

# Chapter 4

## Literature Review of Selected Watermarking Schemes

This chapter gives a review of selected state-of-the-art watermarking techniques that are widely used in watermarking systems.

### 4.1 LSB CODING

One of the earliest attempts of information hiding and watermarking for digital audio signal is least significant bit (LSB) coding / replacement. In the simplest implementation, the least significant bit of the host signal is replaced by the to-be-hidden watermark bit. In a more secure scenario, the watermark encoder uses a secret key to choose a pseudo random subset of the all of the host signal samples. The replacement of watermark is performed on those chosen samples. In the decoder side, the same secret key is used to select those watermarked bits in the received signal.

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In order to recover the whole watermark, the decoder needs all the stego samples used by the encoder. The obvious advantage of LSB is the high watermark capacity. For example, when using only the least significant bit of the CD quality (44.1 kHz sampling rate, 16 bits per sample) host signal, the encoder can achieve 44,100 bits per second (bps) watermark capacity. Some audio watermarking system uses the least 3 or even 4 significant bits of the host audio signal for watermarking embedding, achieving super high 132.3 kbps to 176.4 kbps watermark capacity. Another advantage of LSB coding is the simplicity, which requires very little computation cost for both the watermark encoder and decoder, making real time watermark embedding and extraction possible, even for computation power limited devices. However, although it's simple to implement, LSB has several disadvantages:

- a. The random replacing of the samples selected by the encoder introduces low energy additive white Gaussian noise (AWGN), which is very perceptible to human auditory system (HAS), creating annoying audible distortion.
- b. LSB coding has very little robustness. Simple attack like random cropping or shuffling will destroy the coded watermark.
- c. The depth of LSB is limited. In order to minimize the possible audible distortion, only the least 4 significant bits of the 16 bits per sample host audio signal can be used for watermark coding purpose.

## **4.2 PATCH WORK**

Patch work was originally developed for image watermarking (Bender et al. 1996) and later being used for audio watermarking as well. Patch work algorithm uses statistical hypothesis on two sets of large samples for information hiding, which makes it a good method for audio watermarking due to the huge amount of digital samples in audio host signal. In the simple patch work encoding scenario, a secret key is used to pseudo randomly select two sets of samples, i.e. patches. The amplitude of each sets are slightly changed in the opposite way, i.e. the amplitude of one set samples are increased by a small amount  $d$  and the amplitude of the other set samples are decreased by the same amount.  $d$  is carefully chosen according to the following rules:

- a. It is not too small so that it is robust to possible added noise during transmission and
- b. It is not too large to introduce audible distortion.

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