DISCUSSION INFORMATION PAGE

PhD thesis title: **Research on image processing techniques based on integrated photonics technology**

Specializes Major: Computer Engineering

Code Number: 9.48.01.06

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Science instructor:

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Training institution: Post and Telecommunications Institute of Technology

NEW RESULTS OF THE THESIS

The thesis has successfully researched and designed DHT, DCT and KLT converters in the optical domain, applied for high-speed image processing. At the same time, the thesis has proposed and designed a new all-optical neural structure capable of computing convolution in the high-speed optical domain. From there, the application for edge separation uses Roberts, Prewitt and Sobel operators in the optical domain. The thesis has proposed and successfully designed a photonic neural network and tested for image data classification. Outcomes The thesis is an interdisciplinary research aimed at designing all-optical computing and computing systems in the near future. The new contributions of the research process shown in the thesis are as follows:

1. Design DHT, DCT, KLT all-optical transform for image compression

Image processing in the optical domain was previously performed through lens, optical Fourier, and fiber systems [38]. Since 2013, for the first time, image processing in the optical domain has been implemented in an integrated optical structure using optical waveguides on polymer materials [5, 3], in which the image processing system is designed based on the optical structure. multimode interference architecture combined with directional couplers. The disadvantage of these methods is the large size, the need to combine many sets of directional structures, so the loss is large. At the same time, to achieve the accuracy of the coupler, it is necessary to have a precise manufacturing solution. Bandwidth or data

rate is also limited when using directional multiplexing because the coupling factor changes rapidly with changing operating wavelength, especially operating in the wavelength range of RGB color images.

The thesis has designed and analyzed image compression techniques using DHT, DCT and KLT transformations using only MMI multimode interference structure. The advantage of this new solution is the ability to integrate the entire system on a single chip, capable of integrating with information processing systems in sensor nodes, computers with compact operating systems. , low energy consumption and low resource requirements. In addition, the structures proposed by the thesis have the advantage of accurately performing the transformations with the allowable manufacturing error as large as ±18μm, high bandwidth and processing data rate. The new structure is capable of integrating with smart camera system, high-speed data processing, large bandwidth, real-time. The proposed structures are designed to be simple, with high accuracy compared to current IC technology.

2. Design a new optical neuron, thereby designing an optical neural network for image edge separation and image classification in the optical domain. The new structure has the ability to integrate, the speed is 5 times higher than the current system.

Although optical neural networks have been studied since 1991 [103], previous studies have relied on geometric optics and fiber-optic devices. Since 2017 [21], the first deep learning algorithm has been successfully implemented on optical microchip structure, creating a new research direction for the design of neural network systems for deep learning, regression problems. complex [104]. However, optical neural network design solutions use mainly directed coupler-based microresonance structures. This limits the construction of neural networks with many network nodes with the ability to handle big data problems, which need to store intermediate weight values during the learning process. Besides, it is difficult to control dozens of network nodes at the same time with high accuracy if using that microresonance structure.

Therefore, the thesis has proposed a new architecture and algorithm to design a neural network using a multimode interference structure combined with a ring waveguide to create a compact, high-bandwidth, high-speed micro-resonance. can precisely control the corresponding kernel filter factor. The thesis has designed,

simulated and evaluated algorithms for image edge separation and handwriting recognition on this new structure. Although the accuracy of recognition has not been achieved as achieved through the current computer system due to the limitation of the number of encoded bits in the optical domain compared to 32 and 64 bits, the data processing speed in the optical domain is high. tens of times higher than the electrical domain.

APPLICATIONS, POSSIBILITY OF APPLICATION IN PRACTICE OR ISSUES THAT NEED CONTINUED RESEARCH

On the basis of the results of the thesis, there are a number of new issues and research directions such as:

• Design a system that integrates image converters in the optical domain with optical memories in smart camera systems and real-time image data processing. Simultaneously design all-optical systems that process AR/VR data.

• Develop OONN network model for real-time AI applications, especially design activation functions entirely in optical domain.

• Improved graphene structure waveguide structure to increase data processing and learning speed, thereby performing big data analysis problems.

Confirmation of the collective representative **Postgraduate**

Science instructor

Assoc.Prof.Dr. Le Trung Thanh ***Assoc. Prof.Dr. Dang The Ngoc*** ***Bui Thi Thuy***