Chapter 36
Image Processing for Localization and Parameterization of the Glandular Ducts of Colon in Inflammatory Bowel Diseases

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ABSTRACT

This chapter presents the computerized system for automatic analysis of the medical image of the colon biopsy, able to extract the important diagnostic knowledge useful for supporting the medical diagnosis of the inflammatory bowel diseases. Application of the artificial intelligence methods included in the developed automatic system allowed the authors to obtain the unique numerical results, impossible for achieving at the visual inspection of the image by the human expert. The developed system enabled the authors to perform all steps in an automatic way, including the segmentation of the image, leading to the extraction of all glandular ducts, parameterization of the individual ducts and creation of the diagnostic features, as well as characterizing the recognition problem. These features put to the input of SVM classifier enable to associate them with the stage of development of the inflammation. The numerical experiments have shown that the system is able to process successfully the images at different stages of development of the inflammation. Its important advantage is automation of this very difficult work, not possible to be done manually, even by a human expert.

INTRODUCTION

In medicine the inflammatory bowel disease (IBD), for example Crohn's disease and ulcerative colitis, form a group of inflammatory conditions of the large and small intestines (Carpenter & Talley, 200), (Carter et al. 2004). The important problem is to diagnose the beginning of the illness, i.e. the point, when the glandular ducts are attacked by the human defense system. As a result of such attack the shape and other parameters describing the geometry of ducts are changing. The important consequence of this attack is the appearance of the liquid in the stroma of the tissue, extension of the area between the neighboring glandular ducts, as well as beginning of the division process of the glandular ducts (Carpenter & Talley, 2000).

These facts may be discovered in the image of the biopsy of the colon tissue. Analyzing such image we are trying to extract the information of IBD that is contained in it, especially to associate different stages of IBD with the location, shapes, geometry and parameters of the ducts. Especially challenging is to associate the stage of development of IBD with some parameters of ducts. Knowing this association we will be able to build an automatic system supporting the medical expert in his diagnosis.

Figure 1 presents the image of the biopsy of the colon tissue at different stages of the IBD. Figure 1a corresponds to the individuals with full remission of disease (no clinical and endoscopic signs of IBD). The ducts are clearly visible. Most of them are of regular elongated shape, placed parallel to each other. The space between ducts are filled in by the stroma, representing the background of the image. At the beginning of the illness corresponding to initial acute stage (Figure 1b) we can observe the changes in the shape of ducts. Some of them are split into separate parts. Figure 1c presents the moderately advanced active phase of illness. The most characteristic symptom of it is further split of the ducts into many separate small size parts, not connected into compact regions. In the heavy

state of IBD (Figure 1d) most of the fragmentary parts of ducts have disappeared and are hardly visible in the image. Their place has been taken by the uniform liquid of the stroma.

It is evident that the advancement of IBD is strictly connected with deformation of the shapes of the glandular ducts in the image. The parameters of these shapes may be treated as a measure of advancement of the illness. However it is impossible to determine these parameters by the visual inspection. We have to employ the computer aided image processing, aimed in discovering and recognizing the essential parts of the image and parameterize them. Hence there is a need for development of a specialized computer program able to preprocess such images in order to localize, extract and parameterize the glandular ducts, and in its final stage to classify the analyzed image into appropriate class corresponding to the development stage of IBD. Up to now there are no such systems used in the hospital practice.

This work is concerned with the automatic extraction and parameterization of the glandular ducts existing in the microscopic image of the

Figure 1. The images of the biopsy of the colon tissue at different stages of IBD illness: (a) full remission of disease, (b) initial acute stage, (c) moderately advanced stage of illness, (d) heavy advanced state of IBD
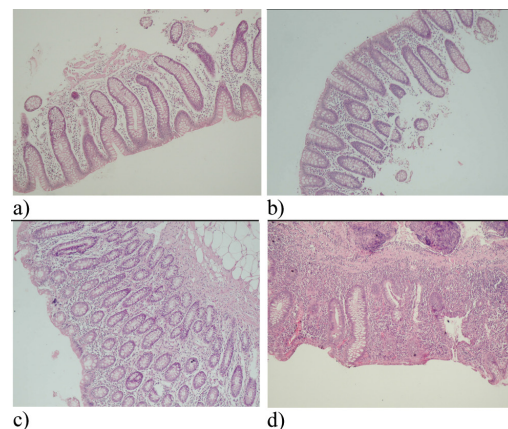
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