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Original Article

STEGANOGRAPHY USAGE TO CONTROL MULTIMEDIA STREAM

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ABSTRACT
In the paper, a proposal of new application for steganography is presented. It is possible to use steganographic techniques to control multimedia stream playback. Special control markers can be included in the sound signal and the player can detect markers and modify the playback parameters according to the hidden instructions. This solution allows for remembering user preferences within the audio track as well as allowing for preparation of various versions of the same content at the production level.

Keywords: steganography, multimedia stream, player.

INTRODUCTION

A new application for steganography is proposed in the article. It is a way of controlling multimedia signal playback. Hidden data attached to other stream of data carries steering instructions to various devices or programs. In the paper, a proposal of a steganographic control system designed to steer a multimedia player is presented.

We have found various applications of the proposed solution. In the first instant, it is employed in a preparation of various versions of the same content. Sometimes it is necessary to create various versions of multimedia signal that differ in small fragments. This situation can take place while preparing two versions of the same film; one with all scenes, the second without violent ones. To avoid creating two independent copies of the film, it is possible to attach additional control data to the signal containing all scenes necessary for both versions of the film. Instructions included into the signal can control the video's playback. Some fragments can be omitted, others can be shown, as needed in the chosen film version.

The second application of the proposed method is to save users' preferences or prepare the version adjusted for people having troubles with controlling the player on their own [9]. During the multimedia content playback, the user can control the track and adjust to the most satisfying version of the content.

The proposed solution describes the control instructions' scheme, steganographic algorithm used to attach control data, and two applications: multimedia player and the way to attach control instructions to multimedia content.

ATTACHING CONTROL DATA METHOD PROJECT

The main part of the system is the method to attach control data to the multimedia signal. The method has to meet following requirements:
- it has to give possibility of attaching various markers in real time,
- markers detection has to be calculative effective,
- markers have to be transparent for people,
- method has to provide signal control precise in time with a possibility of delayed executing of control order,
- method should ensure a big steganographic capacity to allow for attaching a big number of markers.

To fulfil the above requirements, first it is necessary to choose the signal that will be used to attach control data. The sound signal exists in video and sound recordings and allows for meeting all the above requirements. Good quality audio signals are sampled at a frequency of 44.1 kHz. It means that it is possible to place the marker with the 0.02ms resolution in the time. Moreover, audio signal usually contains less data than a video signal. The less data to process the quicker the algorithm. Finally, sound signal was chosen to store the hidden control data. As it will be presented further in the article, the control marker size is small which results in small steganographic capacity use. It allows for using only one soundtrack.

The next problem to solve is to choose an appropriate steganographic method for attaching hidden control data inside the sound signal (further called container). It is possible to find a big number of various steganographic methods in the literature: Least significant bit methods (LSB) replacing container bits with hiding data bits [1, 4, 5, 2], echo methods, consisting of adding echo signal with the defined delay for each hiding bit value [1, 6, 10], transform methods, based on fully reversible transforms and hiding additional data by transform coefficients [1, 7, 8, 11, 12], spread spectrum methods, consisting in spreading secret data over the audio signal's frequency spectrum [13].

The above list does not exhaust the whole classification but shows the most popular sorts of steganographic methods. On the basis of the above overview of various steganographic methods, a comparison was made to choose appropriate method to be used in multimedia stream control. In comparison, parameters important for the projected method have been taken under consideration. The comparison results, according to [3] and [8], showed that the lowest complexity occurs in the LSB method. This method has also the biggest steganographic capacity and allows for obtaining the best resolution in time. LSB method also gains the highest SNR value. The disadvantage of this method is the lack of robustness to stegocontainer signal compression or modification.

The analysis conducted, proved that the most suitable for the presented purpose is the LSB method. The small robustness of LSB method limits the designed steganographic method's usage to sound tracks, that do not need to be compressed, or are to be compressed with lossless compression algorithms.

CONTROL DATA FORMAT

There are two possibilities of control data attaching. One possibility is to attach the whole data in the beginning of the container. This approach allows for reading all control instructions at the beginning of the playback and storing them in the multimedia player. This approach's disadvantage is the necessity to read the beginning of the signal to make it possible to use the hidden control markers. It results in impossibility of continuous signal use.

In order to design a universal method, suitable for stream transmission, it is necessary to attach control orders in the middle of the signal, directly in the place where instructions should be applied or a bit earlier. This solution was chosen to apply in the projected application. It requires placing markers in the whole signal area. It is interchangeable with ensuring possibility of identifying markers in the signal. It is necessary to include a unique sequence at the beginning of the marker. This sequence will be recognized by player as a marker beginning. To reduce the complexity, the sequence was established as a series of identical bit values.

The next step was to determine the length of the starting sequence. A shorter sequence needs less space and causes smaller interference in the container signal. On the other hand, if the sequence is too short it is possible that it exists in many locations in the original signal. In this case it is necessary to change at least one bit value in such a sequence to avoid further false marker detection. This operation, of course, introduces unnecessary interference. To adjust the optimal starting sequence length, an analysis of existing sequences in original signals was conducted. A few various sound tracks were examined to check a number of various length, least significant bits sequences, having the same value. Results of the experiment are presented in figure 1. As we can see, the greatest number sequences have the length of up to 16 bits. Moreover, it is possible to notice a very important difference between ones and zeros sequences series. The longest ones series found during research was 52 samples length. The longest zeros series was over 6000 samples length, and it was possible to notice that the number of long zeros series (over 50 samples) is significantly bigger than the number of long ones series. It is caused by silence fragments in the recording, especially at the beginning and the end

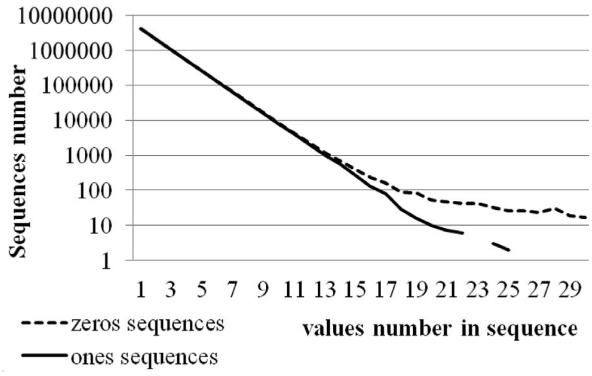

Fig. 1. Number of various length sequences

of the production. This fact made us choose this series as a starting sequence.

To define the optimal length of the starting sequence, the percentage of ones sequences having length bigger than defined was calculated. It was found that in average sound signal there are 0.8% of sequences having more than 7 ones, 0.05% of such sequences having more than 11 ones, 0.003% of such sequences having more than 15 ones and 0.0003% of such sequences having more than 19 ones.

As we can see, it is almost one per cent sequences having eight or more ones. It is about 3.6% of the whole signal length. Choosing the 8 bits starting sequence length demands introducing changes in almost all of these sequences. It is not calculative effective to process such a big part of signal. Moreover, it introduces unnecessary interference.

Starting sequence having 16 bits seems to be a practical solution. Ones sequences having sixteen or more ones occur at a frequency about 0.003% and their total length is about 0.07% of the whole signal length.

After the starting sequence, the control orders are coded. For each time a multiple commands usage necessity can occur. So it is not worthy to create separate marker for each of them. It is more efficient to place multiple commands after the starting sequence. Order code defines an operation to be done. It is encoded on eight bits sequence.

After the order code, the parameter value is encoded. Apart from the order, it is usually necessary to deliver the changed parameter value. In the example, changing of the volume demands determining of the volume level after the change. All parameters values are given as absolute values, not as a change value – it is possible that multimedia player starts in a random position in a signal. In this case it is impossible to determine the previous parameters' values.

To encode parameter value, various bits length sequences are used. For each order code its parameter's sequence length is separately defined in a multimedia player specification. It allows for saving the space where possible and obtaining great precision where needed.

Time stamp defines the time of performing of the operation. Time is encoded as a time from the control marker beginning. It means, that the operation performing time is the sum of the time of the control marker beginning and the time period encoded in the time stamp.

The time stamp size is 16 bits. The established time stamp resolution is one millisecond. It means that this is the maximum precision that can be used while invoking instructions which should be started after the control marker time. It allows for placing in one control marker, instructions that can be applied in 65 seconds period after the marker.

If the greater precision than one millisecond is needed, it is necessary to place separate control marker.

To inform the multimedia player where the end of control orders stream has been placed, the terminator is used. Terminator is a defined sequence of bits. It is an eight ones sequence. This sequence cannot be identical as the order code.

Minimum length of the control marker is 32 bits. Such lengths have markers containing only one order code without a parameter. Maximum length of the marker is not defined. It depends on the orders number included in the marker and their parameters size.

ATTACHING MARKERS

The LSB method is used to attach control markers. Only one least significant bit of each sample is used. It means that to attach a marker having n bits, it is necessary to use n signal samples. It is assumed that the marker is placed in the place of its beginning.

During the attaching procedure, two operations are applied: control markers insertion and false beginning sequences removal.

Control markers insertion relies on changing least significant bits of the following samples by control marker's bits. To start this operation, it is necessary to localize the signal sample placed accurately in the time when control order should be applied. From this sample the control marker insertion starts.

False beginning sequences removal demands the whole signal analysis. Signal is analysed to find existing sequences that can be recognized as a beginning sequence. If such a sequence is found, the sixteenth bit of the sequence is changed. Changing the last bit of the sequence allows for reducing the number of changed bits whenever ones sequence longer than 16 bits is found.

CONCLUSIONS

Adding steganographic markers to control playback is a user-friendly solution. It allows for preparing a copy of multimedia with user preferences included. Moreover, the presented tool can help reduce the amount of data necessary to record on a multimedia carrier (for example DVD disc) if multiple versions of the same multimedia are to be contained therein.

The presented method has big steganographic capacity and allows for attaching a big number of control markers. Even if only one order with 8 bits parameter is included inside the marker, it is possible to place over 1100 markers during one second of audio, sampled with frequency 44.1 kHz.

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