

Strategic Young Researcher Overseas Visits Program  
for Accelerating Brain Circulation 2011

**“Development of Young Researchers  
Based on International Joint Research  
on Green Energy Systems”  
Progress Report**

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2. Title: Assistant Professor

3. Host Institution: Adam Mickiewicz University (Poland)

4. Host Researcher: Professor Alexander Sek

5. Duration: 27- March -2012 – 27- March- 2013

6. Research Topic:

Applied diagnosis based on audible sound enrichment that realize the measurement and control for high efficient energy systems

7. Overview of the Results of the Collaborative Research:

In recent years, a mechanism that controls the system intelligently by using information of the various data shared on the system network has been practiced. New power grid systems (smart grid), and electric vehicles are good representatives of targeting of energy saving and high efficiency. At the same time, we also need to consider the cooperation with equipment that is not connected to the information network. In other words, it is required to have a variety of the means of conveying information of the equipment condition to the network.

In this study, we aim to convey additional information to the receiver by embedding watermark into the sound wave that is emitted from the system. The embedded information is extracted by decoding the received sound wave. Here, it is important to keep the sound wave robust against deterioration during its propagation in air. Furthermore, it is preferable that the quality of the produced watermarked sound is not significantly deteriorated from the original one.

Prof. Sek has studied the detection limits of human discrimination against modulated sound. During my stay at AMU, I developed new digital watermarking method based on the sound modulation and carried out some listening experiments with Professor Sek's support and suggestions.

We proposed a new digital watermarking method that is embedded by re-quantizing the distribution of the time varying sound magnitudes in accordance with watermark message bit. In this method, observing the time-varying magnitudes of the several components on the short-term Fourier spectrum, the relation of selected four bins of the histogram on the magnitudes have been changed. Here, the targeted frequency components are not selected from an equally spaced scale, rather they are selected from the scale of nERBs (Equivalent Rectangular Bandwidth). The nERBs are logarithmic scale according to the frequency resolution of human hearing.

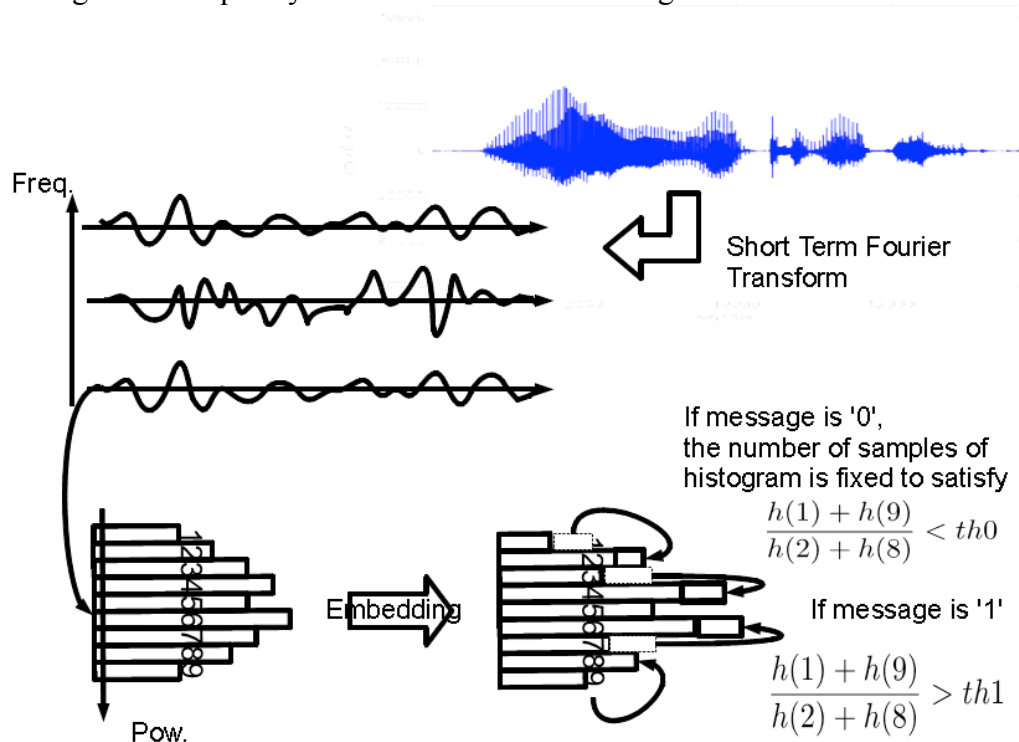


Figure 1: Proposed watermarking method

The robustness test against typical signal manipulations or attacks showed very good performance of the proposed method. Subjective listening tests have also been carried out to assess the quality of the watermarked signal, i.e. audibility of distortions resulting from watermark. The results show that the proposed watermarking technique resists the MP3 compression attacks in the case of embedding payload below 2 kHz. However, the proposed procedure

performs slightly poorer against the attacks of noise addition, band pass filtering and echo addition. Results of hearing tests showed that the proposed method doesn't produce audible deteriorations. Finally, multi-band embedding was investigated. Results showed that the multi-band embedding can embed up to 20 bits without decrease in robustness against MP3.

For the future work, the countermeasure to increase robustness against noise and echo addition, band pass filtering, pitch modification are strongly desired.

## 8. Deployment Plans for Future Collaborative Research:

We, Prof. Sek and I, have been researching the improvement of the above proposed watermarking method, and plan to publish them.

A watermarking method for the musical signal has been proposed and tested during my stat. As the next step, we will try to embed the watermark into the sound wave which is emitted from the mechanical systems.

## 9. List of Collaborative Research Progress:

### Conference Presentation(s)

- [1] Kotaro Sonoda "Content based audio watermarking in DWT domain," Open seminar on Acoustics (OSA2012), 2012
- [2] Kotaro Sonoda, Alexander Sek, "Digital watermarking method based on STFT histogram," International Conference on Intelligent Information Hiding and Multimedia Signal Processing (IIHMSP2013), 2013