Statistical Texture Extraction and Classification Using Variants of Local Binary Pattern

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1 Motivation and Overview

In computational image processing, a texture can be viewed as a function defining the spatial variation of pixels' intensity, and a texture image is created when such variation follows a certain pattern that is repeated throughout the image [1]. Texture classification plays an important role in various areas such as object recognition and defect detection.

Despite the increasing popularity of deep neural networks, traditional methods are still prevalent, especially with small training sets and limited computational resources. One of the most widely used methods for extracting textural features is Local Binary Pattern (LBP). LBP was first proposed by Ojala et al. in [2] in 1996. Since then, it becomes the foundation of many state-of-the-art methods. LBP and its variants are not only used for texture classification, but also in many other fields including face recognition, iris recognition, and medical image analysis.

Hence, this study aims to implement, evaluate, and compare a number of classic and novel LBP-based methods. To provide a thorough and fair evaluation, texture datasets of different characteristics and various levels of difficulty are used. This study also aims to propose a new LBP variant that achieves a better balance between performance and computational costs.

2 Related Work

The foundational LBP in [2] is a gray-scale invariant method. For each local image patch, it binarizes pixel intensities by comparing against the central pixel. The distribution of the resultant binary encoding then becomes a feature descriptor of each texture. However, LBP is not rotation invariant. To address this major drawback, in [3], Ojala et el. proposed rotation invariant LBP (LBP^{ri}) and further improved it to LBP^{riu2} with the detection of uniform pattern.

Another issue of the basic LBP is its sensitivity to noise. Extending upon the binary encoding, a descriptor known as Local Ternary Pattern (LTP) was proposed in [4] to increase the robustness. In the same year, Local Directional Pattern (LDP), which has more discriminant power, was proposed for face recognition in [5]. In a comparative study [6] (2017), 32 LBP variants are compared against 8 deep convolutional neural networks (CNNs) using 13 texture datasets. In terms of the overall averaged performance, the Median Robust Extended Local Binary Pattern (MRELBP) proposed in [7] outperforms the others including the CNN-based methods.

Since then, more LBP variants have been proposed and have demonstrated both effectiveness and computational efficiency. For instance, inspired by LTP and LDP, a method known as Local Directional Ternary Pattern (LDTP) was proposed in [8] (2018). Additionally, in [9] (2019), El-merabet et al. proposed Attractive-and-Repulsive Center-Symmetric Local Binary Patterns (ARCS-LBP). ARCS-LBP is inspired by CS-LBP proposed in [10] and it achieves top performance on 13 datasets when compared against 76 other methods, including 3 deep learning feature extraction methods. Other novel LBP-related texture classification methods include Robust Adaptive Median Binary Pattern (RAMBP) in [11] (2019) and Local Grouped Order and Non-Local Binary Pattern (LGONBP) in [12] (2020). Despite the fast development of CNNs, the LBP operator and its variants are still relevant today and can provide promising results with minimal computational resources. Novel LBP-based methods targeting facial analysis have also been proposed very recently, such as in [13] (2021) and [14] (2021).

3 Project Plan

3.1 Goals

This project aims to
(i) implement at least 5 LBP-based texture classification methods cited in the Related Work section; evaluate them using at least 2 texture datasets;
(ii) ideally expand the above goal to 7 methods and 4 datasets; the datasets should have relatively small training sets and different difficulty levels; and
(iii) propose a new LBP variant that achieves a significantly better balance of performance and computational costs than the implemented methods.

3.2 Milestones

Nov. 17 - Nov. 22: complete goal (i)
Nov. 23 - Nov. 26: complete goal (ii)
Nov. 27 - Nov. 30: complete goal (iii)
Dec. 1 - Dec. 5: complete the report and make the poster
Dec. 6 - Dec. 7: prepare for the presentation
Dec. 8: present the project

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