

Chapter 3

Quantum Geometric Transformations

ABSTRACT

Geometric transformations are basic operations in image processing. This chapter describes geometric transformations of images and videos. These geometric transformations include two-point swapping, symmetric flip, local flip, orthogonal rotation, and translation.

INTRODUCTION

Many applications in both 2D and 3D biomedical imaging require efficient techniques for geometric transformations of images (Arce-Santana & Alba, 2009; Dooley, Stewart, Durrani, Setarehdan, & Soraghan, 2004). Quantum geometric transformations provides a feasible method to implement efficient geometric transformation. Geometric transformations, such as two-point swapping, flip, orthogonal rotation, and restricted geometric transformation, are applied to images based on FRQI (Iliyasu, Le, Dong, & Hirota, 2012; Le, Iliyasu, Dong, & Hirota, 2010, 2011). Next, quantum geometric transformations of images and videos based on NASS were proposed (Fan, Zhou, Jing, & Li, 2016). This chapter introduces quantum geometric transformations of images and videos based on NASS, which include two-point swapping, symmetric flip, local flip, orthogonal rotation, and translation.

DOI: 10.4018/978-1-7998-3799-2.ch003

TWO-POINT SWAPPING

Definition 4.1. A two-point swapping operator G_s^t for images and videos is defined as

$$G_s^t = |s\rangle\langle t| + |t\rangle\langle s| + \sum_{i=0, i \neq s, t}^{2^n-1} |i\rangle\langle i|, \quad (4.1)$$

where $|s\rangle$ and $|t\rangle$ encode the coordinates of the two swapped pixels. The binary expansions of the integers s , t , and i are $s=s_1, \dots, s_n$, $t=t_1, \dots, t_n$, and $i=i_1, \dots, i_n$, respectively.

The NASS state $|\psi\rangle$ represents a multi-dimensional image (i.e., a 2D image or a 3D video) with 2^n pixels,

$$|\psi\rangle = \sum_{j=0}^{2^n-1} \theta_j |j\rangle. \quad (4.2)$$

Applying G_s^t on the NASS state $|\psi\rangle$ implements the two-point swapping of a multi-dimensional image,

$$G_s^t |\psi\rangle = \sum_{i=0}^{2^n-1} \theta_i G_s^t |i\rangle = \theta_s |t\rangle + \theta_t |s\rangle + \sum_{i=0, i \neq s, t}^{2^n-1} \theta_i |i\rangle. \quad (4.3)$$

To design the quantum circuit of the two-point swapping operator G_s^t , we first introduce Gray code (Nielsen & Chuang, 2000). Suppose that s and t are two distinct binary numbers, then a Gray code that connects s and t is a sequence of binary numbers, which starts with s and ends with t , where adjacent members in the list differ by exactly one bit. For example, when n bit binary numbers $s=0\dots 0\dots 0$ and $t=1\dots 1\dots 1$ are the binary expansions of the integers 0 and $2^n - 1$, respectively, the Gray code is as follows,

23 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/quantum-geometric-transformations/261475

Related Content

Quantum Image Cryptography of Gingerbreadman Map by Using Pixel Shuffling

Shilpa M. Satreand Bharti Joshi (2025). *Harnessing Quantum Cryptography for Next-Generation Security Solutions* (pp. 467-494).

www.irma-international.org/chapter/quantum-image-cryptography-of-gingerbreadman-map-by-using-pixel-shuffling/362597

Enabling Smart Power Grids Through Quantum Computing and Artificial Intelligence

M. Sunil Kumar, R. V. V. Krishna, V. Satyanarayanaand A. Purna Chandra Rao (2024). *Real-World Challenges in Quantum Electronics and Machine Computing* (pp. 58-78).

www.irma-international.org/chapter/enabling-smart-power-grids-through-quantum-computing-and-artificial-intelligence/353098

AI-Driven Inventory Management for Optimizing Operations With Quantum Computing

Sumit Mittal, Priyanka Koushik, Iti Batraand Pawan Whig (2024). *Quantum Computing and Supply Chain Management: A New Era of Optimization* (pp. 125-140).

www.irma-international.org/chapter/ai-driven-inventory-management-for-optimizing-operations-with-quantum-computing/351818

Realizing Sustainable Energy Quantum Computing Applications in Power Grids

C. Sushama, Sonal Jain, Soma Parijaand S. Aslam (2024). *Real-World Challenges in Quantum Electronics and Machine Computing* (pp. 312-329).

www.irma-international.org/chapter/realizing-sustainable-energy-quantum-computing-applications-in-power-grids/353114

Role of Quantum Gates Towards Cryptographic Applications

Sharranya Sridharan, Padmapriya Pravinkumar and Nirbhay Kumar Chaubey (2025). *Harnessing Quantum Cryptography for Next-Generation Security Solutions* (pp. 369-412).

www.irma-international.org/chapter/role-of-quantum-gates-towards-cryptographic-applications/362594