Revaluation of Error Correcting Coding in Watermarking Channel*

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Abstract. Robustness is one of the most important issues in digital watermarking. By modeling digital watermarking as digital communications, several researchers proposed using error correcting coding (ECC) to improve watermark robustness. However, the following important facts are neglected. i) The robust watermark channel suffers from a very high bit error ratio (BER), which may exceed the capability of ECC; ii) Due to the imperceptibility requirement, the redundancy introduced by ECC will lead to a decrease of the watermark magnitude. Could the usage of ECC effectively improve the robustness of watermark? This paper addresses this problem from the perspectives of both theoretical analysis and experiments. Our investigation shows that ECC cannot effectively improve the robustness of watermarking against a vast majority of various attacks except for cropping and jitter attacks. Hence, ECC should not be considered as a universal method applied to enhance the watermark robustness.

1 Introduction

Imperceptibility and robustness are two basic requirements of watermarking in many applications. Hence, one of the important goals of watermarking is to improve robustness while keeping the watermark imperceptive. This presents a great challenge.

To improve the robustness of watermarking, much effort has been made. Due to similarities between digital watermarking and digital communications, some papers in the literature viewed watermarking as a digital communication problem [1,2] and hence applied the theories and methods of digital communications to watermarking. It was reported that some watermarking algorithms applied ECC to lower BER of watermarks and thus improve robustness. For example, BCH code, convolutional code [3], RS code [4], and Turbo code [5] have been adopted.

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The above idea seems straightforward since ECC is effectively used in noisy channel in digital communications. It should be, however, noted that there are some differences between watermarking and digital communication. That is, watermark, as a very weak signal, is embedded in a media under the constraint of imperceptivity, and often suffers from extremely noisy attack. In fact, this difference has been overlooked in literature. When applying ECC to enhance robustness of watermarking, the following problems will arise. i) Is ECC effective in the improvement of watermark robustness? And to what extent could ECC improve the robustness? ii) Which error correcting code performs best for watermarking? iii) How to choose the coding ratio in using ECC?

Some efforts to address above issues have been reported. Huang et al. [6] compared the performance of repetition coding and BCH coding, hard-decision decoding and soft-decision decoding. Zinger et al. [7] investigated the performance of BCH coding, repetition coding, and their concatenations over watermarking channel modeled as binary symmetric channel (BSC). They claimed that if the channel error rate is high, it makes sense to adopt repetition coding to embed few watermark bits; if the channel error rate is not high, it is better to apply hybrid coding; if the payload is quite large and the channel error rate is lower than 10%, BCH coding with subtraction is the best choice. Baudry et al. [8] addressed ECC strategies in watermarking. They analyzed the performance of BCH coding, repetition coding, and their concatenations. A new algorithm for BCH soft decoding is proposed. Balado et al. [9] pointed out that Turbo coding schemes has lower error rate than hybrid coding for the same amount of hidden information.

However, the following important facts are neglected in the above efforts, when applying ECC to watermarking. i) The robust watermark channel suffers from a very high BER, sometimes, which may exceed the capability of ECC; ii) Due to the imperceptibility requirement, the redundancy introduced by ECC will lead to a decrease of the hidden watermark magnitude. Naturally, a problem arises: Could the usage of ECC effectively improve the robustness of watermarking?

In this paper, we address this problem from the perspectives of both theoretical analysis and experimental investigation. Based on the analysis of the relationship between embedded watermark strength and ECC coding length, the paper discusses the ECC coding length and the robustness of watermarking. By comparing the robustness performance by applying BCH coding and not using ECC, we claim that for common signal processing including compression and noise corruption, ECC cannot improve the robustness of watermarking. ECC is beneficial only in those attacks where the bit error rate in watermark detection does not depend on the watermarking strength.

The paper is organized as follows. Section 2 describes a general communication model for watermarking channel. In Section 3, we analyze the watermarking channels with different error correcting ability. Experimental results supporting the analysis are given in Section 4. Finally, conclusions are drawn in Section 5.