A Novel Approach in Adopting Finite State Automata for Image Processing Applications

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ABSTRACT

This article describes how robust image processing application rely heavily on image descriptors extracted. Limited work is carried out in adopting probabilistic finite state automata (PFSA) models for image processing. A finite state automata for image processing (FSAFIP) method is presented here. Texture classification and content based image retrieval (CBIR) is considered. In FSAFIP, foreground and background regions of an image are identified and later split into patches. Using a tristate PFSA model, feature descriptors corresponding to background/foreground regions are constructed. A distance based large margin nearest neighbor (LMNN) classifier is considered in FSAFIP to impart intelligence. A performance and experimental study to evaluate performance of FSAFIP for CBIR and texture classification is presented. Comparison results in CBIR obtained prove superior performance of FSAFIP over existing methods on Corel-1K dataset. High texture classification accuracy of 99.2% is reported using FSAFIP on KHT-TIPS dataset. An improved texture classification accuracy is achieved using FSAFIP in comparison to former methods.

KEYWORDS

Content Based Image Retrieval, Feature Descriptor, Feature Vector, Image Processing, Probabilistic Finite State Automata, Texture Classification

1. INTRODUCTION

Expedited growth of world-wide web has to lead to easy access to huge volume of digital multimedia data especially image data. Unfortunately, this image data in most cases are scattered and unorganized, making searching, analysis and retrieval of such data difficult. Extensive work is carried out by researchers towards image feature detectors that are used to establish feature descriptors. Image processing applications like image classification (Fang, 2017), content based image retrieval (CBIR) (Guo, 2015), (Yang, 2017), (Elalami, 2014), image representation (Yap, 2010), image classification (Liu, 2012), motion tracking and crowd analysis (Zerdi, 2014) [7], texture analysis and classification

DOI: 10.4018/IJCVIP.2018010104

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(Song, 2017), medical image processing (Satheesha, 2017), to name a few rely on accurate feature detectors and feature descriptors for robust operations. Significance of image features in image processing applications is clearly highlighted in (Satheesha, 2017), (Godtliebsen, 2004), (Hassaballah, 2016). In this paper discusses about CBIR and texture classification applications.

In CBIR systems a set of visually similar images are obtained from a large collection of images in a database. To retrieve visually similar images, it is essential to understand the content present in images. Researchers have proposed various features to describe content. In (Guo, 2015), color co-occurrence feature and bit pattern features are considered to understand content. Numerous features like gray, color co-occurrence matrix, difference observed between pixels of scan patterns, histogram of oriented gradient and local binary patterns features is considered in (Yang, 2017). Though researchers have considered numerous feature combinations, the existing CBIR systems in place neglect to describe correlation that exists between low-level features and high-level concepts observed in images effecting performance (Zhao, 2016).

Image texture features are critical in numerous image processing applications. Texture feature representation can be broadly classified into transform-based and spatial domain-based (Dong, 2017). Local binary patterns and its variants (Pan, 2017) are predominantly considered for spatial domain based texture feature extraction. In (Dong, 2017) a multiscale rotation-invariant representation of texture is proposed. A locally encoded transform feature histogram (Song, 2017) method for texture classification is proposed. As rightly stated in (Song, 2017) texture features representing images need to be discriminative, robust to noise, low-dimensional, invariant to scale, invariant to illumination, invariant to rotation, invariant to other visual appearances and efficient to implement. Even though numerous texture feature representation techniques have been proposed by researcher’s, satisfying all feature criteria mentioned is a difficult task.

A novel and interesting concept of symbolic pattern analysis is discussed in (Mukherjee, 2011). In symbolic pattern analysis large dimensional data is represented using statistical patterns observed within that data. The statistical patterns observed are low in dimensions enabling real-time applicability in applications. Probabilistic finite state automata (PFSA) is a possible technique to realize symbolic pattern analysis. The applications and significance of PFSA is elaborately described in (Vidal, 2005) and (Vidal, 2005). Based on literature reviewed PFSA based analysis is predominantly carried out for time series or one dimensional data. In (Zaragoza, 2017) music notation recognition using finite-state machines is proposed. In (Mukherjee, 2011) authors have adopted PFSA for mine detection from underwater sonar image data.

Motivated by (Mukherjee, 2011) and limited work carried out in the area of image processing applications using PFSA, authors of this paper propose a novel PFSA based feature extraction technique. To the best of our knowledge and based on extensive literature studied no such attempt to extract image features using PFSA for CBIR and texture classification applications is reported till date. The proposed model is referred to as Finite State Automata for Image Processing (FSAFIP) applications. The FSAFIP considers an image to contain a background region and a foreground region. In CBIR application foreground primarily represents content of image. In texture classification foreground is used to represent significant texture properties. For background identification method described in (Yang, 2016) is adopted. For texture classification, all remaining regions are considered as foreground. In CBIR using proposed method, foreground is identified using the adaptive snake method (Satheesha, 2017). Post identification of foreground and background regions, image is split into patches. Using foreground and background knowledge within patches, correlation among neighboring pixel in patches is expressed using a tristate PFSA model. Additional details are discussed in further section of the paper. To impart intelligence for CBIR and texture classification a distance based similarity identification technique using large margin nearest neighbor (LMNN) classifier (Weinberger, 2009) is adopted in proposed method. Performance of proposed method is compared with existing state of art CBIR techniques considering the Corel 1K (Wang) dataset (Li, 2003). Texture classification using KTH-TIPS image database (Fritz, 2003) is considered. Texture classification performance of
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