Embedding Digital Watermarking Technique in Vehicle Acoustic Signal for Vehicle Identification

Dr.G.Padmavathi[1]
padmavathi.ganapathi@gmail.com
Ms.D.Shanmugapriya[2]
ds_priyaa@rediffmail.com
Ms.M.Kalaivani[3]
kalaivanim@gmail.com
Avinashilingam University for Women, Coimbatore-43.

ABSTRACT

This paper discusses about embedding digital watermarking technique in vehicle acoustic signals for vehicle identification. Vehicle identification means, identifying the category of the vehicle. The assumed category here may be friend or foe. The Digital Watermarking technique has been introduced to make the vehicle acoustic signals authenticated. The vehicle acoustic signals belong to the friend category are authenticated using digital watermarking technique. Vehicle signals belong to friend category are embedded into digital watermarking technique to represent it uniquely. Here the step by step process of embedding digital watermarking technique is discussed along with the results. Once the embedding of the digital watermarking technique done, the resultant signals are further used for vehicle identification or classification. This identification or classification discusses about the two methods of classification, direct method of identification and PCA based Pattern Recognition.

Keywords: Wireless sensor networks, Vehicle acoustic signal, Digital watermarking, Vehicle identification

Introduction

Vehicle Identification in Wireless Sensor network (WSN) is an important application in Battlefield surveillance. The development of wireless sensor networks was originally motivated by military applications like battlefield surveillance. However, Wireless Sensor Networks are also used in many areas such as industrial, civilian, Health, Habitat Monitoring, Environmental, Military, Home and Office application areas [3]. The Wireless Sensor Networks comprise of relatively inexpensive sensor nodes capable of collecting, processing, storing and transferring information from one node to another. These nodes are able to autonomously form a network through which sensor readings can be propagated. Since the sensor nodes have some intelligence, data can be processed as it flows through the network. Sensing devices will be able to monitor a wide variety of ambient conditions: temperature, pressure, humidity, soil makeup, vehicular movement, noise levels, lighting conditions, the presence or absence of certain kinds of objects, mechanical stress levels on attached objects and so on [7]. These devices will also be equipped with significant processing, memory and wireless communication capabilities. Emerging low-level and low-power wireless communication protocols will enable us to network these sensors. This capability will add a new dimension to the capabilities of sensors: Sensors will be able to coordinate among themselves on a higher-level sensing task. Research on vehicle detection and identification using magnetic fields, images, and sounds has been conducted. Magnetic fields are able to detect the movement of vehicles successfully [8], but it is not appropriate for vehicle identification purposes. Magnetic sensors use the direction and magnitude of external magnetic fields for detection and classification, means that the vehicle to be detected and classified must pass through the sensor. In conclusion, magnetic sensors are more appropriate when used with infrastructure support. Visual image processing is widely applied in vehicle identification. This approach, however, may not be suitable for sensor networks because a large volume of data needs to be processed and occupies more memory space as the sensor has only limited built in memory. Finally, vehicle identification using sound is the most promising approach. So the vehicle acoustic signals as a wav file can be used for vehicle identification. Vehicle identification identifies the category of the vehicle as friend or foe. The Digital watermarking technique has been introduced to make the vehicle acoustic signals authenticated. Digital watermarking is the

process of embedding information into a digital signal [10, 2, 9]. The vehicle acoustic signals belonging to the friend category are embedded with digital watermarking to represent it uniquely. The remaining of this paper is organized as follows. Section II describes about the vehicle acoustic signals. Section III gives the proposed method for embedding digital watermark into the vehicle acoustic signals. Section IV discusses about the results and discussion about the proposed method. Section V concludes the paper.

2. Vehicle Acoustic Signals

In this study, the acoustic signals are used as a source for vehicle identification. These acoustic signals are captured by the acoustic sensors mounted in the field as well as on the vehicle. The acoustic sensor in the Smart Dust sensor node is a condenser type microphone. The schematic for a typical condenser acoustic sensor [4] is shown in figure 1; it includes a stretched metal diaphragm that forms one plate of a capacitor. A metal disk placed close to the diaphragm acts as a backplate. A stable DC voltage is applied to the plates through a high resistance to keep electrical charges on the plates. When a sound field excites the diaphragm, the capacitances between the two plates vary according to the variation in the sound pressure. The change in the capacitance generates an AC output proportional to the sound pressure, which is an ultra low-frequency pressure variation. A high-frequency voltage (carrier) is applied across the plates and the acoustic sensor output signal is the modulated carrier. The Figure 2 shows a typical vehicle acoustic signal waveforms.

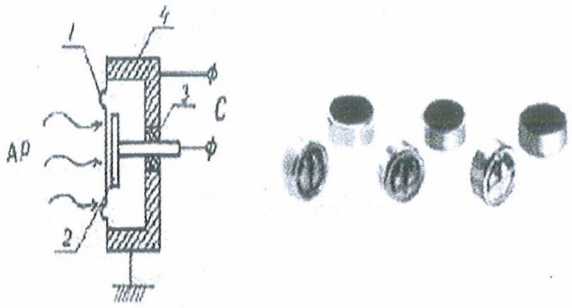
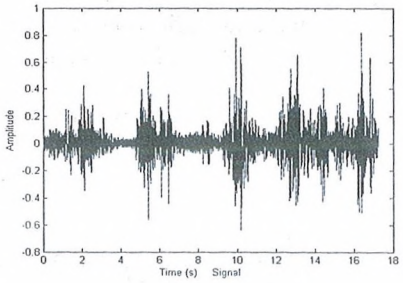


Fig. 1: Condenser Microphone



AP-the acoustic pressure
C-the variable capacitance
1-the metal diaphragm
2-the metal disk
3-the insulator
4-the case

Fig. 2: Waveforms of Acoustic Signals Emitted from a Truck

The acoustic signature is made up of a number of individual elements [6]. These include:

- Machinery noise: Noise generated by a ships engines, propeller shafts, fuel pumps, air conditioning systems etc.
- Cavitation noise: Noise generated by the creation of gas bubbles by the turning of a ship's propellers.
- Hydrodynamic noise: Noise generated by the movement of water displaced by the hull of a moving vessel.

These emissions depend on a hull's dimensions, the installed machinery and ship's displacement. Therefore different vehicle classes will have different combinations of acoustic signals that together form a unique signature.

3. Proposed Method for Embedding Digital Watermark

Digital watermarking technology allows users to embed data into digital contents such as text, still images, video and audio data [1]. In this paper, the signals belong to friend category are inserted with digital watermark. The signals that belong to different category don't have this digital watermark. The insertion of watermarking into acoustic signals is represented as below:

$$X' = E_k(x, w) \qquad (1)$$

where X is the original signal, W is the watermark information being embedded, k is the user's insertion key (Watermark Parameter), and E represents the watermark insertion function, is the resultant signal.

The different types of watermarks used [1,2,10] are classified as shown in figure 3,

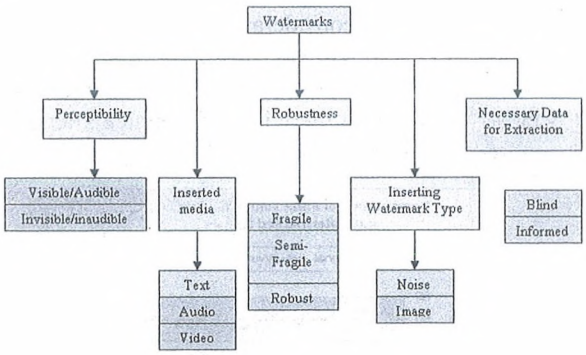


Fig. 3: Types of Watermark

In this study, the inserted watermark type is noise and the inserted media is audio acoustic signal. The proposed insertion process is shown in figure 4.

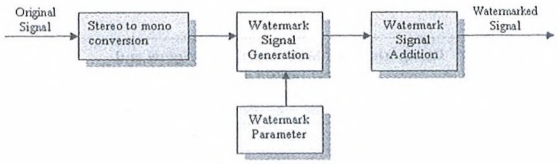
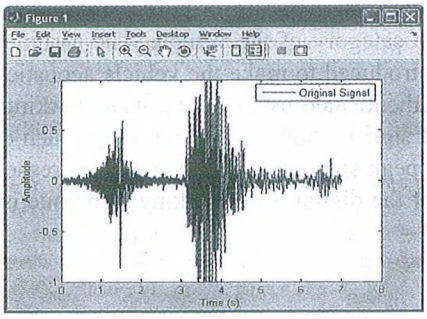


Fig. 4: Proposed Watermark Insertion Process

In this proposed watermark insertion process there are four stages. Original signal is nothing but a vehicle acoustic signal captured by the acoustic sensors mounted in the field. This signal is included into stereo to mono conversion. A separate watermark signal is generated by using the watermark parameter. This generated watermark signal is added to the original signal in order to make it unique. The figure 5 shows the original and digital watermark inserted acoustic signal. After inserting watermark technique the signal is categorized as signal that belong to friend vehicles.



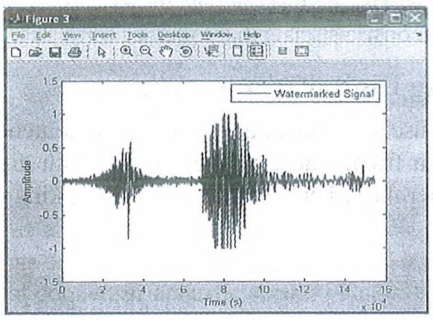


Fig. 5: Digital watermarked acoustic signal

4. Results and Discussion

Acoustic signals that belong to 10 vehicles are taken into consideration. Watermarking is embedded for all the 10 signals. After embedding, PSNR (Peak-signal-to-noise-ratio) and MSE (Mean Square Error) are compared for both original and watermark embedded signals. Here, the watermark is noise, the figure 6 and figure 7 show the PSNR and MSE values for both the original signal and the watermarked signal. It is clearly shown that there is no difference after adding the watermark. So this approach will not affect the nature of the signal captured through the sensors.

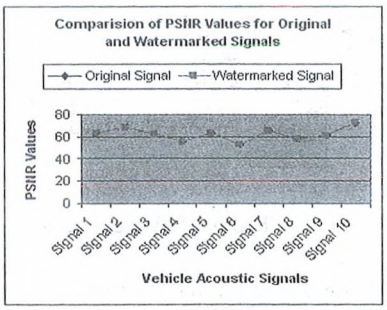


Fig. 6: Comparison of PSNR Values for Original and Watermarked Signals

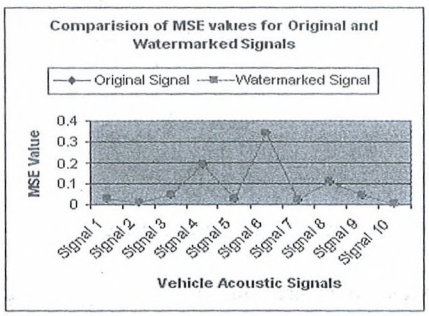


Fig. 7: Comparison of MSE Values for Original and Watermarked Signals

5. Conclusion

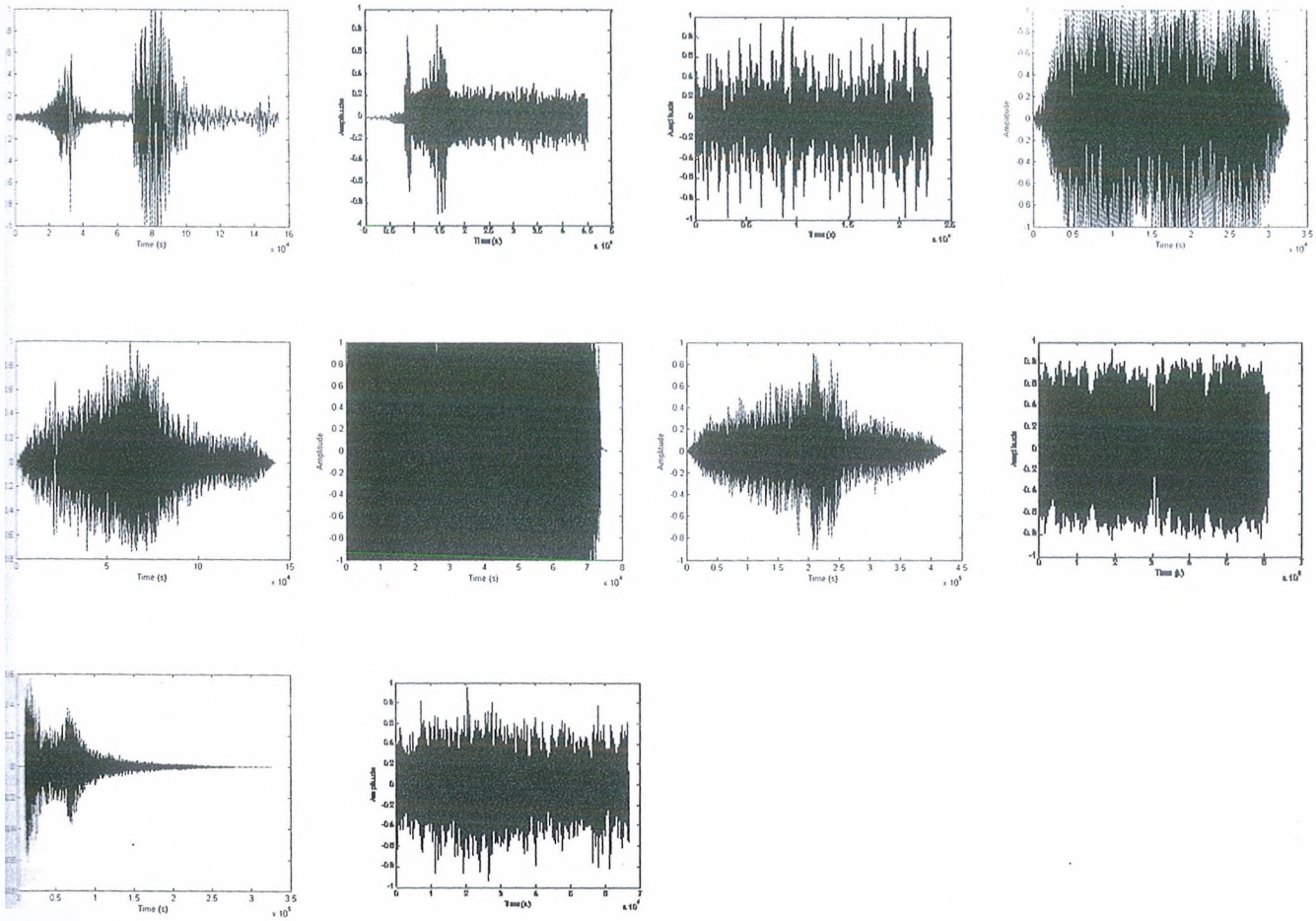
This paper discusses about embedding digital watermarking technique in vehicle acoustic signals for vehicle identification. Vehicle identification means, identifying the category of the vehicle. The assumed category here may be friend or foe. The Digital Watermarking technique has been introduced to make the vehicle acoustic signals authenticated. The vehicle acoustic signals belong to the friend category are authenticated using digital watermarking technique. This process of embedding the digital watermarking technique into acoustic signals shows that there is not much disturbance in the signal. Comparatively, the graphs shows that there is only a minimum peak signal to noise ration is decreased and mean square error is increased in the watermarked signal. Once the embedding of the digital watermarking technique is done, the resultant signals are further used for vehicle identification.

Acknowledgment

The authors would like to thank the Armament Research Board (ARMREB-DRDO) for supporting this Research project by funding.

ANNEXURE I

Acoustic Signals taken for Study



EFERENCES

Arnold, M. 2000."Audio watermarking: features, applications and algorithms." IEEE International Conference Multimedia and Expo, vol. 2, pp. 1013-1016.

Boney, L. Tewfik, A.H. Hamdy, K.N. 1996."Digital watermarks for audio signals". IEEE International Conference on Multimedia Computing and Systems, page(s): 473-480

F. L. Lewis.2004. "Wireless Sensor Networks." Smart Environments: technologies, protocols, and Applications. John Wiley, New York.

G. E. Sleefe, S. Peglow, and R. Hamrick.July 1997. "The application of unattended ground sensors to stationary targets," in Peace and Wartime Applications and Technical Issues for Unattended Ground Sensors. SPIE, vol. 3081, pp. 21–29.

Huadong Wu, Mel Siegel, and Pradeep Khosla. October 1999. "Vehicle Sound Signature Recognition by Frequency Vector Principal Component Analysis." IEEE Trans. On Instrumentation and Measurement, vol. 48, no.5

Jiagen Ding, Sing-Yiu Cheung, Chin-Woo Tan and Pravin Varaiya. "Signal Processing of Sensor Node Data for Vehicle Detection." IEEE Proceedings on International Intelligent Transportation Systems Conference.

Lan F. Akyildiz and et al. August 2002. "A Survey on Sensor Networks," IEEE Communication Magazine.

Marco F. Duarte and Yu Hen Hu .July 2004. "Vehicle Classification in Distributed Sensor Networks." Journal of Parallel and Distributed Computing, vol. 64, issue 7.

MIKDAM A.T., ALSALAMI and MARWAN M. AL-AKAIDI. "DIGITAL AUDIO WATERMARKING: SURVEY". Computer Science Dept, Zarka Private University, Jordan

R. Chandramouli, Nasir Memon and Majid Rabbani."Digital Watermarking". Department of ECE, Stevens Institute of Technology, Hoboken, NJ

Seung S. Yang, Yoon G. Kim and Hongsik Choi. APRIL 2008. "Vehicle Identification using Discrete Spectrums in Wireless Sensor Networks". JOURNAL OF NETWORKS, Vol. 3, NO. 4.

S-Y. Cheung, S. Coleri, B. Dundar, S. Ganesh, C-W. Tan and P. Varaiya. January 2005. "Traffic measurement and classification using a single magnetic sensor" .84th TRB Annual Meeting, Washington, D.C.

Tatiana Bokareva, and et al. October 2006. "Wireless Sensor Networks for Battlefield Surveillance." Proceedings of Land Warfare Conference 2006, Brisbane

Y. Tian, H. Qi. May, 2002."Target detection and classification using seismic signal processing in unattended ground sensor systems." International Conference on Acoustics Speech and Signal Processing (ICASSP), Orlando, FL, vol. 4, page 4172.