Chapter 7
Quantum Image Segmentation Algorithms

ABSTRACT

Quantum image segmentation has always been one of the difficult tasks in quantum image processing. This chapter introduce two quantum image segmentation algorithms. One is quantum edge detection algorithm; the other one is quantum image segmentation based on generalized Grover search algorithm.

INTRODUCTION

A typical image processing task is the recognition of boundaries (intensity changes) between two adjacent regions. Classically, edge detection methods rely on the computation of image gradients by different types of filtering masks. Therefore, all classical algorithms require a computational complexity of at least $O(2^n)$ because each pixel needs to be processed (Yao, Wang, Liao, Chen, & Suter, 2017). A quantum algorithm has been proposed that is supposed to provide an exponential speedup compared with existing edge extraction algorithms (Zhang, Lu, & Gao. 2015). However, this algorithm includes a COPY operation and a quantum black box for calculating the gradients of all the pixels simultaneously. For both steps, no efficient implementations are currently available. A highly efficient quantum algorithm, named as quantum Hadamard edge detection, was proposed to find the boundaries (Yao, Wang,

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Liao, Chen, & Suter, 2017), which is the first algorithm of quantum image segmentation in this chapter.

The accuracy or efficiency of image segmentation isn't high enough for some special images by employing classical segmentation algorithms. The special images, such as overlapping target objects (Venegas-Andraca & Ball, 2010), and the target object and the background with similar colors (Zhang, Fritts, & Goldman, 2008) are difficult to be segmented by classical algorithms.

For the above special image, segmentation information of target objects from the image is given by human-computer interaction. For instance, for the image in Figure 1 (a), its edge information is shown in Figure 1 (b) by using Photoshop software.

Figure 1. The target object and the background with similar colors.

(a) (b)

The colors, coordinates and segmentation information of an image can be stored in a quantum system by using NAQSS (see Chapter 3). A generalized Grover search algorithm with arbitrary rotation phases was used to efficiently retrieve a target for the special images (Li, Zhu, Zhou, Song, & Yang, 2014). It is the second algorithm of quantum image segmentation in this chapter.