Chapter 22
Quantum Local Binary Pattern for Medical Edge Detection

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ABSTRACT

Edge detection is one of the most important operations for extracting the different objects in medical images because it enables delimitation of the various structures present in the image. Most edge detection algorithms are based on the intensity variations in images. Edge detection is especially difficult when the images are textured, and it is essential to consider the texture in edge detection processes. In this article, the authors propose a new procedure to extract the texture from images, called the Quantum Local Binary Pattern (QuLBP). The authors introduce two applications that use QuLBP to detect edges in magnetic resonance images: a cellular automaton (CA) edge detector algorithm and a combination of the QuLBP and the Deriche-Canny algorithm for salt and pepper noise resistance. The proposed approach to extracting texture is designed for and applied to different gray scale image datasets with real and synthetic magnetic resonance imaging (MRI). The experiments demonstrate that the proposed approach produces good results in both applications, compared to classical algorithms.

INTRODUCTION

Medical image segmentation is necessary as a preliminary stage for several of medical image analysis. Medical images often exhibit poor image quality, such as low contrast, decoy structures, and the complex shape and appearance of some anatomical structures, which makes segmentation in medical imaging a difficult and challenging problem. Several algorithms have been developed to address these problems and enhance such segmentation. These algorithms fall into two categories: region-based methods and boundary-based methods.

Region-based segmentation methods group pixels with similar properties together to produce regions that represent meaningful objects or areas in the images. The grouping methods include region growing (Zhang, Li, & Feng, 2015) splitting and merging, and watershed methods (Shen, et al., 2015).

Boundary-based segmentation involves identifying the boundaries of adjacent regions in an image by detecting edges and isolated points. The classical boundary-based algorithms use abrupt changes and discontinuities of intensity, e.g., Roberts (1963), Prewitt and Sobel (1970) calculate the first-order derivative of a pixel value as a measure of the edge's magnitude and orientation. The Canny operator (Canny, 1986) is a more optimal edge detector that is capable of good detection and localization with a low error rate.

In real-world applications, each of these classical methods still has challenging limitations and drawbacks depending on different variables in the medical images, such as several objects with similar intensities, noise, and even the edge structures.

To enhance medical image edge detection, this paper has investigated the use of another image feature, namely, texture. In MRI images, texture is the most important characteristic for distinguishing between different brain tissues. Several texture analysis operators for extracting texture features are described. In (Massich et al., 2014) the self-invariant feature transform (SIFT) with low-level and high-level descriptors is used to differentiate the tissues present in breast images, a Gaussian Markov random field has also been used for texture recognition (Krishnamachari & Chellapa, 1997) and the Gabor filtering method (Manjunath & Ma, 1996) has shown good results in comparative studies of texture analysis. In addition, Ojala et al. (1996) have developed a robust, fast, and simple texture analysis operator to meet the requirements of real-world applications.

Many variants of the local binary pattern (LBP) procedure in the literature that cover several tasks for medical image analysis. Ghose et al. (2011) proposed a segmentation method for prostate images that used the LBP to propagate their Active Appearance Model (AAM) and provided an enhancement of texture features for its training. Their approach was validated on a transrectal ultrasound (TRUS), and it showed good results in the presence of intensity heterogeneities and imaging artifacts as well as computationally efficient performance. In (Oliver, Lladó, Freixenet, & Martí, 2007) the authors used another efficient and effective LBP-based model to describe the salient mass micro-patterns in mammographic images in order to reduce false positives; in this model, a support vector machine (SVM) was used to classify the detected masses.

Lakovidis et al. (2008) combined fuzzy logic and the LBP, which proved to be a good, efficient combination for ultrasound texture extraction. They used the Fuzzy LBP (FLBP) approach for supervised classification of nodular and normal samples from thyroid ultrasound images.

The present work proposes the Quantum Local Binary Pattern (QuLBP) as a new variant involving quantum information. The QuLBP model is proposed for characterizing the MR images, and two main applications are presented. The first application performs an edge detection task using a CA as a next process to obtain the edges of images, and the second combines the edge filter with Deriche-Canny edge detection for salt and pepper noise resistance (Deriche, 1987). Compared to traditional edge detection operators, the QuLBP efficiently and accurately obtained edges for several datasets.

The remainder of this paper is organized as follows. Section 2 discusses the technical preliminaries for the LBP and its variants. Section 3 describes the QuLBP descriptor used in both applications. Section 4 introduces and discusses robustness experiments, and Section 5 concludes the paper.

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