BM13.1-ĐT-BVCS

MINISTRY OF EDUCATION AND TRAINING **THE SOCIALIST REPUBLIC OF VIETNAM**

**HO CHI MINH CITY UNIVERSITY OF Independence – Freedom - Happiness**

**TECHNOLOGY AND EDUCATION**

**SUMMARY OF CONTRIBUTIONS OF THE DISSERTATION**

PhD candidate: : **Duong Hien Thuan** Fellows code: 1927002

Major : Electronic Engineering Major code: 2019 – 2022

Dissertation title : Secure Cooperative Transmission of Image Super-

Resolution in Wireless Relay Networks

Supervisor one : Assoc. Prof. Phan Van Ca

Supervisor two : Dr. Vien Quoc Tuan

**Summary of theoretical and academic contribution of the dissertation:**

This dissertation is an interdisciplinary research work that integrates knowledge from cooperative wireless communications, digital image processing, Random Linear Network Coding (RLNC), and deep learning (DL) techniques.

The core contribution of the dissertation is the proposal of a novel Secure Cooperative Relay (SCR) protocol for cooperative relay wireless networks, simultaneously targeting three critical objectives: (i) bandwidth efficiency, (ii) transmission reliability, and (iii) data security against unauthorized access by eavesdroppers. SCR leverages RLNC to encode and protect the transmitted data, incorporates a mechanism to downscale high-resolution (HR) images into low-resolution (LR) images to save bandwidth, and embeds the LR images into reference images selected from a shared database available to legitimate nodes. At the receiver, the embedded data is recovered through RLNC decoding, denoised using a DnCNN neural network, and upscaled via the VDSR deep super-resolution method to reconstruct the final HR image.

For system implementation, the dissertation adopts a cooperative relay network model integrating Decode-and-Forward (DF) and Coded Cooperation (CC) strategies. Image data is transmitted over both the Secure Direct Transmission (SDT) channel and the Secure Relay Transmission (SRT) channels, and then combined to exploit spatial diversity while mitigating noise, attenuation, and channel fading. The proposed framework is validated through MATLAB simulations using a benchmark dataset of 20,000 images. Objective performance metrics, namely Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM), are evaluated over both AWGN and Rayleigh fading channels, with additional analysis of the impacts of channel attenuation, node placement, and receive diversity on the reconstructed image quality.

Experimental results indicate that in the low-SNR region, the SRT channel outperforms the SDT channel, whereas in the high-SNR region, SDT achieves better performance. Notably, the SCR protocol consistently delivers the highest efficiency and security across all test conditions, ensuring that eavesdroppers are practically unable to reconstruct the transmitted HR images. Furthermore, the study highlights a clear trade-off between bandwidth usage and image quality, enabling the design of optimal strategies to balance channel utilization efficiency with the desired Quality of Service (QoS) in image transmission applications.

From a practical standpoint, the proposed SCR protocol can be applied to various scenarios requiring high-reliability and secure image transmission over wireless networks, such as remote monitoring, medical image delivery over wireless sensor networks, and UAV-based imaging in harsh environments. The research outcomes offer a feasible technical solution for future 5G/6G networks, IoT systems, and image transmission applications in medical and military domains, where both bandwidth efficiency and reliability are of paramount importance.

*Ho Chi Minh City, July 18, 2025*

**PhD candidate**

*(Sign and name)*

**Duong Hien Thuan**