A Modified Dirty Paper Trellis Codes for Digital Watermarking

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Abstract—**Watermark algorithm relies on informed coding which is the scheme of representing of watermark message with patterns that dependents on the host. It offers a large number of alternative vectors to represent the same message. And the feature is trade-off between the robustness and fidelity. The paper describes a modified trellis to embed our data, instead of complex trellis, to reduce the computational time to find the vector among the alternative vectors appropriate to the host.**

Keywords— **Informed coding, robustness, watermarking.**

1. INTRODUCTION

Watermarking (data hiding) is a process to embed some information in the signal that we transmit. The basic idea about watermarking is to hide the information into the signal so that the distortion of the signal is minimal. When the receiver get the signal, he or she can regain the embedded information completely. Here are the two major issues : fidelity and robustness. To keep the balance between fidelity and robustness, It has led to the design of algorithms for informed embedding and informed coding. In informed embedding [1], each watermark pattern is modified according to the host. In informed coding, many watermarks represent.

2. TRELLIS CODE FOR WATERMARKING

Fig.1 illustrates the watermarking system we take. We have a message m and a host C_0.for hiding m into C_0, the encoder generates many code vectors and chooses the one (W_m) which is suitable for C_0. Next, for enhancing the robustness, we modify W_m to produce W_a. Finally, W_a is added to C_0 to produce the watermarked signal C_m. In this paper, we focus the process of encoding step.

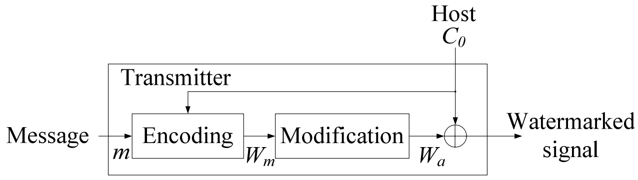

Fig. 1. Informed coding watermarking

2.1. Blind Coding

Before informed coding, we discuss the "blind" coding. The word "blind" means the host C_0. It does not play any role when we encode the message m. That means the identical message m is mapped into one code vector. Fig.2 depicts a trellis structure of blind coding. We define a "section" of the trellis as a previous node column going to the next column. Every state node has two arcs linked to the state of next column e.g. A0 links to A1 and C1. Each arc in a section is labeled a N-length codeword. The dotted arc corresponds to "1" and the other corresponds to "0". Each L-length message with connected arcs in trellis is encoded into a $L \times N$ code vector by the concatenation of labels for the arcs.

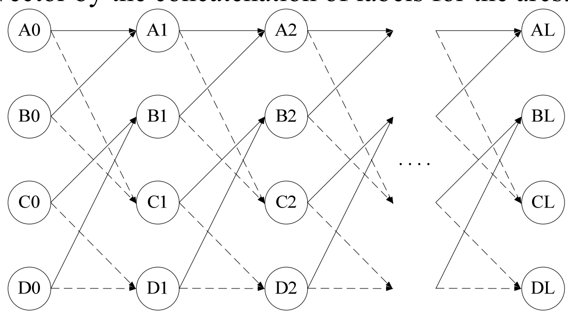

Fig. 2. Blind coding: four states, eight arcs trellis

2.2. Informed Coding

The key difference between blind coding and informed coding is that there are two or more code vectors occurred to represent the same message [3]. We still use one section of trellis to encode a single bit of message here. The trellis is showed in Fig.3, each state node has four arcs. In first encoding process, we remove the unnecessary arcs. For example, if the message is $(0,1,1,\cdots,0)$, the trellis is showed in Fig.4. Next, we apply the Viterbi decoding algorithm [4] to the host. To find the closet Euclidean Distance code vector through the removed-arcs trellis.

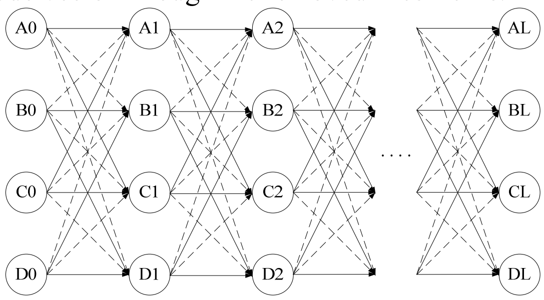

Fig. 3. Informed coding: four states, sixteen arcs trellis

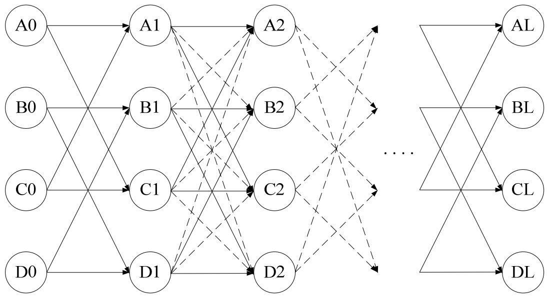

Fig. 4. Informed coding trellis for Viterbi algorithm

2.3. Modifying Informed Coding

Here we modify the above trellis structure, Fig.2 and Fig.3. We use a parallel arc type of trellis. Depicted in Fig.5. In this trellis, the connection of each node state is equivalent to blind coding but there are two arcs from one state node to the same state node in next column. In other word, we have the same trellis as blind coding, but we have double arcs of blind coding for this trellis. Like informed coding, both host C_0 and message m participate in encoding. We take off the redundant arcs by message m. However, we pick the closest code vector in trellis without the Viterbi decoding algorithm. See fig.6. The message m is $(0,1,1,\cdots,0)$ and one bit mapped one section. In first section, we choose the arc which is closet Euclidean Distance to host from A0 to A1, and go to second section. We choose the arc which is closest host from A1 to C2, and go to third section, and so forth till the end.

2.4. The Detection

If the length of message m is L, for the same message and starting A0, we have only one code vector in using blind coding. $(\frac{A}{2})^L$ [5] (A is the number of arcs per state) code vectors is using informed coding and modified informed coding is used in 2^L code vectors. After the encoding, the closest length $L \times N$ code vector, W_m is produced by above three trellis code methods. To the receiver, the detector applies Viterbi algorithm by using the entire trellis. It identifies a path that is the closet Euclidean Distance with the received host $C_w^{'}$. The hiding message is decoded by the corresponding with the bit represented by the arcs in this path.

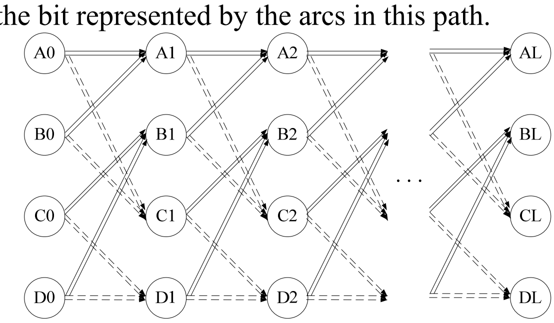

Fig. 5. Modified informed coding: four states, sixteen arcs trellis

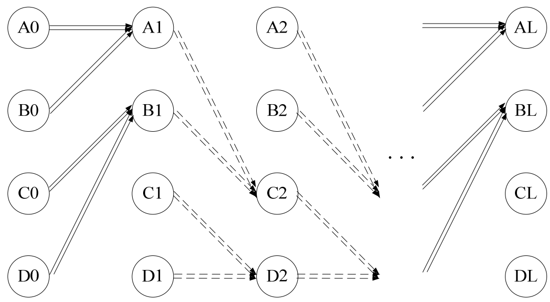

Fig. 6. Modified informed coding trellis for encoding

3. EXPERIMENTS AND RESULTS

In this section, we test the performance of the three trellis codes described above, such as blind coding, informed coding and modified informed coding. We use the same image but the random message we want to embed. The steps of this experiment are as follows. Transmitter:

1) Covert image to 8×8 frequency domain block by DCT (Discrete Cosine Transform).

2) Extract the low-frequency coefficient from the blocks into a single $L \times N$ vector, V_e, called as extracted vector.

3) Use the three trellis codes to encode the desired message, m into a $L \times N$ code vector, W_m.

4) Enhance W_m and add to V_e, with blind embedding, $W_a = W_e + \alpha W_m$, α is the W_m's strength coefficient.

5) Replace the value of the low-frequency coefficient of the DCT blocks in the same order by W_a.

6) Covert the embedded-message image, C_m to spatial domain.

7) Corrupt C_m with two attacks: Additive white Gaussian noise and JPEG compression attack.

Receiver:

1) Covert the received image $C_w^{'}$ and extract the vector $V_e^{'}$ e as transmitter step 2.

2) Apply Viterbi algorithm to $V_e^{'}$ in the entire trellis. Find the closest path.

3) Get the hiding message by the bits that correspond to arcs in this path. We use the same number of states and arcs per state to keep the equal trellis complexity. We choose 16 states and 4 arcs per state. Each arc was labelled with (31, 5) simplex code. (31, 5) that means the code has 25 codewords with length N = 31, and {0, 1} codewords is mapped to $\{-1,1\}$. For example, $(00101) \Rightarrow (-1-11-11)$. To match the number of codewords to the number of arcs in informed coding and modified informed coding, we produce a complement of this (31,5) simplex code to be the (31,6) code. We place these codewords in trellis arcs, but we have to keep the parallel arcs' distance maximal in the modified type. This test image is 512 × 512 pixels. We use the 12 low-frequency coefficient each 8 × 8 blocks, fig.7. So, we have $12 \times \dfrac{(512 \times 512)}{64} = 49512$ coefficients and pick the former 49135 coefficients for extracted vector. We embed 1585 bits with N = 31. Fig.8 and Fig.9 shows the result, Fig. 7.

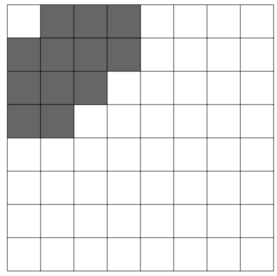

Fig. 7. 12 low-frequency coefficients

12 low-frequency coefficients of the watermark. As we can see when α increases, BER decreases. Keeping the PSNR, modified informed coding gets the better BER performance. In PSNR= 34dB, modified informed coding can be close to 10^{-5},informed coding, 5×10^{-4}, and blind coding is equal to 10^{-2}. We compare the performance with different trellis codes except blind coding. We use different trellis structures (informed coding and modified-informed coding)with different labels in the arcs(simplex code and Gaussian random code). We keep the same PSNR change the α. The result is depicted in fig.10. In the other hand, see Fig.11 and Fig.12, we use the same α to maintain the quality of the embedded image (α = 8 PSNR= 37.34) and corrupt this image by two attacks with different strength. Fig.11 is under AWGN attack and Fig.12 is through JPEG compression attack. According to the result above, Fig.10, Fig.11, Fig.12), we found that By using the modified informed coding with simplex code, it has the better performance among the all trellis codes.

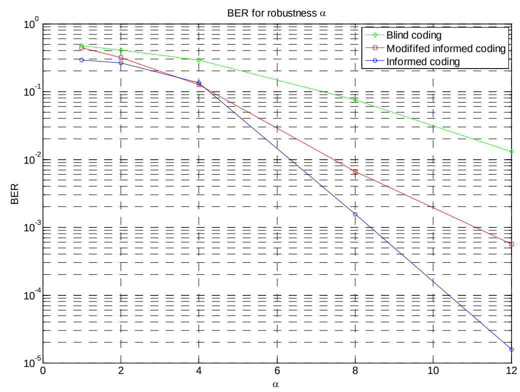

Fig. 8. BER for robustness alpha

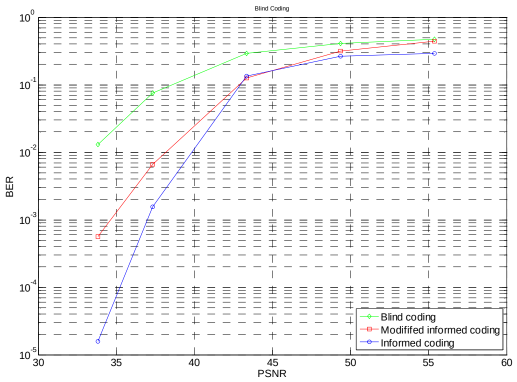

Fig. 9. BER for image quality (PSNR in dB)

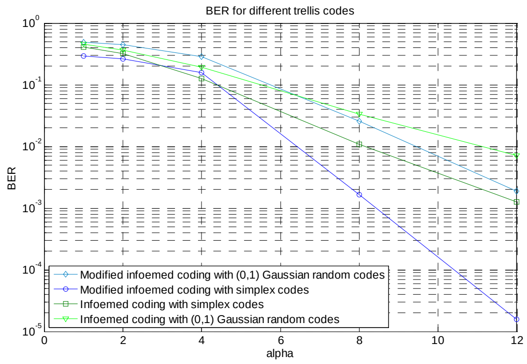

Fig. 10. BER for different trellis codes

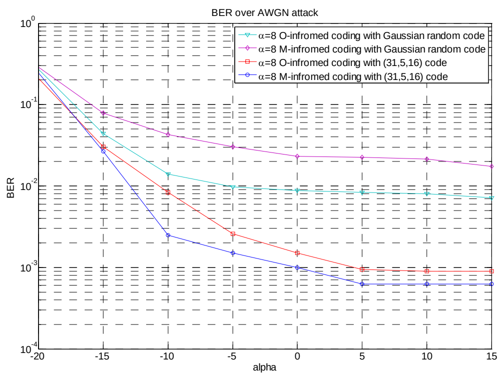

Fig. 11. BER over different trellis codes

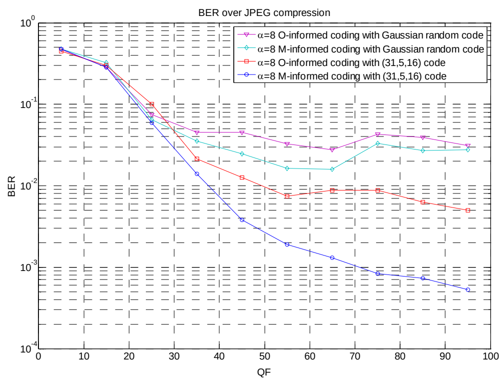

Fig. 12. BER over JEPG attack

4. Conclusions

Here, we have presented the modified informed coding trellis code for data hiding. We take this trellis code with the modified trellis structure and simplex code to embed 1585 bits in 512×512 pixels image. The above trellis code can resist the channel attack and keep the fixed amount being accurate efficiently. In further steps, how to use informed embedding[1] to enhance the robustness of hiding message with this trellis structure and increase the hiding message payload to get higher capacity but not to change the size of image.

References

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