection scheme is better than that of the equal error protection scheme.

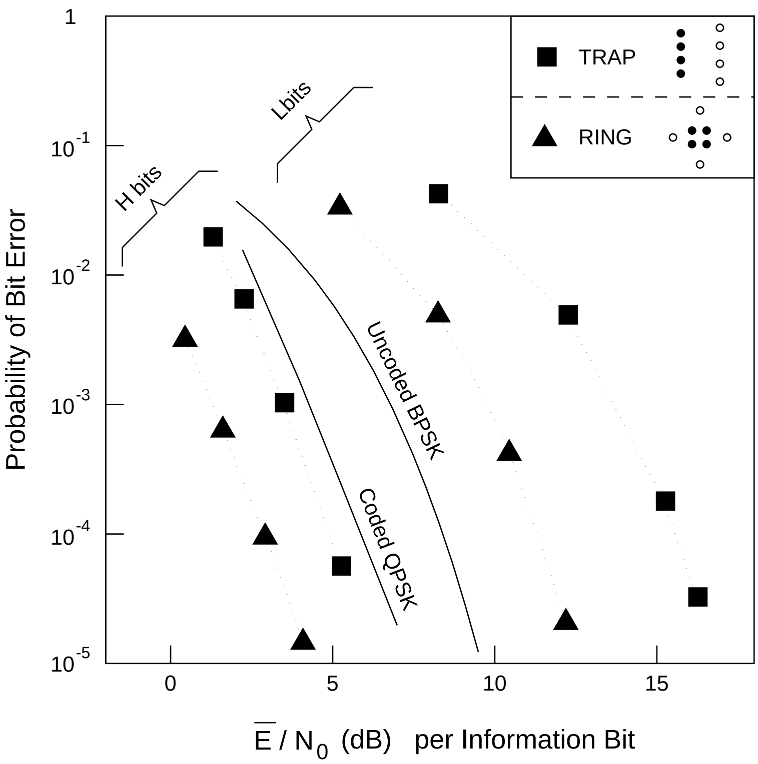

Figure 4: Performance of UEP coding system.

III Combined Source and Channel Coding

Another technique that takes advantage of the different importance of information is combined source and channel coding. This technique uses the output of the source decoder to correct errors in the channel decoder. Specifically, the source decoder can detect whether the reconstructed information is valid or not.

As an example, we propose the system shown in figure 5 [7]. The information is converted to codewords by the source encoder and passed to the channel encoder along with the importance of the codeword. The channel encoder adds error protection depending on the importance of the codeword. At the receiver side, the channel decoder decodes the received bits and sends them to the source decoder with the estimated importance of the bits. The source encoder reconstructs the source information. If the length of the reconstructed data is not correct, then this indicates that the channel decoder has chosen the wrong decoder when decoding the received bits. This system improves the performance of combined source and channel coding.

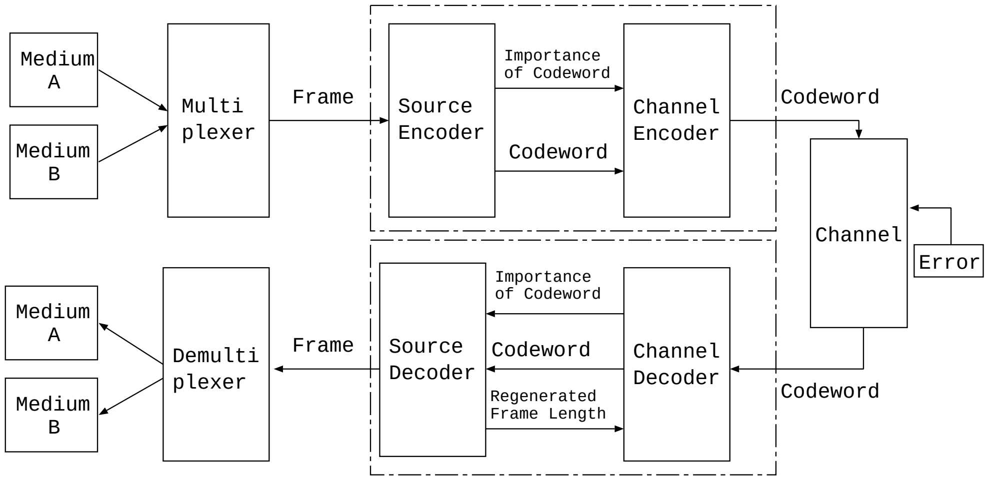

Figure 5: A combined source and channel coding system.

IV Satellite Transmission Experiments

A Text Transmission

To test the proposed intelligent error control coding techniques, we propose to use the COMETS satellite's communications link. Natural language text is encoded by the proposed intelligent error control technique and transmitted. The performance of the system can be evaluated by examining the received text after intelligent decoding. The combined source and channel coding technique can also be tested using the same system.

B Image Transmission

The system that we consider for use in this experiment is shown in figure 6. The images that we consider here are facial images. A CCD camera connected to a workstation is used to load the image. The workstation then processes the image and converts it to a series of low rate commands that describe the movement of the image. This information is transmitted over the COMETS satellite's communications link and then the original image is reconstructed using a workstation at the receiver.

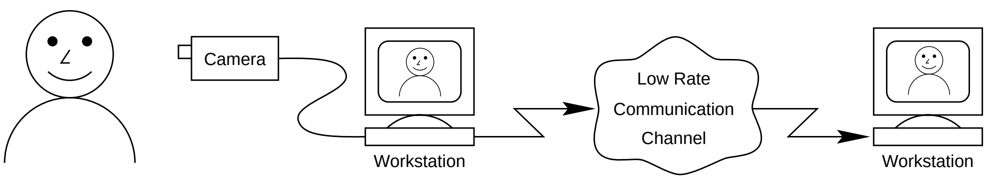

Figure 6: Intelligent image transmission system.

Intelligent error control coding is added to the commands before transmission. Similarly to the text experiment, the performance of the proposed technique can be evaluated by examining the received images after intelligent decoding and comparing it to a conventional error control coding scheme. Again, the proposed combined source and channel coding technique can also be tested with this system.

V Conclusions

In this paper, intelligent error control coding and combined source and channel coding techniques have been proposed for use over a satellite link, such as the COMETS satellite. The intelligent error control coding scheme can protect important information more than a conventional equal error protection technique. The combined source and channel coding system can improve the performance of the entire system, since the source decoder can detect errors that may go undetected by the channel decoder. Finally, text and image transmission experiments are proposed that use the COMETS satellite.

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