New Synchronization Method for Robust Watermarking using Dual PN

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Abstract: This paper presents new synchronization method for audio watermarking although it is applicable in other media as same. This method, which has been based on using two-PN for synchronization, presents lower overhead beside its robustness that makes it more interesting.

Key-Words: Audio Watermarking, Two-way Synchronization, Spread Spectrum, Framing

1 Introduction
Hiding meta-data inside a media such as video clip, audio clip or picture calls watermarking. Watermarking methods concatenate data into clip content not to removable with usual transforms [7,4]. Internet explanation has made a good market for watermarking methods for media authorization and copyright protection so method robustness becomes one of quality parameters of watermarking methods. Watermark proposed applications also include media indexing, advertising coverage research and broadcast coverage research which provides wide range of methods [5].

Synchronization is one of the most critical parts of a frame base watermarking structure. Actually most of intentionally and unintentionally attacks aim this point to remove watermark.

As the most of other methods [1, 3, 8] we use direct sequence spread spectrum (DSSS) method to embed data but we combine it with new synchronization method for novel watermarking algorithm.

2 Method Presentation
In this part we are going to explore new synchronization method.

2.1 Watermark Embedding
Usual synchronization methods, as applied in previous works [1,2], use single preamble mechanism to find frame start point. Each frame contains couple of sub-frame. In preamble methods some of first coming sub-frames in each frame, is allocated to known pattern. This pattern must be enough powerful to able detectors to find first sample of frame exactly. In very low power channel, as a watermark channel, preamble needs to be long and with low repetition period. It ends up to two complications: first reduction of overall usable power for data transition and second low preamble security which may be attacked easily. Here a modification will propose to eliminate synchronization problems in a watermarking channel.

![Figure 1 Watermark Embedding Structure](image)

New synchronization method structure has been shown in Fig.1.Here main sub-frames as usual methods, is divided into preamble and data part.

![Figure 2 Frame Structure](image)

Using spread PN (PNₙ) this frame structure becomes more robust. A stream of non-spread PN (PNₛ) adds to main frame synchronously. We assume,
So additive stream does not disturb data extraction but because of power limitation it would reduce main frame available power,

\[ \sigma_{\text{frame}}^2 + \sigma_{\text{stream}}^2 < \eta_{\text{TH}} \]  

(1)

, where \( \eta_{\text{TH}} \) is maximum in sensible power noise power. The tread-off between main-frame and additive stream power will discuss later.

### 2.2 Watermark Extracting

Synchronization in receiver includes three steps:

- **Step 1:** Use preamble pattern to find first sub-frame in each frame.
- **Step 2:** Use stream-PN to find sample offset for first frame.
- **Step 3:** Go to synchronized state and start data extraction. Also use stream-PN to track watermark sample shifts. If shift is not recoverable go back to step 1.

#### This strategy guarantees sample shift detection before data corruption. Also frame size increasing, decreases synchronization header and acquisition time at all.

### 3 Methods comparison

Generally watermark signal can model in detector as:

\[ S_R = S_T + W + \eta \]  

(2)

Detector synchronization and alliance point finding formulate as:

\[ y = \arg[\max_{t} \sum_{t} S(t) \cdot H(t)] \Rightarrow \]

\[ y = \arg[\max_{t} \sum_{t} W(t) \cdot H(t) + \sum (S + \eta) \cdot H(t - \tau)] \]  

(3)

, where \( H \) stands for watermark synchronization header.

With independency between original clip and watermark assumption, synchronization preamble minimum length is achievable:

\[ N \sigma_w^2 \geq 2(\sigma_s^2 + \eta^2) \]  

(4)

, where it is assumed \( \eta \) is Gaussian noise. After a while inaccurate sampling rate (clock PPM) or phase noise (clock jitter), may change sampling position by fraction of a sample (may express as \( \theta \) radian). Sampling error decrease data power by \( \cos(\theta) \) factor. This factor limits frame length base on maximum tolerable power loss.

New method overcome problem with tracking sampling shift. As \( \cos(\theta) \) power factor decreasing in stream-PN, Data power corrupt only \( \cos(\theta/\text{spreadin_factor}) \) time. Re-sampling process can compensate shift without data loss. Regarding to very low PN-stream power, it allows frame to exceed length limitation that reduce overall header and PN-stream frame overhead.

### 4 Experimental Results

In this experiment new method has been compared with [1] which used usual synchronization method. Each frame sampled in 48 kHz rate and 10PPM sampling error has been applied to signal.
As curves Fig. 4 shows, in very short frame length, new method throughput is just a little lower than usual throughput but because of high overhead percentage this frame length is not economical. Experiment shows about 7s can rich to optimal efficient bit rate.

![Figure 5 Three Phase of System](image)

5 Conclusion

Base on experimental results, new method increases bit rate using extending frame length. Also channel tracking make method more robust against intentionally re-sampling attack. But increasing computation and buffer size can mention as method disadvantages.

References: