터보 코드의 적용을 통한 워터마크 신호 보호 및 원 영상의 화질 보존

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Protection of Watermark Signals and Preservation of Original Images by Turbo Encoding

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Abstract

This paper proposes on the implementation of efficient image transmission system by generation and protection of watermark signals. For this, the image structure understanding is performed for improving the image quality and the generation of watermark signals. Then, the histogram is constructed and the watermark signals are selected from this. At this stage, by embedding of the coefficients of curve fittness into the lower 4 bits of the image data pixels, image quality degradation due to the embedding of watermark signals are prevented. Finally, turbo encoding is performed to solve the problem of watermark signal losses that may occur on channels when transmitting. Especially, a new interleaving method called semi-random interleaver is proposed.

I. Introduction

Due to rapid increase in the number of computers in the coming knowledge information society, a vast amount of document and data, which are used in the existing off-line world, are converted to electronic documents usable in the online world. However, although, as a positive function, the mutual exchanges of electronic documents, i.e., multimedia data, provides conveniences for editing, transmitting and storing of multimedia data, it results in, as a negative function, problems such as copyright disputes or illegal copying.

Therefore, in order to achieve the efficient multimedia communication system, the protection of ownership rights must be guaranted. For this, Watermark techniques have been developed [1]~[6]. Also, the watermark signals are conserved in transmission processes. Therefore, we propose the efficient transmission system for generation of watermark signals and protection of watermark signals in transmission processes.

For this, in this paper, the image quality is improved through image structure understanding and the histogram analysis of the improved image provides the watermark signals which uses the coefficients of curve fitting. This method not only automatically provides each different watermark signals but also improves the image quality. Also, by using the coefficients of curve fitting, it prevents image quality degradation due to the embedding of watermark signals. Finally, turbo encoding is performed to prevent watermark signal losses due to the noises on channels when transmitting. Finally, we demonstrates the efficiency of the proposed paper.

II. Generation and Embedding of Watermark Signals

1. Generation of Watermark Signals

To generate watermark signals, we improve the image quality by understanding image structures.
The image structure is defined as follows.

L	L	L		S	S	L		S	L	L		L	L	S		S	S	S
L	C	L		S	C	L		S	C	L		L	C	S		S	C	S
L	L	L		S	S	L		S	S	S		S	S	S		L	L	L

S	L	S		S	S	S		L	L	S		L	L	L		L	L	L
S	C	S		L	C	S		L	C	S		L	C	S		S	C	L
S	S	S		L	L	L		L	S	S		S	S	S		S	S	L

S	S	S		S	S	L		S	S	L		L	L	L		L	S	S
S	C	L		S	C	L		S	C	L		S	C	L		L	C	S
L	L	L		S	L	L		L	L	L		S	S	L		L	L	S

L	S	S		L	L	L		S	S	S
L	C	S		L	C	S		S	C	S
L	L	S		L	S	S		S	S	S

(Fig. 1) The Set of Image Structures

The functions of 'S' and 'L' are defined as equation (1) and (2) respectively.

$$f_{Large}(X) = \frac{X}{255} \quad \text{----------- (1)}$$

where X= | C-L |

$$f_{Small}(X) = \frac{-X+255}{255} \quad \text{--- (2)}$$

where X= | C-S |

The histogram of the resulted image is used to provide watermark signals. To use a histogram for watermark signals, the analysis of the histogram is performed.
Firstly, region segmentation is done. For this, the evaluation function is defined as the ratio of between-variance(V_b) to total-class variance(V_t).
Secondly, features of segmented histogram are analyzed and are selected as watermark signals. This is peformed applying curve fitting of n^{th} order on each segmented region. i,e.,

$$E = \sum_{i=0}^{M} (y_i - P(Xi))^2 \quad \text{-----------(3)}$$

where $P_n(X) = \sum_{k=0}^{n} a_k X^k$

Partial derivatives is applied for finding the coefficients of curve fitting.

$$\frac{\partial E}{\partial a_j} = (-2 \sum_{i=0}^{M} y_i X_i^j) + 2 \sum_{k=0}^{i} a_k \sum_{i=0}^{M} X_i^{j+k} = 0 \quad \text{-----------(4)}$$

At this stage, we obtain the normal equation as following.

$$\sum_{k=0}^{n} a_k \sum_{i=0}^{M} X_i^{j+k} = \sum_{i=0}^{M} y_i X_i^j \quad \text{-------(5)}$$

In this paper, parabola curve fitting is adopted.

2. Embedding of Watermark Signals

Two pairs of three coefficients of parabola curve fitting are embedded into the original image as watermark signals. At this stage, as all 18 signals are embedded into the lower 4 bits of image data, as integer values between 0 to 9, there does not occur any image quality degradation. Also the positions of watermark signals are selected using equation (6).

$$X_{i+1} = (aX_i + C) \bmod m \quad \text{-------(6)}$$

where i=0,1,⋯,35

III. Protection of Watermark Signals and Noise Removals in Transmission Processes

1. Semi-Random Interleaver

In this paper, a new interleaving method, the semi-random interleaver, is proposed. Let the number of input bits be N, then the size of interleaver is N/2. The data are sequentially written in the memory in columns.

<Table 1> Data Input Processing in Interleaver

1	2	3	4
5	6	7	8

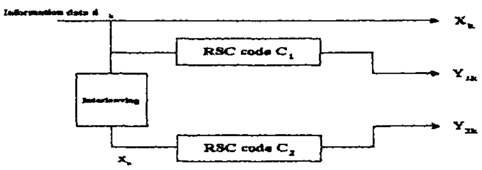
When all the data are stored in the memory, the data are read using random number generation. Finally, the $(N/2 + 1)^{th}$ one is put at the last position.

<Table 2> Writing Procedure in Interleaver

1(13)	2(10)	3(15)	4(14)
5(9)	6(12)	7(11)	8(16)

2. Turbo Encoder

Turbo coder consists of two RSC (Recursive Systematic Convolutional Code) and an interleaver.



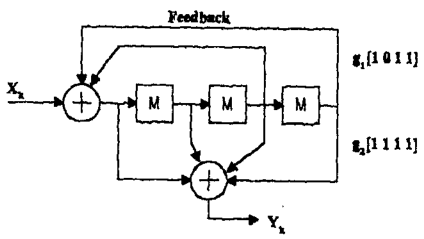
(Fig. 4) Typical Turbo Encoder

In the above figure, let the code rate be 1/2, the length of constrained length be K, and the k-th coder input of convolutional coder be d_k bit. Then the output (X_k, y_k) can be given as:

$$X_k = \sum_{i=0}^{u} g_{1i} d_{k-1} \qquad d_{1i} = 0,1 \text{ ------- } (7)$$

$$Y_k = \sum_{i=0}^{u} g_{2i} d_{k-1} \qquad d_{2i} = 0,1 \text{ ------- } (8)$$

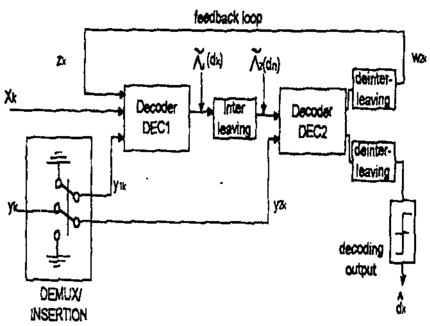
Here, G_1:{g_{1i}}, G_2:{g_{2i}} are the generation sequence, which are presented in octal digits. The constituent code of turbo coder is selected considering the transmission rate and error correction capability.
Two RSC codes are regarded as a feedback form from the feedback of convolutional code system: (Fig. 3) is a practical example and other various forms can also be configured. The structure of RSC code has an important role affecting the overall performance of turbo code coder, and so do the various constituent codes.



(Fig. 3) RSC Coder

3. Turbo Decoder

To decode the output code from two RSC codes, the decoder in the decoder part consists of two serially connected decoders, DEC1 and DEC2.
DEC1 decodes the information bit d_k and the first RSC coder's output, Y_{1k}. The decoded signal by DEC1 is put through the interleaver, and, with the second RSC's output Y_{2k}, is fed into DEC2. The decoded signal by DEC2 is put through the inverse interleaver, and is feedbacked to DEC1, and performs the recursive decoding to improve the performance.
The algorithm used in DEC1 and DEC2 is briefly described as follows:
The information bit is transmitted via the channel as frames of size N. Decoding is performed using MAP algorithm: MAP is an algorithm which observes the all received signal frames and choose the value which has the bigger probability, to be either 0 or 1, at any visual point.



(Fig. 4) Turbo Decoder

i.e., LLR (Logarithm of Likelihood Ratio) is calculated as follows:

$$\Lambda(d_k) = \log \frac{\Pr\ \{d_k = 1 \mid observation\}}{\Pr\ \{d_k = 0 \mid observation\}}$$

Decoding is performed:

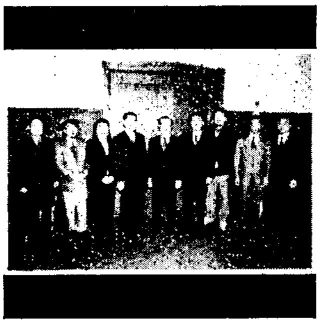
$$\Lambda(d_k) \geq 0 \text{ 이면 } d_k = 1$$

$$\Lambda(d_k) < 0 \text{ 이면 } d_k = 0$$

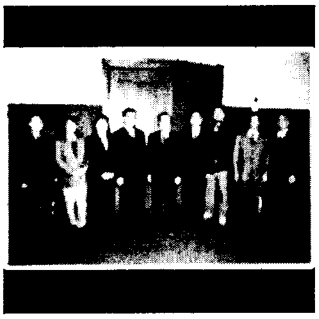
Ⅳ. Experments and Observations

The experiments in this paper have been performed

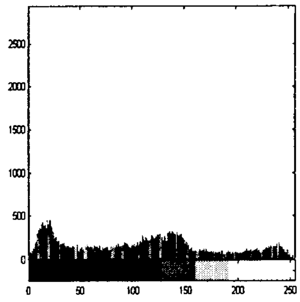
on a Pentium CPU based PC using Visual Basic
(Fig.5), (Fig.6) and (Fig.7) show the original image, quality improved image and the histogram respectively. Finally, watermark embedded image is shown in (Fig.8) Also semi-random interleaver for Turbo coding is experimented and the performance test results are given <Table3>. As shown in the experimental results, each different watermark signal is generated for individual images, which is then embedded into the original images without image quality degradation. Also semi-random interleaver has been proved to be applicable to real time image communication.



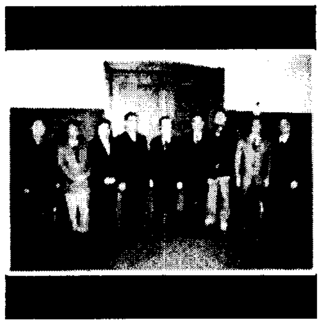
(Fig.5) Original Image



(Fig.6) Quality Improved Image



(Fig.7) Histogram



(Fig.8) Watermark Embedded Image

<Table3> Performance Evaluation Analysis of Interleaver Methods

Length of Interleaver	No. of Repetation	BER	Interleaver Methods	Eb/No [dB]
65536	6	10^{-4}	Random	0.96
			Diagonal	1.81
			Block	1.92
			Semi-Random	2.45

V. Conclusions

An efficient image transmission method in multimedia communication system by generation and protection of watermark signals is proposed. The proposed digital watermarking method automatically provides each different watermark signals for individual images, which is not possible in the existing watermark techniques. Additionally it improves the image quality.
Future work will seek to address the issues, such as to apply turbo encoding on watermark embedded images.

References

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