Multimedia Information Hiding Technologies and Methodologies for Controlling Data

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Section 1
Information Hiding for Audio and Speech

Chapter 1
Information Hiding for Audio Signals ...................................................................................... 1
Akira Nishimura, Tokyo University of Information Sciences, Japan
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This chapter provides a general overview of audio data hiding. The general issues are discussed first, followed by the basic techniques used to hide data in audio signals, including bit stealing, spread spectrum methods, echo methods, and quantization index modulation. This is followed by a brief description of the recent proposals presented at the Institute of Electronics, Information, and Communication Engineers of Japan (IEICE) Multimedia Information Hiding (MIH) Technical Group Meetings.

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Reversible Audio Data Hiding in Spectral and Time Domains .............................................. 19
Akira Nishimura, Tokyo University of Information Sciences, Japan

Reversible data hiding is a technique whereby hidden data are embedded in host data in such a way that the host data consistency is perfectly preserved and the host data are restored when extracting the hidden data. This chapter introduces basic algorithms for reversible data hiding, histogram shifting, histogram expansion, and compression. This chapter also proposes and evaluates two reversible data hiding methods, i.e., hiding data in the frequency-domain using integer Discrete Cosine Transform (DCT) and modified DCT and hiding in the time domain using linear prediction and error expansion. As no location map is required to prevent amplitude overflow, the proposed method in the time domain achieves a storage capacity of nearly 1 bit per sample of payload data. The proposed methods are evaluated by the payload amount, objective quality degradation of stego signal, and payload concealment.
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Method of Digital-Audio Watermarking Based on Cochlear Delay Characteristics ............................................. 42
Masashi Unoki, Japan Advanced Institute of Science and Technology, Japan
Ryota Miyauchi, Japan Advanced Institute of Science and Technology, Japan

This chapter introduces a state-of-the-art scheme of non-blind digital-audio watermarking, based on the properties of the human cochlear. It is based on the concept of embedding inaudible watermarks into an original sound by controlling its phase characteristics in relation to the characteristics of Cochlear Delay (CD). Inaudible watermarks are embedded into original signals by applying Infinite Impulse Response (IIR) all-pass filters with CDs and they are then extracted from the phase difference between the original and watermarked sounds. The results obtained from objective and subjective evaluations and robustness tests revealed that the CD-based approach is considerably more effective in satisfying the requirements for non-blind inaudible watermarking. Embedding limitations with the CD-based approach were investigated with various evaluations. These results also revealed that embedding limitations with the CD-based approach could be improved by using parallel, cascade, and composite architectures for the CD filters.

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Mamoru Iwaki, Niigata University, Japan

In this chapter, a time-domain high-bit-rate information hiding method using interpolation techniques, which can extract embedded data in both informed (non-blind) and non-informed (blind) ways, is proposed. Three interpolation techniques are introduced for the information hiding method, i.e., spline interpolation, Fourier-series interpolation, and linear-prediction interpolation. In performance evaluation, spline interpolation was mainly examined as an example implementation. According to the simulation of information hiding in music signals, the spline interpolation-based method achieved audio-information hiding for CD-audio signals at bit rate of about 2.9 kbps, and about 1.1 kbps under MP3 compression (160 kbps). The objective sound quality measured by the Perceptual Evaluation of Audio Quality (PEAQ) was maintained if the length of interpolation data increased. The objective sound quality was also evaluated for the Fourier series-based implementation and the linear prediction-based one. Fourier series interpolation achieved the same sound quality as spline interpolation did. Linear prediction interpolation required longer interpolation signals to get good sound quality.

Chapter 5
Acoustic OFDM Technology and System .......................................................... 90
Hosei Matsuoka, NTT DOCOMO, Japan

This chapter presents a method of aerial acoustic communication in which data is modulated using OFDM (Orthogonal Frequency Division Multiplexing) and embedded in regular audio material without significantly degrading the quality of the original sound. It can provide data transmission of several hundred bps, which is much higher than is possible with other audio data hiding techniques. The proposed method replaces the high frequency band of the audio signal with OFDM carriers, each of which is power-controlled according to the spectrum envelope of the original audio signal. The implemented system enables the transmission of short text messages from loudspeakers to mobile handheld devices at a distance of around 3m. This chapter also provides the subjective assessment results of audio clips embedded with OFDM signals.
Chapter 6
Data Hiding for Stereo Audio Signals
Kazuhiro Kondo, Yamagata University, Japan

This chapter proposes two data-hiding algorithms for stereo audio signals. The first algorithm embeds data into a stereo audio signal by adding data-dependent mutual delays to the host stereo audio signal. The second algorithm adds fixed delay echoes with polarities that are data dependent and amplitudes that are adjusted such that the interchannel correlation matches the original signal. The robustness and the quality of the data-embedded audio will be given and compared for both algorithms. Both algorithms were shown to be fairly robust against common distortions, such as added noise, audio coding, and sample rate conversion. The embedded audio quality was shown to be “fair” to “good” for the first algorithm and “good” to “excellent” for the second algorithm, depending on the input source.

Chapter 7
Advanced Information Hiding for G.711 Telephone Speech
Akinori Ito, Tohoku University, Japan
Yōiti Suzuki, Tohoku University, Japan

G.711 is the most popular speech codec for Voice over IP (VoIP). This chapter proposes a method for embedding data into G.711-coded speech for conveying side information for enhancing speech quality such as bandwidth extension or packet loss concealment. The proposed method refers to a low-bit rate encoder to determine how many bits are embedded into each sample. First, a variable-bit rate data hiding method is proposed as a basic framework of the proposed method. Then, the proposed method is extended to achieve fixed bit rate data hiding. According to comparison experiments, the proposed method is proved to achieve higher speech quality compared with the conventional method. Moreover, the authors developed a low-complexity speech bandwidth extension method that uses the proposed data hiding method.

Chapter 8
Enhancement of Speech Quality in Telephone Communications by Steganography
Naofumi Aoki, Hokkaido University, Japan

Steganography can transmit supplementary data without changing conventional data formats. The concept of high value-added communications is drawn from this advantage of steganography. As a specific application of the concept, this chapter describes two topics about the enhancement of the speech quality in telephony communications by steganography. A packet loss concealment technique and a band extension technique are explained. These techniques employ steganography for transmitting side information for improving the performance of signal processing. In addition, this chapter describes an efficient steganography technique devised for G.711, the most common codec for telephony speech standardized by ITU-T. The proposed technique, named selective LSB replacement technique, outperforms the conventional one in order to decrease the degradation caused by embedding side information into speech data by steganography.
These authors are developing audio watermarking techniques that enable the extraction of embedded data by mobile phones. They applied acoustic interpolation of human auditory organs to embed data in full phone-line frequency ranges, where human auditory response is important for facilitating data extraction, using 3G mobile phones. They are interested in applying this technique to a mobile guide system for use in museums. In particular, they are considering applying audio watermarking techniques for synchronizing the stored contents of mobile terminals based on the spatial positions of the terminal and the temporal positions of playback contents in surrounding media. For this purpose, they are developing five linear spatial location identification codes that transfer to mobile terminals via two-channel stereo audio media that have embedded watermarks. They are also developing time codes that continuously transfer to mobile terminals via audio media. In this chapter, the authors initially describe their proposed audio watermarking algorithm and then present the main topic of novel audio watermarking applications for position information delivery to mobile terminals.

Section 2
Information Hiding for Images and Video

This chapter reviews information hiding methods, with a focus on steganography and steganalysis. First, the authors summarize image data structures and image formats required by computers and the Internet. They then introduce several information hiding methods based on image formats including lossless (non-compression based), limited color-based image data, JPEG, and JPEG2000. The authors describe a steganographic method in detail, which is based on image segmentation using a complexity measure. They also introduce a method for applying this to palette-based image formats, reversible information hiding for grayscale images, and JPEG2000 steganography. The steganographic methods for JPEG and JPEG2000 described in this chapter give particular consideration to the naturalness of cover data. In the steganalysis section, the authors introduce two methods, i.e., a specific steganalysis method for LSB steganography and Bit-Plane Complexity Segmentation (BPCS) stegnography.

Chapter 11
Reversible Information Hiding and Its Application to Image Authentication

This chapter addresses a new class of Reversible Information Hiding (RIH) and its application to verifying the integrity of images. The method of RIH distorts an image once to hide information in the image itself, and it not only extracts embedded information but also recovers the original image from the distorted image. The well-known class of RIH is based on the expansion of prediction error in which a location map, which indicates the pixel block positions of a certain block category, is required to recover the original image. In contrast, the method described in this chapter is free from having to memorize
any parameters including location maps. This feature suits the applications of image authentication in which the integrity of extracted information guarantees that of a suspected image. If image-dependent parameters such as location maps are required, the suspected image should first be identified from all possible images. The method described in this chapter reduces such costly processes.

Chapter 12
New Proposals for Data Hiding in Paper Media

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Keiichi Iwamura, Tokyo University of Science, Japan

Digital watermarks provide the capability to insert additional information onto various media such as still images, movies, and audios, by utilizing features of the media content. Several techniques that use content features such as text or images have already been proposed for printed documents. The authors propose two new techniques using a single dot pattern and an Artificial Fiber (AF) pattern in order to address the disadvantages of conventional information hiding technologies for paper media. In this chapter, the authors describe each scheme's characteristics, and how to improve its robustness. As a result, they have attained greater than 80% extraction rate with an information hiding capacity of 91 Kbits in the case of the single dot pattern, and a 100% extraction rate with color characters as the foreground in the case of using artificial fiber patterns.

Chapter 13
Watermarking for Still Images Using a Computation of the Watermark Weighting Factor and the Human Visual System in the DCT Domain

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Rae-Hong Park, Sogang University, Korea

In this chapter, the authors propose a Discrete Cosine Transform (DCT)-based watermarking method using the calculation of the watermark weighting factor and the Human Visual System (HVS) for the given peak signal to noise ratio of still image as well as the specified length of watermarks to be inserted. Using the energy relationship of the DCT, they derive the equation that directly computes the watermark weighting factor in the DCT domain. In addition, the authors propose a digital watermarking method for still images, in which the HVS is used in the DCT domain. The modulation transfer function of the HVS model is employed to increase the invisibility of the inserted watermark in images. Experimental results show that the proposed watermarking method is an effective objective evaluation method to compare the performances of watermarking algorithms.

Chapter 14
Self-Embedding Watermarking with Content Restoration Capabilities

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In this chapter, the authors give a survey about self-embedding watermarking, which enables not only detection of tampered regions but also recovering the damaged information. They introduce the pioneering method as well as the representative schemes, including adjacent-block detection, hierarchical detection and self-recovery, dual watermarks, reference sharing, and flexible self-recovery. The authors analyze the distinguishing features and loopholes by considering four key techniques, namely the secure block-mapping function, the unambiguous authentication, the reference information extraction, and the watermark embedding approaches. They make comparative studies on the above works and then outline further research directions and a conclusion.
Chapter 15
A Benchmark Tool for Digital Watermarking
Keiichi Iwamura, Tokyo University of Science, Japan

This chapter presents an overview of benchmark tools for digital watermarking and describes a new benchmark tool that supports various attacks and has a graphical user interface. Digital watermarks are used to prevent unauthorized use of digital content such as illegal copying, unauthorized distribution, and falsification. Benchmark tools are required to measure the strength of digital watermarks. Stirmark and JEWELS are well-known benchmark tools. However, the functionality of existing tools is insufficient because they lack evaluation functions for multiple image attacks. In addition, users need to memorize each attack command and check results on another viewer because almost all the existing tools are implemented as command-line-based software without image viewers. Therefore, the authors classify attacks on digital watermarks and develop a new benchmark tool that includes attacking functions using multiple as well as single images. In addition, the tool has a graphical user interface that makes it easy to perform combinations of two or more attacks.

Section 3
Information Hiding for Text and Binary Data

Chapter 16
Data Hiding for Text and Binary Files
Hirohisa Hioki, Kyoto University, Japan

This chapter presents an overview of text-based and binary-based data hiding methods. Text methods, through which secret information is embedded into innocent-looking textual data, are mostly used for steganography. Binary methods are applied to program binary codes: executables and libraries. In binary methods, information is embedded into a binary code so that its functionality is preserved. Data hiding methods for binary codes have been studied intensively to perform watermarking for protecting software from piracy acts. A message can also be embedded into a binary code in a steganographic manner. Another method is also introduced, which is proposed for enhancing the performance of an executable file.

Chapter 17
Data Embedding Methods Not Based on Content Modification
Hirohisa Hioki, Kyoto University, Japan

Creation of a stego object by embedding information in a cover object often distorts the cover object. As more information is embedded, more annoying noise is introduced in stego objects. Although reversible embedding methods enable us to restore the original cover object even after embedding, stego objects are not free from distortions. Embedding information does not, however, always result in damaging the contents of the cover object. This chapter introduces data embedding methods that are not based on modification of the contents of cover objects: permutation steganography, metadata steganography, and cover generation methods. This chapter focuses on elaborating the basic principles of these techniques.
Section 4
New Directions in Multimedia Information Hiding

Chapter 18
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Marcus Liwicki, German Research Center for Artificial Intelligence (DFKI), Germany
Masakazu Iwamura, Osaka Prefecture University, Japan
Shinichiro Omachi, Tohoku University, Japan
Koichi Kise, Osaka Prefecture University, Japan

In this chapter, the authors present a new writing device called data-embedding pen, where a single
inkjet nozzle is attached to its pen tip. When writing a stroke, the nozzle produces an additional ink-dot
sequence along the stroke. The ink-dot sequence can represent various meta-information, such as the
writer’s ID, the writing date, and a certain URL. Since the embedded meta-information is placed on the
paper, it can be extracted by scanning or photographing the paper. Accordingly, by the data-embedding
pen, a physical paper conveys any digital information. In other words, handwriting by the data-embedding
pen can be a new medium connecting the physical and cyber worlds.

Chapter 19
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Rinna Whidiana Ciptasari, Kyushu University, Japan & Telkom Institute of Technology, Indonesia
Kouichi Sakurai, Kyushu University, Japan

This chapter discusses the direct feature-based method as an alternative approach to digital watermark-
ing. Fundamentally, the direct feature-based method is an extension of the digital signature scheme,
which aims at multimedia authentication. The method covers several copyright protection properties,
i.e. robustness to content manipulations and sensitivity to content modification. In addition, this method
provides solutions to inherent problems that arise in traditional watermarking, such as quality degrada-
tion, the trade-off between data payload, and imperceptibility or robustness.

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