Computer Methods and Programs in Biomedicine 157 (2018) 39–47

Contents lists available at ScienceDirect

Computer Methods and Programs in Biomedicine

journal homepage: www.elsevier.com/locate/cmpb

Computer assisted gastric abnormalities detection using hybrid texture descriptors for chromoendoscopy images

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ARTICLE INFO

Article history:
Received 17 June 2017
Revised 25 November 2017
Accepted 10 January 2018

Keywords:
Chromoendoscopy
Co-occurrence matrix
Filter bank
Texture analysis
Gabor filter
Stomach cancer

ABSTRACT

Background and Objective: The early diagnosis of stomach cancer can be performed by using a proper screening procedure. Chromoendoscopy (CH) is an image-enhanced video endoscopy technique, which is used for inspection of the gastrointestinal-tract by spraying dyes to highlight the gastric mucosal structures. An endoscopy session can end up with generating a large number of video frames. Therefore, inspection of every individual endoscopic-frame is an exhaustive task for the medical experts. In contrast with manual inspection, the automated analysis of gastroenterology images using computer vision based techniques can provide assistance to endoscopist, by finding out abnormal frames from the whole endoscopic sequence.

Methods: In this paper, we have presented a new feature extraction method named as Gabor-based gray-level co-occurrence matrix (G2LCM) for computer-aided detection of CH abnormal frames. It is a hybrid texture extraction approach which extracts a combination both local and global texture descriptors. Moreover, texture information of a CH image is represented by computing the gray level co-occurrence matrix of Gabor filters responses. Furthermore, the second-order statistics of these co-occurrence matrices are computed to represent images' texture.

Results: The obtained results show the possibility to correctly classifying abnormal from normal frames, with sensitivity, specificity, accuracy, and area under the curve as 91%, 82%, 87% and 0.91 respectively, by using a support vector machine classifier and G2LCM texture features.

Conclusion: It is apparent from results that the proposed system can be used for providing aid to the gastroenterologist in the screening of the gastric tract. Ultimately, the time taken by an endoscopic procedure will be sufficiently reduced.

1. Introduction

Gastric cancer is a primary cause of cancer-related deaths around the world [1]. A normal screening strategy for detecting gastric malignancies involves visual inspection of tissues. The early detection of gastric malignancies can help in treating cancer timely. Several studies confirm the benefits of diagnosing cancer at its early stages [2–5].

In normal practices, gastroenterologist uses an endoscope to inspect a human's inner cavity. An endoscope is equipped with a camera and light source mounted on its distal tip [6]. There are several advancements have been made in the endoscopy technology to assist the gastroenterologist in the detection of abnormal regions [7].

Chromoendoscopy (CH) is an image-enhanced endoscopy technique; Traditionally, in chromoendoscopy, surface of mucosal wall is enhanced by spraying methylene blue. Currently, band-pass filters and image processing algorithms are used to render the effects of a dye-based CH [8]. CH makes the gastric mucosal surface of a patient more prominent thus, provides help to medical analyst in visualization of irregular patterns.

Consequently, the inspection of the gastric tract for detection of abnormalities is a critical and time-consuming task for an endoscopist. Specifically, in a case when there are too many gastric patients for screening and false detection rate increased when the endoscopist became tired [9].

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https://doi.org/10.1016/j.cmpb.2018.01.013
0169-2607/

Sometimes cancer in its early stages is hard to detect because there are a few abnormal frames in the whole video sequence which can be easily unnoticed by an endoscopist [10]. Computer-aided analysis of endoscopy videos is still an emerging field in the medical imaging and in its early stages of development. The automated detection of abnormal frames from an endoscopic session could offers the possibility to deal with this dilemma (time taken by an endoscopic procedure). Then gastroenterologist has to analyze a few frames after abnormal frames are classified by automated system. Moreover, it will also able to provide a second opinion to medical experts about the diagnosis. The gastric environment poses many challenges to the automatic detection of tumors from gastric frames.

The dynamics of image acquisition such as uncontrolled camera movements, poor focus of the camera, illumination variations, body positions, and poor cleansing of gastrointestinal are the main reasons for miss-classification. However, even in the ideal imaging scenarios, it is hard to detect tumor regions due to lack of color space and a specific geometric structure of lesions. Therefore, there is a need for such computer aided diagnosis (CAD) systems which can cope with these issues [11].

Previously, several methods have been developed to detect gastric cancer by employing the vision techniques. These methods include various descriptors to represent characteristics of endoscopic images further learning models are trained using these features. Different types of features can be used for classification and extraction methods have been developed for gastric images. Colors are basic descriptors to represent the endoscopic frames, within different color spaces images can be represented with different color characteristics. RGB is a basic color space [9] and colors are good descriptors for detection of bleeding and ulcer. Other color features were described in color space HSV [12] and CIELAB [13].

However, for detection of cancerous regions using only color features is not sufficient due to certain limitations (e.g., illumination variation). Therefore, the texture is a good choice for representing the mucosal structures in endoscopic frames. Numerous methods of texture analysis have been reported in literature [14–16]. The texture of an image delivers the information about the spatial arrangement of frequencies. Local binary patterns (LBP) [17], gray level co-occurrence matrix (GLCM) [18], and wavelet-based features are employed in various systems which are targeted to the analysis of gastric abnormalities.

Homogeneous texture features are extracted using an array of Gabor filters which explicitly tuned to different scales, frequencies, and orientations. Further the mean and standard deviation of responses of these filters are used to represent the texture of images [19]. Similarly, the gray level co-occurrence matrix of an image is calculated by computing the occurrence of same intensities distributed on a specified distance. Moreover, the second order statistics of these matrices are calculated to represent the textual information of images [20]. In this paper, we have proposed an automated method for classifying the normal and abnormal CH images. We have used a hybrid feature extraction method to extract texture information from CH frames. Moreover, the suggested method is based on an incorporation of Gabor filters and gray level co-occurrence matrices (GLCM). A Gabor filter bank with various filters as it is represented in Fig. 1 was created. Then, GLCM was computed from the Gabor filters' responses, instead of extracting the micro-statistics (mean and standard deviation) of these responses. Furthermore, the texture of an image has represented a second order statistics calculated from GLCM of Gabor filters' responses. The performance of the proposed method is tested against the traditional feature extraction methods on the classification of CH images. Moreover, several classification models are trained and tested on proposed features.

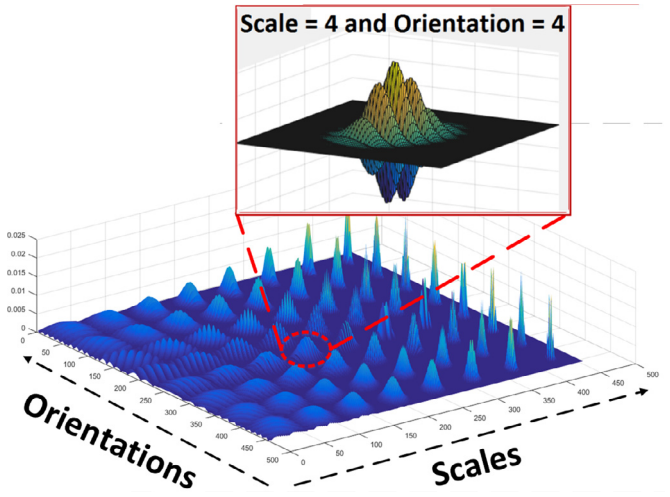

Fig. 1. A filter bank obtained by selecting different orientation (k) and scale (s) of Gabor filter to get multi-resolution responses of CH images.

1.1. Contributions

As mentioned earlier, the texture is important visual cues for analysis. Therefore, texture features are our main focus in this article. The main contributions of this paper are summarized as follows:

- A new method G2LCM for texture feature extraction has proposed for classification of CH images. Furthermore, the GLCM and HT features are also used for the classification of CH images.
- A performance comparison of existing feature extraction methods with G2LCM has given. Moreover, the performance of GLCM, HT, and G2LCM feature extraction methods are validated by training several classifiers on extracted features stated and compared.

The rest of paper is organized as follows: a brief overview of existing methods is described in Section 2. The proposed methodology is described in Section 3. Section 4 gives a summary of experimentations, and Section 5 describes results which are presented with a great detail. The average results of the proposed method are compared with results of existing features extraction methods in Section 6. The paper is finally concluded in Section 7 with some future directions.

2. Related work

Many researchers have developed several methods for automatic detection of abnormalities in gastric tract via analyzing endoscopic frames. We have grouped these methods into three categories according to their description models.

2.1. Methods use texture features to detection abnormalities in gastric-tract

A normalize gray level co-occurrence matrix (NGLCM) was computed by performing the discrete wavelet transform to represent the texture of the images further the extracted features were used to distinguish wireless capsule endoscopy (WCE) frames containing any bleeding signs. Furthermore, the classification was performed by using the support vector machine (SVM) classifier [21]. LBP and vector quantization based approach for extracting texture features was presented in [22], and magnified stomach images were labeled using this approach with a great accuracy. Likewise,