Chapter 7
Techniques for Improved Spread Spectrum Detection

In this chapter, techniques for improved spread spectrum detection are reviewed.

A typical detection method for spread spectrum is the computation of the cross-correlation between the received stego-signal and the actual watermark. If the computed output exceeds a threshold then a watermark is considered to have been detected in the received signal.

7.1 MATCHED FILTER APPROACH

Some watermarking system employs a pseudo random sequence (PN sequence) for synchronization purpose. Matched filter is usually used in such cases to detect the existence of the PN sequence and to precisely locate the starting sample of the PN sequence.

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In the watermarking system, the PN sequence is considered as noise added to the host signal. Since the PN sequence only lasts a very short period of time, it could be treated as transient noise pulses and detected by a filter whose impulse response is matched to the PN sequence. Such is the matched filter whose frequency response is defined as (Vaseghi, 2000):

$$H(f) = K\,\frac{PN^{*}(f)}{PSx(f)} \tag{7.1}$$

Where K is a scaling factor, $PN^{*}(f)$ is the complex conjugate of the spectrum of PN sequence $\{u\}$ and $PSx(f)$ is the power spectrum of the host signal x.

In real world applications, the host signal is very close to a zero mean process with variance σ_x^2 and is uncorrelated to the PN sequence. Then, Equation (7.1) becomes

$$H(f) = \frac{K}{\sigma_x^2}\,PN^{*}(f) \tag{7.2}$$

with impulse response

$$h(n) = \frac{K}{\sigma_x^2}\,u(-n) \tag{7.3}$$

When the received signal contains the PN sequence, it is defined as

$$y(n) = x(n) + \alpha u(n) \tag{7.4}$$

where α is a strength control factor. Then the output of the matched filter is

$$\begin{aligned} o(n) &= \frac{K}{\sigma_x^2}\,u(-n) * (x(j) + \alpha u(j)) \\ &= \frac{K}{\sigma_x^2}\,u(-n) * x(j) + \frac{\alpha K}{\sigma_x^2}\,u(-n) * u(j) \\ &= d_{\mu x} + d_{\mu} \end{aligned} \tag{7.5}$$

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