Chapter XXII
Pit Pattern Classification Using Multichannel Features and Multiclassification

ABSTRACT

Wavelet-, Fourier-, and spatial domain-based texture classification methods have been used successfully for classifying zoom-endoscopic colon images according to the pit pattern classification scheme. Regarding the wavelet-based methods, statistical features based on the wavelet coefficients as well as structural features based on the wavelet packet decomposition structures of the images have been used. In the case of the Fourier-based method, statistical features based on the Fourier-coefficients in ring filter domains are computed. In the spatial domain, histogram-based techniques are used. After reviewing the various methods employed we start by extracting the feature vectors for the methods from one color channel only. To enhance the classification results the methods are then extended to utilize multichannel features obtained from all three color channels of the respective color model used. Finally, these methods are combined into one multiclassifier to stabilize classification results across the image classes.
INTRODUCTION

Today, the third most common malignant disease in western countries is colon cancer. For that reason a regular examination of the colon is recommended, especially for people at an age of 50 years and older. Colonoscopy is currently the best test available to identify colon cancer.

Colonoscopy is a medical procedure which allows a physician to investigate the inside of the colon. This is done by using a colonoscope, a flexible instrument equipped with a CCD chip for visualisation of the organ and controlled by the physician. In case a lesion is detected, tissue samples can be taken and relevant lesions can be removed, avoiding thus surgery.

Modern colonoscopies allow the acquisition of digital images and video sequences from inside the colon during the colonoscopy. This makes it easier for the physician to review the results from a colonoscopy and to document the growth and spreading of an eventually tumorous lesion. To obtain images which are as detailed as possible a magnifying colonoscope is used. This type of colonoscope provides images which are up to 150-fold magnified and thus are very detailed as they uncover the fine surface structure of the mucosa as well as small lesions.

A common procedure to visually enhance the structure of the mucosa is to spray indigo carmine or methylen blue onto the mucosa. While dyeing with indigo carmine causes a plastic appearance of the mucosa, dyeing with methylen blue helps to highlight the boundary of a lesion. Cresyl violet is often used to actually stain the margins of the pit structures, which is also referred to as staining.

In this work we document the good performance of several texture classification techniques to perform an automated classification of pit pattern images acquired by a magnifying colonoscope. Based on these methods, we show the benefit of using features based on three color channels. Finally, we present one possible way to combine several methods and classifiers to build a multiclassifier.

Note that the developed techniques are not meant to replace the physicians’ diagnosis but are designed to act as a decision support system for the human operator during colonoscopy – here a reliable and immediate diagnosis is a significant advantage since a second colonoscopy required in many cases can be avoided as there is no need to wait for the histological classification of eventually extracted biopsies.

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.

To be able to differentiate between the different types of lesions a classification method is needed.

The most commonly used classification system for distinguishing between non-neoplastic and neoplastic lesions in the colon is the pit pattern classification originally reported by Kudo, Hirota et al. (1994) and Kudo, Tamura et al. (1996).

This system allows a differentiation between normal mucosa, hyperplastic lesions (non-neoplastic), adenomas (a pre-malignant condition), and malignant cancer based on the visual pattern of the mucosal surface. Hence, this classification scheme is a convenient tool to decide which lesions need not, which should, and which most likely can’t be removed endoscopically. The mucosal pattern as seen after dye staining and by using magnification endoscopy shows a high agreement with the histopathologic diagnosis. Furthermore, due to the fact that this method is based on the histopathologic (and therefore visual) structure of