Illumination and Rotation Invariant Texture Representation for Face Recognition

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ABSTRACT

This article presents a novel approach for illumination and rotation invariant texture representation for face recognition. A gradient transformation is used as illumination invariance property and a Galois Field for the rotation invariance property. The normalized cumulative histogram bin values of the Gradient Galois Field transformed image represent the illumination and rotation invariant texture features. These features are further used as face descriptors. Experimentations are performed on FERET and extended Cohn Kanade databases. The results show that the proposed method is better as compared to Rotation Invariant Local Binary Pattern, Log-polar transform and Sorted Local Gradient Pattern and is illumination and rotation invariant.

KEYWORDS

Face Recognition, Galois Field, Gradient, Illumination Invariance, Rotation Invariance

1. INTRODUCTION

Texture analysis is important in many applications of computer image analysis and has been widely studied in the literature. Many existing approaches deal with limited problems that do not fully take into account the image variations with respect to orientation, intensity and spatial scale.

Over the years, description of texture has interested many researchers. Few have incorporated at least one property of invariance. Some of the work related to gray scale and rotation invariant classification of texture images is listed as follows. Chen and Kundu (1994) were among the first researchers to propose a rotation and gray scale transform invariant texture recognition scheme using the combination of quadrature mirror filter bank and hidden Markov model (HMM). This was followed by Wu and Wei (1996) who developed a method using spiral resampling, subband decomposition and hidden Markov model. Ojala, Pietikainen, and Maenpaa (2000) implemented a gray scale and rotation invariant texture classification method based on Local Binary Patterns (LBP) and non-parametric distribution of sample and prototype distributions. Ojala, Valkealahti, Oja, and Pietikainen (2001) used signed gray level differences and their multidimensional distributions for texture description. Dalal and Triggs (2005) evaluated Histograms of Oriented Gradients (HOG) for human detection. Pok, Pyu, and Lyu (2005) improved the spatial distribution of features by using correlations among local texture patterns for rotation and gray scale invariant texture classification. Zeng, Naghedolfeizi,

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The study presented in this paper consists of a Centre to Ring Gradient Galois Field based transform which is robust to gray scale (illumination) and rotation variations. Extending the earlier work (Shivashankar et al., 2017; Shivashankar et al., 2018), the gradient values with respect to the centre pixel satisfies the gray scale invariance property. The addition of all the eight gradient elements in Galois Field is rotation invariant. The performance of the proposed approach is compared with four methods, namely, Rotation Invariant Local Binary Pattern (RILBP), Log-polar transform, Sorted Local Gradient Pattern (SLGP) and our earlier work using Galois Fields. The results demonstrate the usefulness of the illumination (gray scale) and rotation invariant texture descriptor for face recognition.

The paper is organized as follows. The Gradient Galois Field operator is described in Section 2. Feature extraction and classification are presented in Section 3. The face description using the proposed method is presented in Section 4. Section 5 gives the experimental results and Section 6 concludes the paper.

2. PROPOSED METHOD

2.1. Center_to_Ring Gradient Galois Field Transform

The Center_to_Ring (CR) encodes the gradient values between each central pixel and its neighbours. Given a texture image \( I \) of size \( M \times N \), we define the gradient value of central pixel \( x_i \) with respect to its neighbour \( x_{r,p} \) as:

\[
g_{r,p} = |x_{r,p} - x_i| \tag{1}
\]

where \( x_i \) is the gray scale value of the central pixel, \( x_{r,p} \) is the gray value of its neighbours evenly distributed on a circle of radius \( r \) and \( p \) is the number of its neighbours (Song et al., 2018). When the circle considered is of radius 1 and the value of \( p \) (neighbours) is 8, then this operator is denoted as Centre_to_Ring Gradient Galois Field (CR_GGF) level 1. This is shown in Figure 1.
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