VIETNAM NATIONAL UNIVERSITY-HCMC
Ho Chi Minh City University of Technology

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INFORMATION OF THE DISSERTATION

PhD candidate: **NGUYEN THANH TUAN**

Dissertation's title: **IMPROVING THE EFFECTIVENESS OF BLIND WATERMARKING TECHNIQUES FOR MEDICAL IMAGES AND MULTI-CHANNEL IMAGES**

Major: **Telecommunications engineering**

Major code: **62.52.02.08**

Science advisor: **Prof. LE TIEN THUONG**

Institution: **Ho Chi Minh City University of Technology, Vietnam National University- Ho Chi Minh City**

Objectives of the dissertation

Watermarking is a technique of embedding and extracting message (information) in multimedia data. Recently, it has received great attention in theoretical research as well as application to solve practical problems. Although there are many different implementation solutions, in general, watermarking methods can be divided into two types: obvious and blind. Most of the improved solutions obtain good results with obvious watermarking but are limited in practical applications due to the requirement of original data or its features in the information extraction process. On the other hand, in the case of image watermarking, many authors only focus on improving algorithms for a specific type of image, most of which are common grayscale images. The number of studies for medical images and multi-channel images is still limited and challenging. In addition, the parameters in these algorithms are mainly selected based on experience without optimal evaluation analysis. In addition, many authors do not consider the robustness of embedded information against the full range of different types of attacks or security when performing information extraction.

Therefore, the objective of the dissertation is to provide solutions to improve the effectiveness of blind watermarking techniques for medical images and multi-channel images in the spatial domain as well as in the transform domains suitable for each specific application requirement. The proposed solutions can be applied to both single-bit and multi-bit watermarking cases. The theoretical results have been verified through simulation and practical applications. The results are performed with a variety of common and specific image types and consider different types of attacks including both synchronous and nonsynchronous types. In addition to assessing the imperceptibility and robustness, the thesis also assesses the reliability and enhances the security to match the specific requirements in the medical field.

Contributions of the dissertation

The first contribution of the dissertation is to propose two solutions DICOM_LSB_AES and DICOM_LSB_AES_RONI by combining coding technique, Advanced Encryption Standard technique and Least Significant Bit based watermarking technique for embedding and

extracting personal information in whole or only the RONI (Region Of Non-Interest) of DICOM (Digital Imaging and COmmunications in Medicine) medical images to enhance security for telemedicine applications. With the characteristic that DICOM images often use more than 8 bits compared to common grayscale (monochrome) formats, can be supported up to 16 bits to achieve high display quality for diagnostics, the research on LSB watermarking technique for DICOM images brings a noticeable effect in terms of imperceptibility. In addition, this method also has the advantage of being simple in embedding and extracting information because it can be performed directly in the spatial domain, so it is suitable for practical applications.

Next, another research content of the dissertation focuses on proposing effective watermarking solutions for medical images based on quantization techniques to improve robustness by selecting stable SIFT (Scale-Invariant Feature Transform) while the extraction process still does not need to use the original image or original feature information to match features like some traditional methods. In addition to the watermarking solution for a single bit of information Q_SIFT (Quantization_SIFT), the thesis also expands analysis and evaluation of multi-bit watermarking with two solutions FSMQ_SIFT (Fan-shaped Multi-bit Q_SIFT) and HRSMQ_SIFT (Half-Ring-shaped Multi-bit Q_SIFT). For each solution, the thesis adds double security by exploiting the parameters of the SIFT feature through the solution SQ_SIFT (Secure Q_SIFT) and the secret key. Simulations were implemented with a variety of common medical imaging modalities including Computed Tomography, Magnetic Resonance Imaging, X-Ray, and UltraSound to evaluate the effectiveness of the proposed solutions, which are highly effective against many typical attacks in medical image processing, from non-synchronous types such as noise, compression, filtering, to synchronous ones such as rotation, scaling, cropping, and even super-resolution using artificial intelligence based on deep learning netwotk architecture model of the RRDN (Residual-in-Residual Dense Network).

Finally, the dissertation makes extensive improvements to MISS (Multi-bit Improved Spread Spectrum), MISS_DCT (MISS_Discrete Cosine Transform) and MISS_DWT (MISS_Discrete Wavelet Transform) to improve the the effectiveness of spread spectrum based watermarking method for single-channel images in order to overcome some existing limitations, from which to develop a novel solution for cooperative blind spread spectrum based watermarking CSS (Cooperative SS) and exploit KLT (Karhunen-Loève Transform) with new solution CSS_KLT to decorrelate the signal components of multi-channel images. Besides, improved solutions to remove interference between watermark and image channels as well as extend multi-bit watermarking are also proposed and analyzed, including ICSS (Improved CSS), MCSS (Multi-bit CSS), ICSS_KLT (Improved CSS_KLT), MCSS_KLT (Multi-bit CSS_KLT). The results are theoretically analyzed by mathematical model and verified through simulation and experiment with different types of medical images.

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