Software and Harware Implementation of Digital Audio Watermarking

[Madhuparna Chakraborty, Dr. G. N Rathna]

Abstract— **Many digital files are shared nowadays through internet especially due to the increase in the number of cell phone users. However, digital files can be easily copied, distributed, and altered leading to the copyright infringement of intellectual property. One way to prevent this is by using watermarking technique. The file in which watermark is embedded can be audio, image, text or video file. In this paper watermarking on audio file is done. The audio watermarking algorithm using fast Fourier transform is studied here. The watermarking system consists of two main steps watermark embedding and watermark extraction system. The technique used here is to put the watermark into the selected prominent peaks of the magnitude spectrum of the audio signal. The reason of hiding the watermark in this position is that it will be imperceptible for the human auditory system. The algorithm is also implemented on Beagle board hardware for online operation.**

Keywords—watermarking, embedding, detection, copyright

I.   Introduction

Watermarking is a technology to hide information in a signal without the information being perceptible. The information need not have any relation to the actual carrier signal. Digital watermarking is basically used to protect the ownership of the content, as digital data can be easily shared and distributed on the internet so unauthorized copying and distribution of digital data have become easy. The digital watermarking is a broad concept that can be applied to any form of multimedia file. Digital audio watermarking involves hiding of data within a digital audio file in such a way that it cannot be detected by the human senses nor does it corrupt the data in which it resides. The process mainly involves embedding into the host signal a transparent digital signature carrying a message about the host signal in order to mark its ownership. The watermark remains permanently in the host data which in this case is audio file. The internet connects the whole world together and with all data going digital new challenges is coming up. Flexible and easy to use software and decreasing prices of digital devices have made it possible for people to create and share many multimedia file.

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A possibility of copying data exactly has made the protection of intellectual ownership an important issue. For example, many people download and compress music from the internet, creating exact copies of the original data. It is this flexibility of copying or reproducing data that causes copyright violations and unauthorized distribution. In order to stop the theft and unauthorized distribution of data, many cryptographic schemes have been implemented. However, encryption techniques are unable to solve this problem completely. The reason is that once the encrypted information has been removed, there is no other data that proves the owner's authenticity [1]. Digital watermarking is an alternative to enforce intellectual property rights to protect their material against illegal copying and distribution.

Some of the characteristics or the properties of an audio watermarking are

i) Perceptual transparency: The watermark embedding algorithm has to insert the watermark data without changing the quality of the host audio signal. The watermarking technique should not add noise or include any additional sounds to the host audio file.

ii) Robustness: The robustness is defined as the ability to detect or extract the watermark after any signal processing attack like filtering, compression, re sampling etc. being done to the file.

iii) Computational complexity and cost: Effectiveness and time are the main issues related to this property. A cheaper but effective watermark system is necessary for many day to day applications.

iv) Data rate: This property indicates the number of bits per second that can be embedded in a watermark signal.

v) Multiple watermarks: The aim of this property is the ability to embed more than one watermark signal into a file. This property must preserve a watermark signal that has been embedded previously.

vi) The watermark should be easy to extract so that minimal time and processing power are spent authenticating the audio file.

Watermarking can be classified as temporal and spectral. Temporal watermarking hides watermarks directly into digital audio signals in the time domain. The spectral audio watermarking applies certain frequency transforms such as Fast Fourier Transform (FFT), Discrete Cosine Transform (DCT), and Discrete Wavelet transform (DWT) etc. to the data block of the audio signal and hides the watermark information into the transformed data block [4, 5]. In this paper the spectral audio watermarking has been implemented.

There are various applications of watermarking:

Copyright protection: This is the most important watermark application. To protect an original work from unauthorized

International Journal of Advances in Computer Science & Its Applications– IJCSIA
Volume 5: Issue 1   [ISSN : 2250-3765]

Publication Date : 30 April, 2015

publication, a creator needs a technique that proves rightful ownership [2]. Watermarking systems are used to solve this matter by inserting copyright information into the audio file. Robustness of audio watermarking systems is necessary for this application to make the watermark signal neither detectable nor separable from the original audio file.

Source tracking: Transaction tracking is another interesting application of watermarking. In this case the watermark embedded in a digital work can be used to record one or more transactions taking place in the history of a copy of this work. For example, watermarking could be used to record the recipient of every legal copy of a movie by embedding a different watermark in each copy. If the movie is then leaked to the internet, the movie producers could identify which recipient of the movie was the source of the leak.

Broadcast monitoring: One of the first applications for watermarking was broadcast monitoring. It is often crucially important to track when a specific video is being broadcast by a TV station. This is important to advertising agencies who want to ensure that their commercials are getting the air time they paid for. Watermarking can be used for this purpose. Information used to identify individual videos could be embedded in the videos themselves using watermarking, making broadcast monitoring easier.

Data authentication: Another very important application is owner identification. Being able to identify the owner of a specific digital work of art, such as a video or image can be quite difficult. Nevertheless, it is a very important task, especially in cases related to copyright infringement. So, instead of including copyright notices with every image or song, we could use watermarking to embed the copyright in the image or the song itself [3].

II. Scheme Used for Digital Audio Watermarking

Several watermarking techniques are there for audio application. The main reason of existence of the various algorithms is the need for which they were created. A challenge for audio watermarking systems is the fact that the human auditory system has a wide dynamic range and it is also sensitive to noise. Therefore, audio watermarking systems are concentrated on inserting the watermark in such a manner that the watermark is undetectable. It is very crucial to find the significant regions and embed a watermark into those regions without distortion of the original audio signal. If the watermark is embedded in some insignificant region then some signal processing attack may remove the watermark. In order to watermark a file various algorithms have been proposed and implemented. The watermarking algorithm consists of the two crucial steps; the watermark insertion and the watermarking extraction process. The watermarking insertion process refers to the methodology and content of the watermark data to be embedded. The extraction process is concentrated in detecting and extracting the watermark signal from the host audio file. The purposes of the extraction might

vary for the application, but mainly it is used to prove ownership and copyright protection.

In this paper, the watermark used is a 10X10 binary image and is embedded in the frequency domain of the audio data. The watermarks are embedded into the selected prominent peaks of the magnitude spectrum of the audio [6, 7, 8].

A. *Watermark Embedding Process*

The watermark embedding process is defined in the following steps:

1. The original audio signal is first split into non overlapping frames.
2. The FFT of each frame is found.
3. The magnitude and phase spectrum is calculated.
4. From the magnitude spectrum the n most prominent peaks P= {p_1, p_2, p_3... p_n} using a peak detection algorithm is found out.
5. In those n prominent peaks of magnitude spectrum, the watermark is placed. This ensures that the watermark is located at the most significant perceptual components of the audio.
6. An amplification factor for the watermarked spectral value for better detection is also included.
7. The n modified peaks are inserted into the magnitude spectrum of each non-overlapping frame.
8. The inverse FFT of the complex spectrum is taken to calculate the watermarked frame.
9. Finally all the watermarked frames are concatenated to calculate the watermarked audio signal.

B. *Watermark Detection Process*

The detection process is implemented in the following steps:

1. The original audio signal is split into non overlapping frames.
2. FFT is applied to each frame.
3. The n most prominent peaks were found from the magnitude spectrum of each frame.
4. The watermark sequence is extracted by performing the inverse operation.

III. Simulink Implementation of the Digital Audio Watermarking Algorithm

The matlab/simulink based programming language of watermark insertion and extraction processes for the algorithm is described. The aim of this system is to have a baseline model to be able to obtain suitable results so that it can be implemented on beagle board for online results. The advantage of using simulink is that sophisticated signal processing systems can be defined and simulated to analyze the behaviour of the system. The signal processing blockset software tool is one of the special tools that simulink provides to create signal processing models.

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A. *General system Requirements*

The matlab/simulink model can be divided by two crucial processes, the watermarking insertion and the extraction process. This model has several configuration parameters that must be considered to obtain accurate resulting simulations. The model was simulated using the fixed-step discrete matlab solver which is suitable for discrete states and can provide precise results for small fixed step sizes. To optimize the model in terms of speed during signal processing execution, the signal can be processed as frame-based M by N matrix input. In this paper a 1024 sample per output frame simulation was set due to the requirement for the FFT length to be a power of two.

The audio signal used has the following parameters:

Resolution	16 bits
Frequency	44100 Hz
No. of channels	2
Duration	17sec

The watermark to be embedded is a 10X10 image shown below in figure 1

Figure 1 Watermark image

The watermark was embedded in both the channels of the audio file. The watermark was resized to fit into the audio file length. For watermark embedding two loops were created one running through the watermark bytes in steps of 2 and another running through the two channels of the stereo signal.
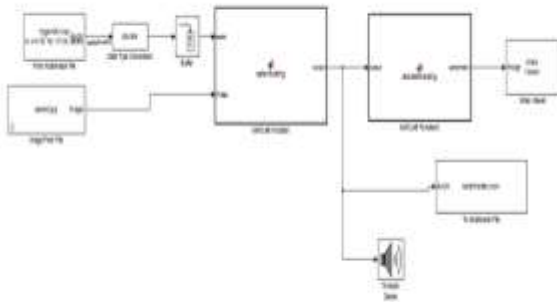

Figure 2. Simulation block for watermarking insertion and

extraction

The 10X10 binary image was inserted into the input audio signal using the algorithm mentioned earlier. The input audio signal was used using the 'from multimedia file' block of the simulink. The watermarked audio signal was heard using 'to Audio device' block of the simulink. The audio output was heard and was found similar to the input audio file with very little distortion.

IV. Simulink Model Implementation on Beagle Board

Beagle Board is a low power open source hardware single board computer produced by Texas Instruments. Simulink Support package for Beagle Board Hardware enables to create and run simulink models on beagle board hardware. The target includes a library of simulink blocks for configuring and accessing beagle board hardware I/O peripherals and communication interfaces. Also the target enables to monitor and tune algorithms running on beagle board hardware from the same simulink models from where the algorithms were developed.

To run the model the following hardware were required:

- Beagle Board XM
- Speakers or headphone connected to the audio out port of the beagle board hardware

To configure the simulink model of watermarking to run on beagle board hardware the following steps were used:

1. The beagle board hardware is first connected to the Ethernet network
2. The simulink model was modified according to figure 3 so as to run on the beagle board hardware
3. In the simulink model then the following steps were done: go to tools -> run on target hardware -> prepare to run
4. The parameters on the page are then reviewed the host name parameter should be same as IP address in which beagle board is connected
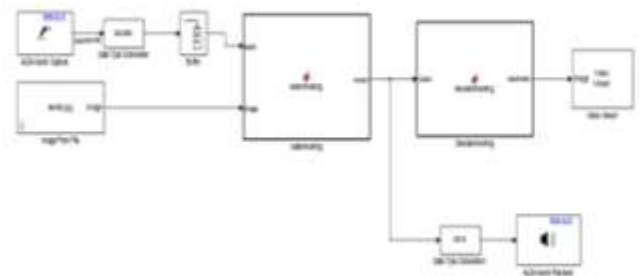5. The enable external mode operation is then checked
6. The simulink model is run

Figure 3. Simulink block for execution in Beagle Board

The main reason of implementing the watermark insertion model in a Beagle Board is that superior signal processing performance can be achieved. Using 'image video viewer' block the watermark binary image was retrieved back from the watermarked audio signal and the image was found to be similar. The watermark was retrieved properly.

V. Conclusion

Like most watermarking schemes, the audio watermarking algorithm done in this paper requires two crucial processes to achieve the watermarking, namely insertion and extraction, where the watermark signal is embedded in the host audio signal. The audio watermarking system used in this paper have embedded the watermark signal without producing any perceptible alteration in the original audio file, so that the watermark signal is imperceptible to the human auditory system. In this paper the watermarking technique was implemented using matlab simulink programming software. Also the algorithm was implemented on beagle board hardware and the watermark was implemented successfully. Although the watermarking scheme used in this paper is robust to attack like re-sampling and compression there still remains a scope of improvement. The basic scheme of watermarking contains a lot of possibilities both for compressed file and for uncompressed files.

Acknowledgment

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