

About the Book

Foundation of Computer Security: Cryptography, Attacks, and Emerging Technologies" is a comprehensive guide to cybersecurity in the digital age. Covering topics from cryptography to emerging technologies like IoT and blockchain, this book offers insights and practical advice for professionals, researchers, and students. It explores secure communication, network security, AI in cybersecurity, healthcare security, cloud security, and the potential of emerging technologies to enhance security measures. With a focus on theoretical understanding and practical applications, it's an essential resource for navigating the ever-evolving landscape of computer security.

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Mr. Rohit Maheshwari an esteemed academician, possesses an extensive 18 years of experience in the education sector. Currently engaged in the pursuit of a PhD in computer science, his academic interests encompass Network Security, Artificial Intelligence, and Machine Learning. Mr. Maheshwari holds the position of Assistant Professor at Career Point University in Kota, Rajasthan.

Deepak Mahawar has dedicated over 19 years to academia, showcasing versatility and a pursuit of excellence. He holds a Bachelor's in Computer Science & Engineering, a Master's in Technology, and is pursuing a Ph.D. in Computer Science and Artificial Intelligence. His career includes research roles at Indian Institute of Technology, Kanpur, with publications and presentations in international forums. As an educator, he has contributed to institutions like Poornima University, Suresh Gyan Vihar University, and Career Point University, focusing on curriculum development and student mentorship.

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FOUNDATION OF COMPUTER SECURITY

cryptology, Attacks and Emerging Technologies



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FOUNDATION OF COMPUTER SECURITY

CRYPTOGRAPHY, ATTACKS AND EMERGING TECHNOLOGIES

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Preface

In today's digital age, computer security is of utmost importance as technology pervades every aspect of our lives. This book offers a comprehensive exploration of computer security, covering topics from cryptography to emerging technologies like IoT, AI, cloud computing, and blockchain.

Beginning with cryptography, we delve into the fundamentals of secure communication, exploring classical encryption methods and modern cryptographic algorithms. We then move on to network security, discussing advancements and strategies to safeguard interconnected systems against cyber threats.

The section on IoT security addresses the unique challenges posed by the interconnectedness of devices, offering strategies for securing IoT ecosystems. AI's role in cybersecurity is examined, highlighting how machine learning can automate threat detection and response effectively.

A focus on healthcare security introduces a technique using AI for secure image watermarking to protect sensitive medical data. Cloud security best practices are outlined, covering encryption, access control, and threat detection in cloud environments.

Emerging technologies like quantum computing and blockchain are explored for their potential to enhance cloud security. Finally, we discuss blockchain's applications beyond cryptocurrency, offering transparency, immutability, and security in various industries.

This book is tailored for cybersecurity professionals, researchers, and students, providing theoretical insights and practical guidance to navigate the evolving landscape of cyberspace effectively.



Book Description

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A Secure Image Watermarking Technique for Healthcare Using Artificial Intelligence

Ms. Preeti Gupta

ABSTRACT

Watermarking using AI involves embedding digital watermarks into multimedia content, such as images, videos, or audio, to protect intellectual property, indicate ownership, or track the source of the content. AI-based watermarking techniques often leverage advanced algorithms to ensure robustness, imperceptibility, and resistance against removal or tampering.

The proposed technique leverages advanced watermarking algorithms to embed imperceptible and robust watermarks directly into medical images, ensuring the integrity and authenticity of the visual data. The primary objectives of this technique include protecting patient confidentiality, preventing unauthorized tampering, and facilitating the traceability of medical images throughout their lifecycle.

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3. Prerequisites for Medical Image -Watermarking Techniques
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1. Introduction

Image watermarking is a technique employed to embed information, often imperceptible to the human eye, into digital images for various purposes such as copyright protection, authentication, and tamper detection. In the context of digital media, a watermark serves as a unique identifier or signature that is embedded within the content, allowing for the verification of its authenticity and protecting it from unauthorized use or manipulation.

The primary goals of image watermarking include:

Copyright Protection: Digital images are easily replicated and distributed, making them susceptible to unauthorized use and infringement. Image watermarking helps protect the intellectual property rights of content creators by embedding unique identifiers or ownership information into the images.

Authentication: Watermarks can be used to verify the authenticity and origin of digital images. This is particularly crucial in applications where the integrity of visual content is essential, such as medical imaging, legal documentation, and forensic analysis.

Tamper Detection: It is possible to build image watermarks that are resistant to standard image processing techniques and modifications. This offers a way to guarantee the integrity of visual data by detecting any illegal changes made to the original image.

Data Integrity in Communication: In the era of digital communication and information exchange, ensuring the integrity of transmitted images is paramount. Watermarking can be employed to embed additional information that aids in verifying the -integrity of images during transmission.

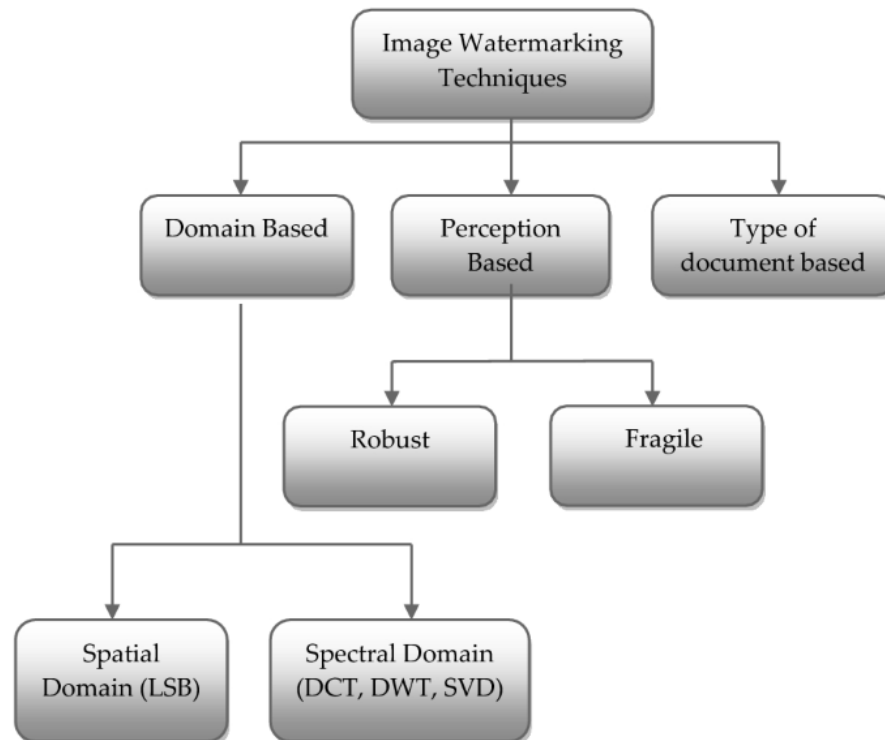


Figure 7.1 Types of Image Watermarking Techniques

There are two main categories of image watermarking techniques:

Spatial Domain Watermarking: In this approach, the watermark is directly embedded into the pixel values of the image. Spatial domain methods are relatively simple and fast but may be more susceptible to attacks and image manipulations.

Frequency Domain Watermarking: This technique involves transforming the image into the frequency domain (e.g., using Fourier or wavelet transforms) and embedding the watermark in the transformed domain. Frequency domain methods often offer better robustness against common image processing operations.

Image watermarking has found applications in various domains, including multimedia, medical imaging, digital forensics, and content authentication. The choice of watermarking technique depends on the specific requirements of the application, considering factors such as imperceptibility, robustness, and security.

As technology continues to advance, image watermarking remains a critical tool in addressing the challenges of digital content protection and authentication, contributing to the secure and trustworthy use of digital images across diverse fields.

2. Digital image watermarking Application using AI

Embedding Process:

- **Deep Learning-Based Embedding:** Utilize deep neural networks for intelligent embedding of watermarks into medical images. Train the model to identify optimal locations and intensity for watermark embedding while considering image content, ensuring that the watermark is inconspicuous.
- **Adaptive Watermarking:** Develop an adaptive system that tailors watermarking parameters based on the type of medical image (e.g., X-rays, MRIs, CT scans). Different imaging modalities may require specific embedding techniques to maintain both watermark visibility and medical image quality.

Robustness and Security:

- **Deep Learning for Robustness:** Employ deep learning models to enhance the robustness of watermarks against common attacks like image compression, cropping, or noise addition. Train the model to embed watermarks in a way that is resistant to alterations while maintaining diagnostic image quality.
- **Cryptography Integration:** Combine AI-based watermarking with cryptographic techniques to enhance the security of embedded watermarks. This ensures that the watermark information remains confidential and tamper-resistant.

Detection and Authentication:

- **AI-Based Detection:** Train neural networks to detect and extract watermarks from medical images. This AI-based detection ensures accurate verification of the presence and authenticity of the watermark.
- **Machine Learning for Authentication:** Utilize machine learning algorithms to distinguish between genuine and manipulated medical images. Analyze patterns and anomalies in the watermark or image content to authenticate the integrity of the data.

Dynamic Watermarking:

- **Temporal Variation:** Implement dynamic watermarking by introducing variations in the watermark over time. This dynamic feature increases security by making it harder for unauthorized users to anticipate or routinely remove the watermark.
- **Contextual Adaptability:** Develop a system that adapts watermarking based on contextual information, such as patient information, imaging facility details, or date of acquisition.

Invisible Watermarking:

- **Perceptual Models:** Leverage perceptual models and deep learning to embed watermarks that are imperceptible to the human eye. This ensures that the watermark does not compromise the diagnostic quality or clinical utility of the medical images.

Integration with PACS (Picture Archiving and Communication System):

- **Seamless Integration:** Ensure seamless integration with healthcare systems, particularly with PACS, to facilitate the widespread adoption of watermarked medical images. This integration should not disrupt existing workflows or compromise the efficiency of image retrieval and analysis.

Regulatory Compliance:

- **Compliance with Privacy Laws:** Design the watermarking technique to comply with healthcare privacy regulations and standards, such as the Health Insurance Portability and Accountability Act --(HIPAA) in the United States or similar regulations in other countries.

User Accessibility:

- **User-Friendly Interfaces:** Develop user interfaces that allow healthcare professionals to easily visualize and manage watermarks. Ensure that the watermark information is accessible and understandable without hindering the interpretation of medical images.

3. Prerequisites for Medical Image -Watermarking Techniques

Medical image watermarking involves embedding information into medical images to ensure authenticity, integrity, and ownership. Before delving into specific techniques, it's essential to have a foundation in certain prerequisites. Here are key prerequisites for understanding and implementing medical image watermarking techniques:

Image Processing Fundamentals: Understanding of basic image processing concepts, including image acquisition, enhancement, compression, and transformation.

Medical Imaging Modalities: Knowledge of different medical imaging modalities such as X-ray, MRI, CT, ultrasound, etc. Understanding of the characteristics, advantages, and limitations of each modality.

Digital Signal Processing (DSP): Fundamentals of digital signal processing, as image watermarking often involves manipulation of image signals in the frequency or spatial domain.

Cryptography Basics: Understanding of cryptographic concepts for securing watermark data, ensuring confidentiality, integrity, and authentication.

Steganography Concepts: Familiarity with steganography, the science of hiding information within other data. This is relevant for embedding watermarks imperceptibly within medical images.

Image Compression Techniques: Awareness of image compression techniques, as compression may affect the efficiency of watermarking algorithms.

Information Theory: Understanding the principles of information theory, which is crucial for assessing the capacity and robustness of watermarking techniques.

Programming Skills: Proficiency in programming languages such as Python, MATLAB, or others commonly used in image processing and watermarking research.

Ethical Considerations: Knowledge of ethical considerations related to medical data, patient privacy, and legal implications of manipulating medical images.

Image Quality Assessment Metrics: Understanding metrics used to assess image quality, as watermarking should not significantly degrade the quality of medical images.

Regulatory Compliance: Knowledge of relevant regulatory standards and compliance requirements, such as the Health Insurance Portability and Accountability Act “(HIPAA) for medical data in the United States.

Clinical Understanding (Optional): A basic understanding of clinical practices and medical workflows can provide context for designing watermarking systems that align with the needs of healthcare professionals.

By having a solid foundation in these prerequisites, you'll be better equipped to comprehend, implement, and contribute to advancements in medical -image watermarking techniques.

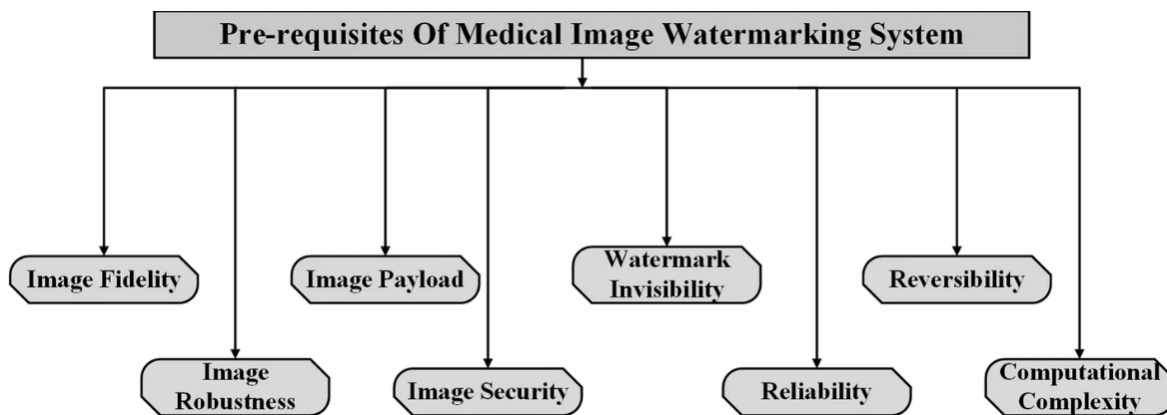


Figure 7.2: Prerequisites for Medical Image Watermarking Techniques

4. Basic component of medical image watermarking

Medical image watermarking shares fundamental components with general image watermarking, but it also has specific considerations due to the sensitive nature of medical data. Here are the basic components of medical image watermarking:

a) Patient Information:

Medical images often contain patient information. In medical image watermarking, protecting patient privacy is crucial. The watermark may include patient identifiers, study information, or other relevant metadata.

b) Watermark Payload:

Medical picture watermarking works similarly to ordinary image watermarking in that the watermark payload might contain data like patient specifics, dates, hospital details, or research identification. To preserve the image's diagnostic quality, this information is usually incorporated in a method that is undetectable.

c) Embedding Algorithm:

The embedding algorithm is responsible for incorporating the watermark payload into the medical image. It should be designed to minimize distortion and avoid negatively impacting the clinical interpretation of the image.

d) Key or Secret:

To ensure security and control access, a secret key is often used in medical image watermarking. This key is crucial for both embedding and extracting the watermark and is known only to authorized parties.

e) Watermarked Medical Image:

The result of embedding the watermark payload into the original medical image. The watermarked image should be clinically usable and visually similar to the original image.

f) Detection/Extraction Algorithm:

Similar to general image watermarking, a detection or extraction algorithm is used to recover the embedded watermark from the watermarked medical image.

g) Quality Assessment Metrics:

Medical images are subject to rigorous quality standards, and any watermarking should not compromise diagnostic accuracy. Quality assessment metrics are essential to ensure that the watermarking process does not significantly degrade the medical image's quality.

h) Robustness Measures:

Robustness is crucial in medical image watermarking to withstand common image processing operations and ensure the watermark's integrity during clinical procedures such as compression or archiving.

i) Regulatory Compliance:

Adherence to healthcare regulations, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States or similar regulations in other countries, is essential to protect patient privacy and ensure legal compliance.

j) Authentication and Integrity Checks:

Medical image watermarking may include mechanisms for authenticating the embedded information and checking the integrity of the watermarked image to ensure it has not been tampered with.

k) Security Measures:

Incorporating security measures, such as encryption or digital signatures, to protect the watermarking system from unauthorized access and tampering.

l) Ethical Considerations:

Considering the ethical implications of watermarking medical images, including the potential impact on patient trust, and ensuring that the process aligns with medical ethics.

By considering these components, medical image watermarking can be designed to fulfill its purpose of providing traceability, authentication, and protection of patient information while maintaining the quality and integrity of medical images.

5. Applications of MIWT's

Medical Image Watermarking Techniques- (MIWT) find applications in various areas within the healthcare industry. Some of the key applications include:

- a) **Data Authentication and Integrity:** MIWT is used to authenticate and ensure the integrity of medical images. By embedding watermarks containing patient information, study details, and other metadata, healthcare professionals can verify the authenticity of the- medical images.
- b) **Ownership and Copyright Protection:** Watermarking medical images helps protect the ownership and copyright of healthcare institutions, researchers, or individual healthcare professionals. It serves as a digital signature, indicating the source and ownership of the medical images.
- c) **Patient Information Embedding:** MIWT allows for the embedding of patient-specific information directly into medical images. This aids in the identification of patients, linking images to the correct medical records, and enhancing traceability in healthcare workflows.
- d) **Clinical Trials and Research:** In clinical trials and research studies, MIWT can be employed to mark and track specific sets of medical images. This helps in maintaining the integrity of the data, preventing unauthorized alterations, and ensuring the reliability of research outcomes.
- e) **Telemedicine and Remote Diagnostics:** In telemedicine scenarios, where medical images” are transmitted over networks for remote diagnostics, MIWT can secure the transmitted images. This ensures that the images have not been tampered with during transmission, preserving the accuracy of diagnostic interpretations.
- f) **Legal and Forensic Applications:** MIWT plays a role in legal and forensic investigations involving medical images. Watermarks can serve as evidence, establishing the authenticity of images for legal purposes and forensic analysis.
- g) **Quality Control and Assurance:** MIWT assists in quality control and assurance by providing a means to track and verify the authenticity of medical images throughout their lifecycle. This is particularly important in maintaining the diagnostic accuracy of images for patient care.

6. Conclusions

In conclusion, the application of image watermarking in the medical field offers valuable solutions to address various challenges related to data integrity, security, and traceability. As healthcare systems increasingly rely on digital imaging for diagnosis, treatment, and research, the need to protect, authenticate, and manage medical images becomes paramount.