Classification of Endoscopic Images Using Delaunay Triangulation-Based Edge Features

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Abstract. In this work we present a method for an automated classification of endoscopic images according to the pit pattern classification scheme. Images taken during colonoscopy are transformed using an extended and rotation invariant version of the Local Binary Patterns operator (LBP). The result of the transforms is then used to extract polygons from the images. Based on these polygons we compute the regularity of the polygon positions by using the Delaunay triangulation and constructing histograms from the edge lengths of the Delaunay triangles. Using these histograms, the classification is carried out by employing the k-nearest-neighbors (k-NN) classifier in conjunction with the histogram intersection distance metric.

While, compared to previously published results, the performance of the proposed approach is lower, the results achieved are yet promising and show that a pit pattern classification is feasible by using the proposed system.

1 Introduction

Today, the third most common malignant disease in western countries is colon cancer. Therefore a regular colon examination is recommended, especially for people at an age of 50 years and older. Currently the gold standard for colon examination is colonoscopy, which is performed by using a colonoscope. Modern colonoscopes are able to take pictures from inside the colon which allows to obtain images for a computer-assisted analysis with the goal of detecting tumorous lesions. To get highly detailed images a magnifying endoscope is used [1]. Such an endoscope represents a significant advance in colonoscopy as it provides images which are up to 150-fold magnified, thus uncovering the fine surface structure of the mucosa as well as small lesions.

In Sect. 2 we review the classification of pit patterns of the colonic mucosa. Section 3 describes the feature extraction process, including image transformation using a LBP extension, polygon extraction, Delaunay-based feature computation, histogram creation, and the classification. Experimental results and configuration details of the classification system proposed are given in Sect. 4. Section 5 concludes the paper.

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2 Pit Pattern Classification

Polyps of the colon are a frequent finding and are usually divided into metaplastic, adenomatous, and malignant. As resection of all polyps is time-consuming, it is imperative that those polyps which warrant endoscopic resection can be distinguished: polypectomy of metaplastic lesions is unnecessary and removal of invasive cancer may be hazardous. For these reasons, assessing the malignant potential of lesions at the time of colonoscopy is important.

The most commonly used classification system to distinguish between non-neoplastic and neoplastic lesions in the colon is the pit pattern classification, originally reported by Kudo et al. [2]. This system allows to differentiate between normal mucosa, hyperplastic lesions (non-neoplastic), adenomas (a pre-malignant condition), and malignant cancer based on the visual pattern of the mucosal surface. Thus this classification scheme is a convenient tool to decide which lesions need not, which should, and which most likely can not be removed endoscopically. The mucosal pattern as seen after dye staining and by using magnification endoscopy shows a high agreement with the histopathologic diagnosis. Due to the visual nature of this classification it is also a convenient choice for an automated image classification.

As illustrated in Fig. 1(a)-(f) in this classification scheme exist five main types according to the mucosal surface of the colon. Type III is divided into types III-S and III-L, designating the size of the pit structure. It has been suggested that type I and II pattern are characteristic of non-neoplastic lesions (benign and non-tumorous), type III and IV are found on adenomatous polyps, and type V are strongly suggestive of invasive carcinoma, thus highly indicative for cancer.

Furthermore lesions of type I and II can be grouped into non-neoplastic lesions and types III to V can be grouped into neoplastic lesions. This allows a grouping of lesions into two classes, which is more relevant in clinical practice as indicated in a study by Kato et al. [3].

![Fig. 1. Pit pattern classification according to Kudo et al.](image-url)

Schematically and example images for the respective classes taken from the available image database.