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INFORMATION OF THE DISSERTATION

PhD candidate: **NGUYEN CHI SY**

Dissertation's title: **DIGITAL IMAGE WATERMARKING SCHEMES BASED ON MULTIRESOLUTION ANALYSIS**

Major: **Telecommunications engineering**

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Science advisors: **Assoc. Prof. HA HOANG KHA**
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Objectives of the dissertation

The explosive growth of the Internet and social networks has provided the increasing convenience for the transmission and sharing digital multimedia applications such as audio, images and videos. With the development of the advanced multimedia signal processing technologies, digital multimedia can be easily and simply acquired, copied and tampered. Thus, the issues related to multimedia information protection, copyright and content authentication have been of great concerns. With digital image data, there have been extensive studies on how to prevent unauthorized users from illegally copying, and distributing, modifying the digital images. The digital watermarking techniques which embed hidden information (known as a watermark) to a host media to detect and trace copyright violations have attracted considerable interest from academia and industry. Digital image watermarking can be found in various practical applications of copyright protection, image authentication, medical applications, tamper detection, digital finger printing. The objective of the thesis is to develop algorithms for embedding and extracting watermarks that satisfy the requirements of watermarking applications in copyright protection. This thesis mainly focuses on digital image watermarking schemes based on multiresolution analysis. The performance of the proposed algorithms will be evaluated by various parameters on standard gray and color image datasets.

Contributions of the dissertation

At first, the thesis investigates on the digital image watermarking techniques in spatial domain and transform domains. In each method, the basis of mathematics, watermarking schemes, the advantages and disadvantages will be presented. Then, we propose the appropriate region in spectral domain for watermarking to enhance the robustness and invisibility of watermarked images. The experimental results of digital image watermarking on spatial domain, DCT, DWT, combined DCT-DWT are also presented and discussed. The experimental results show that watermarking in spatial domain is not guaranteed the robustness when the watermarked images are attacked by signal processing operations; the robustness of watermarking in DWT domain is better than that in DCT domain, however under the JPEG compression attacks, the robustness of watermarking in DCT domain is

slightly better than that in DWT domain; By embedding the watermark into the subband of middle frequencies, the digital image watermarking algorithm in DCT-DWT domain is guaranteed to balance between the invisibility and robustness. As such, watermarking for applications with the required robustness, the schemes of embedding watermark in spatial domain or DCT domain are proved less suitable; embedding the watermark in the multi-resolution domains (DWT and DCT-DWT) can be applied for watermarking applications that need the robustness.

Next, the thesis proposes a novel method exploiting the improved Laplacian pyramid (LP) transform to develop a new image watermarking scheme in which the improved Laplacian pyramid transform is used to decompose and reconstruct the host image. Then, to select an appropriate watermarking solution, we investigate the various frequency subband regions with different the levels and strength factors to perform the watermark embedding. The experimental results of the proposed algorithm show that images which have much high frequency components result in the better invisibility when embedded with watermarks; the robustness and invisibility guaranteed with different strength factors on the low and mid frequency subbands. As compared to the watermarking schemes using the curvelets, our watermarking scheme is more robust for the lossy JPEG compression and Gaussian low pass filtering attacks. In addition, our method is also efficient in terms of computational time. Thus, the approach of the digital image watermarking in LP domains is applicable for applications requiring the robust watermarking and low complexity computation.

In the other research, the thesis introduces the usage of curvelet transform domain for image watermarking since curvelet transform is effective when representing curves with fewer coefficients than other transforms such as wavelets for the same accuracy. The thesis investigates the different scales of curvelet transform domain for embedding the watermark to achieve both invisibility and robustness. The performance of image watermarking in curvelet transform domain is compared with the same algorithm but applied on DCT-DWT combined domain. Experimental results have shown that invisibility (PSNR) under no attack is higher than 42 (dB) and the robustness (NC) in most attacks is more than 0.9. The performance in terms of the invisibility and robustness of the proposed algorithm is better than the given algorithm applied on DCT-DWT domain when the watermarked images are attacked by lossy JPEG compression, speckle noise and Gaussian noise. This is also a blind, invisible, robust watermarking method which can be effectively applied in practice.

Another contribution of the research in this thesis is concerned with a digital watermarking technique for color images based on directional transforms. This research investigates the performance of the watermarking schemes using FDCT and CT. The research conducts the experiments to select appropriate strength factors and analysis levels for the proposed watermarking scheme. We evaluate the performance of the watermarking schemes using the directional transforms on a standard database of color images in terms of invisibility and robustness. The experimental results reveal that watermarking schemes in the directional transform domains outperform the other schemes in DWT domains in terms of invisibility and robustness, especially for images with much directional information. These watermarking schemes on directional transforms are especially suitable for images with directional information.

Finally, a novel scheme of digital image blind watermarking based on the combination of the DWT and the convolutional neural network (CNN) is proposed. Firstly, the host images are decomposed by DWT and, then, the low frequency sub-bands and the high frequency subbands, the middle frequency sub-bands are used as the input data and the output target data to train the CNN model for embedding and extracting the watermark. Experimental results show that the proposed scheme has superior performance against common attacks of JPEG compression, mean and median filtering, salt and pepper noise, Gaussian noise, speckle noise, brightness modification, scaling, cropping, rotation, and shearing operations.

Scientific Advisors **PhD Candidate**

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