Preface

In recent years, the tremendous advancement of digital technology has increased the ease with which digital multimedia files (image, video, and audio) are stored, transmitted, and reproduced. Consequently, content providers and owners are faced with the problem of protecting against copyright violation and other forms of abuse of their digital property. The nature of digital multimedia content makes traditional copyright methods unsuitable for establishing ownership. Therefore, digital watermarking was proposed, and strongly advocated, as a solution to prevent illegal and malicious copying and distribution of digital media. Many multimedia watermarking algorithms have been proposed in the last decade, however as the amount of digital multimedia production increases exponentially, the need for better and more advanced techniques for watermarking multimedia digital objects increases as well.

The primary objective of the book is to introduce readers to state-of-the-art research in multimedia watermarking in order to enable high quality research in the different disciplines of watermarking. Therefore, this book is considered useful as a reference for professionals and researchers working in areas such as image and document watermarking, audio and video watermarking, multimedia fingerprinting, information hiding, secured e-commerce, copyright protection, authentication, information management, and hardware implementation of real-time multimedia watermarking. The book consists of four sections, and eighteen chapters, covering a wide spectrum of multimedia watermarking topics. Section 1 compromises four chapters covering new advancements in digital image watermarking. Watermarking of other multimedia objects such as video, audio, text and 3D meshes are covered in Section 2. Techniques for files containing different multimedia objects are covered in Section 3. Optimization and hardware implementation of digital watermarking techniques are covered in section 4.

In section 1, four chapters have been chosen to address new advancements in different image watermarking areas; spatial domain watermarking, frequency domain watermarking, color in watermarking, and geometric-invariant image watermarking. Chapter 1 presents two original spatial authentication techniques for digital images. The two techniques are based on the utilization of virtual (2D or 3D) graphs embedded into the digital images, where the colors of some vertices of the virtual graph are slightly modified for obtaining the watermark. The watermark is inserted in the most perceptually significant sub-image or in entire image, thus eliminating chances of being subjected to severe digital attacks. Both techniques require less computation than traditional techniques, both are secure since watermark application remains in the virtual graph nodes, and both can be used for colored as well black and white digital images.

Chapter 2 deals with advancements in image watermarking in the frequency domain. It describes a framework for image hiding that exploits spectral properties of the Fourier magnitude and phase of natural images. The theory is that as long as the Fourier phase of an image is maintained intact, the overall appearance of an image remains specious if the Fourier magnitude of the image is slightly modified. This hypothesis leads to a data hiding technique that promises high fidelity, capacity, security, and
robustness to tampering. Experimental results are presented throughout the chapter to demonstrate the effectiveness of the proposed approach.

Color is still an unresolved issue in digital watermarking. Chapter 3 summarizes the state-of-the-art color techniques used in image watermarking. The chapter first describes the major difficulties associated with the treatment of color images, and then presents a panorama of both classical and new directions taken in the field of color images watermarking. Color techniques summarized in the chapter are classified into three categories; color watermarking through color histograms and quantization, color watermarking through the spatial domain, and color watermarking through a transform domain.

The last chapter in this section, chapter 4 presents two geometric-invariant digital image watermarking techniques, which apply the source-independent watermark signals to the original images. These techniques exploit the invariant properties of images for the watermarking purposes. The first technique utilizes the scale-invariant features and discrete moment invariants of the images to establish a non-blind watermarking system. The second technique utilizes only the discrete moment invariant features of the images and the whole image is used for embedding the watermark information. Implementations of the two techniques are supported with a thorough discussion, and experimental results are presented to demonstrate the effectiveness of the proposed techniques against several kinds of geometric attacks.

Research in video, audio and text watermarking received less attention than image watermarking due to the inherent difficulties in these media types, such as larger amount of data, unique attacks, and sensitivity of the human visual and auditory systems. In section 2, five chapters have been chosen to address advancements in different areas in video watermarking, audio watermarking, text watermarking, and 3D mesh watermarking. Chapter 5 deals with video watermarking and in-band enrichment, chapters 6 and 7 describe current status advancements in audio watermarking, chapter 8 describes text watermarking, and the last chapter introduces watermarking of 3D meshes and outlines it importance.

Chapter 5 brings into evidence the role watermarking techniques may play in the new applicative field of video in-band enrichment. Following the watermarking philosophy, the in-band enrichment supposed that the enrichment video is inserted into the video to be enriched. Thus, three main advantages are ensured: backward compatibility, format coherence, and virtually no network overhead. The discussion is structured on both theoretical aspects and on developed applications.

Chapter 6 recapitulates the state-of-the-art of digital audio watermarking, including descriptions of audio watermarking algorithms and malicious attacks against these algorithms. The chapter gives a literature survey of audio watermarking algorithms that form the mainstream research, and outlines the areas in which audio watermarking has been implemented along with possible future applications. The chapter also provides a comprehensive list of attacks used by adversaries to interfere with the embedded watermark and to prevent its detection.

In chapter 7, Independent Component Analysis (ICA) based watermarking methods are used to embed copyright information in audio signals. The integrity of a hidden message when the cover text in which it is hidden, is attacked by applying signal processing techniques such as filtering and addition of noise to the signal will be investigated. The results of the application of the ICA based method are compared with the results of the application of the discrete wavelet transform (DWT) based approach. The chapter reveals the advantages of using a data dependent transform (for example ICA) based watermarking method for copyright applications when compared with static transform domain (having fixed coefficients, for example DWT) based methods.

Literature piracy, though not being given much attention, constitutes a major bulk. Therefore, chapter 8 deals with text watermarking, which is a very important technology to solve the literature piracy problem. The chapter embarks on review of technological advancements for text copyright protection along with issues and challenges for their implementation. Appraisal comprises of watermark embedding
algorithms and distribution infrastructure. A brief discussion over the document structure, watermark composition and type, classification of algorithms and future direction is also given. To make approach holistic, a couple of systems are also studied.

Chapter 9 deals with digital watermarking of three-dimensional (3-D) meshes. This relatively new area of digital watermarking has numerous potential applications which already received attention from both academic researchers and industrial practitioners. The authors, first, review the existing methods proposed so far by classifying them into three groups: fragile schemes, high-capacity schemes and robust schemes. Then, they present their recent work on quantization-based blind watermarking of semi-regular meshes. Finally, the authors suggest some future working directions in watermarking of three-dimensional meshes.

The number of digital files with multimedia objects (images, audio, video, and text) is increasing across the Internet. In section 3, five chapters are introduced to present new advancements in multimedia watermarking. Chapter 10 describes a unified dual-transform approach for watermarking multimedia objects, while chapter 11 gives a survey on the use of the SVD (Singular Value Decomposition) transform in multimedia watermarking. Chapters 12 proposes feature-based watermarking for copyright protection of images and video documents. Chapter 8 furnishes the theoretical foundation for embedding multiple watermarks in multimedia objects. Finally, chapter 14 describes copyright protection in the distribution of multimedia digital objects across the Internet.

Chapter 10 describes imperceptible and robust watermarking algorithms for three different types of multimedia objects (image, video, audio). Proposed algorithms are based on cascading two powerful mathematical transforms; the Discrete Wavelet Transform (DWT), and the Singular Value Decomposition (SVD). The two transforms are different, and thus provide complementary levels of robustness against the same attack. In the proposed dual-transform algorithms, the watermark bits are not embedded directly into the wavelet coefficients, but rather on the elements of singular values of the DWT sub-bands of the media object. Effectiveness of the proposed algorithms is demonstrated through extensive experimentation.

Chapter focuses 11 on the Singular Value Decomposition (SVD) transform, with the aim of providing an exhaustive overview on those steganography and watermarking techniques leveraging on the important properties of such a transform. The large number of algorithms operating in the image, video and audio context is first classified by means of a general approach, and then analyzed to highlight the advantages and disadvantages of each method. The chapter also gives a detailed discussion about the applicability of each reviewed and compared data hiding scheme, in order to identify the most appropriate candidates for practical applications.

Chapter 12 presents a new paradigm for rendering any watermarking scheme resistant to geometric attacks such as rotation, scale change or cropping. This is done by means of a new image transform to a Rotation, Scaling, and Translation (RST) invariant domain based on ideas from shape theory. The chapter also proposes extensions of this technique to video watermarking. An example is provided of how these ‘shape based’ concepts can be extended to more general relational databases, provided that an abstract notion of shape is employed.

The goal of chapter 13 is to provide important technical insights, as well as intuitive and well-developed discussions, onto how multiple watermarks can be embedded efficiently into the same host signal. The chapter adopts communication and information theoretic inclinations, and argues that this problem has tight relationship to conventional multi-user information theory. By virtue of this tight relationship, the author shows that design and optimization of algorithms for multiple watermarking applications can greatly benefit from recent advances and new findings in multi-user information theory.

The last chapter in this section, chapter 14, presents the most significant approaches developed so far for the distribution of multimedia digital contents with copyright protection, highlighting their most
interesting features. The approaches may be classified into two categories: systems that try to prevent unauthorized uses of the contents, and systems whose purpose is to detect unauthorized uses of the contents and to identify involved offenders. The chapter is focused on systems that fit in the second of these strategies; most of which are based on the use of multimedia watermarking techniques.

The last section of this book presents four chapters that deal with performance improvement of digital watermarking through optimization and hardware implementation. Chapter 15 suggests improving performance by treating watermarking as an optimization problem, and chapter 16 by using error correction codes. On the hand, chapter 17 gives a survey on how hardware implementations of image and video watermarking algorithms can accelerate watermarking speed and makes real-time watermarking feasible. The last chapter takes spread spectrum watermarking as a special case, and gives a detailed FPGA architecture for an actual watermarking system.

Chapter 15 looks at digital watermarking as an optimization problem to resolve the conflicting requirements of different parameters and properties of digital watermarking. The chapter presents a review of recent advances in the state-of-the-art algorithms for optimized watermarking techniques. Optimized watermarking methods are discussed from the rigorous mathematical analysis to theoretical derivations of algorithms with the aid of soft computing techniques. The design and implementation of optimized watermarking methods for the image, video and sound signals are discussed in the context of various diverse applications.

Chapter 16 describes how application of Error Control Coding (ECC) improves performance of watermarking schemes. The authors study various properties of watermarking systems, looking into their specific requirements, and then try to search for suitable error control code in order to boost the overall performance of watermarking techniques. The chapter also discusses the state-of-the-art research in this direction, and presents a watermarking method based on facts covered in the chapter.

The use of watermarking in real-time applications and consumer products, such as digital cameras and camcorders, dictates the development of hardware architectures. Chapter 17 presents a survey of existing hardware implementations of image and video watermarking. It first discusses the design issues and implementation challenges in image and video watermarking with emphasis on computational complexity aspects. This is followed by a classification and detailed survey of the different hardware implementations reported in the literature. Future perspectives to address the challenges of hardware architecture design for image and video watermarking are then discussed.

The last chapter, chapter 18, describes a special hardware implementation of a spread spectrum (SS) watermark system. It first presents a brief review on the hardware implementation of digital watermarking algorithms, followed by the development of a hardware architecture for a spatial domain and fast Walsh transform (FWT) domain Spread spectrum (SS) watermark system design using field program- mable gate array (FPGA) techniques. Few challenges for hardware design of watermarking algorithms are then described with an objective to give an idea how to develop watermarking algorithms so that it can be implemented in hardware.