

論文 / 著書情報
Article / Book Information

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学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

(博士課程)
Doctoral Program

論文要旨

THESIS SUMMARY

専攻： Department of	知能システム科学	専攻	申請学位 (専攻分野)： 博士 (工学)
学籍番号： Student ID Number			指導教員 (主)： 廣田 薫 教授
学生氏名： Student's Name	孫 博		指導教員 (副)： Academic Advisor(sub)

要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

This thesis, entitled "RGB Multi-Channel Representation for Quantum Images and Its Application to Color Image Watermarking", is written in English, and constructed by 5 chapters.

Chapter 1 「Introduction」 mentions the concept of quantum computation and based on the principle of the quantum computing, the multi-channel representation for quantum images, and quantum algorithm of image processing and application to the image processing are discussed.

In Chapter 2 「RGB multi-channel representation for images on quantum computers」, an RGB Multi-Channel representation for Quantum Image (MCQI) using the property of quantum parallelism to encode the color information and their corresponding positions is proposed. Specifically, RGB color information is stored using three entangled qubits simultaneously and pixels' positions of a 2^n by 2^n pixels image is represented using $2n$ qubits. MCQI Provides a basis for further quantum image processing. MCQI based quantum image processing includes three steps: 1. preparation of MCQI quantum state; 2. designing of quantum image operators; 3. quantum measurement based image data retrieval. The preparation procedure for MCQI is indicated by using Hadamard, CNOT and controlled rotation operations. As proven by proposed Multi-Channel Polynomial Preparation Theorem, total number of simple operations used in the process is polynomial for number of qubits that are used to encode all positions in an image. The designing of image processing operators is convenient as all information of the R, G, and B channels are encoded into three qubits independently and simultaneously. The results of the image retrieval experiment of MCQI image reveal that the classical images can be stored in normalized quantum states simultaneously by using basic gates; the multi-channel information (color information) can be retrieved based on measurement; the PSNR of the retrieved images are greater than 45 dB, which proves the feasibility of the retrieval method.

In Chapter 3 「Color information transformations on Multi-Channel Quantum Images」, Channel Swapping (CS) operator, Color Space Transformation (CST) operator, and the Alpha Blending (AB) operator are proposed based on MCQI representation. Channel of Interest is the operator shifting the color information on only one channel (R, G, B, or Alpha channel) by applying Controlled Rotation gates. Channel Swapping operator is designed to swap the information between two channels (R and G, R and B, or G and B) which can be realized using CNOT and SWAP (constructed by 3 CNOT gates) gates. Color Space Transformation converts the color space of an image from RGB to other color spaces such as YIQ, YUV, and XYZ, etc. Alpha Blending operator is used to combine the color information of two different images. Complexities of the proposed four operators are low compared with their classical version. Firstly, as the multi-channel information are stored in the 3 color qubits simultaneously, the proposed color information operators applying on the whole image can be designed by using unitary quantum gates within these three qubits irrespective of the position qubits. It means that the complexity of the MCQI-based color information operators are image size independent, namely, $O(1)$ for an N -sized image, whereas the color information must be shifted pixel by pixel in the case of operators on classical computers.

In Chapter 4 「Quantum measurement based double-key double-domain watermarking strategy for multi-channel quantum images」, a quantum measurement based double-key, double-domain multi-channel watermarking strategy for quantum images (MC-WaQI) is proposed, which can be used to find the real

owner. Specially, this strategy includes three parts:

- Preprocessing part: in MC-WaQI strategy, the copyright information is requested to be embedded into both frequency domain and spatial domain of the carrier image, and hence, the logo information is requested to be generated from the original watermark image. To transform the two meaningful logo images into meaningless images, which is used to strengthen the power to resist invalid attack, two keys are generated to scramble both the position and the color information;
- Embedding part: after preprocessing procedure, the watermark images have been transformed into two meaningless images, and then the two noise-like images are embedded into both the spatial and frequency domain (the QFT coefficients of the carrier image);
- Extracting part: using the two keys generated in preprocessing part, only the owner can extract the two watermark images correctly, which ensures security.

Simulation results show that average PSNR of the watermarked images is 53 dB, which is about 8 dB better than the chosen strategy.

Chapter 5 「Conclusion」, concludes whole proposals and their application. Perspectives for quantum image processing are also mentioned.

To sum up, MCQI representation and quantum algorithms for image processing are proposed. Based on the representation and the quantum algorithm, the watermarking strategy is also discussed. The experiment results show that the proposed methods can speed up the classical algorithms. As a result, these works construct this doctor of engineering dissertation.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 2 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 2 copies of 800 Words (English).