

Chapter XLV

Automated Image Analysis Approaches in Histopathology

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ABSTRACT

The field of histopathology has encountered a key transition point with the progressive move towards use of digital slides and automated image analysis approaches. This chapter discusses the various methods and techniques involved in the automation of image analysis in histopathology. Important concepts and techniques are explained in the 5 main areas of workflow within image analysis in histopathology: data acquisition, the digital image, image pre-processing, segmentation, and machine learning. Furthermore, examples of the application of these concepts and techniques in histopathological research are then given.

INTRODUCTION

As computing technology advances at a rapid pace worldwide, the impact is starting to be seen in the field of histopathology. Digital imaging offers a wealth of advantages over traditional microscopy

procedures, including storage of image data for later use, automation of image analysis tasks, and the application of novel image processing and machine learning techniques.

The development of large-scale image databases opens the door for collaboration amongst remote laboratories by giving concurrent access to the same data. In clinical pathology, this type of collaboration can lead to better consensus in image reading, as well as the potential to develop new training techniques. In systems biology, access to remote image data allows researchers to engage in wide-ranging studies far beyond the constraints of a single lab.

Automated image analysis approaches can serve as a valuable aide to clinical pathologists and systems biology researchers in the domain of histopathology. The objectives of automation are to analyse data efficiently, accurately, and reproducibly in high-throughput environments. Appropriate image processing techniques must be employed so as to extract, from images, as much relevant information as possible in as short a time as possible.

This chapter is divided into five main sections which describe the key steps in a digital histopathology environment. The first section deals with data acquisition, including tissue sample preparation, staining, digital slide management, and a brief introduction to tissue microarrays (TMAs).

Section two provides an overview of digital image content, including grayscale and colour representations, as well as textural features of images. The third section provides a detailed overview of image pre-processing techniques which are used to prepare image data for analysis. Techniques which are covered include grayscale transformations, contrast enhancement, smoothing and edge detection.

Segmentation, the fourth section, deals with the critical process of automatically identifying important image regions. Segmentation topics discussed include thresholding, region-based segmentation, watershed segmentation, template matching, and active contour models.

The fifth and final section, Machine Learning, introduces methods of image data analysis, including dimensionality reduction and supervised learning techniques.

DATA ACQUISITION

There are a number of crucial steps that take place before a tissue sample can be digitally imaged and subsequently analysed. Artifacts, i.e. anything that interferes with the examination of the tissue, can be introduced during each of these steps that can greatly reduce the quality of the image and, therefore, the accuracy of the image analysis performed later.

Tissue Processing

The tissue sample is first removed during surgery, biopsy or autopsy and placed in a fixative, typically formalin, to prevent decay. It is then dehydrated by submerging it in ethanol. The sample is then permeated with paraffin and encased in a paraffin block. If the processes above are not carried out correctly, the paraffin-embedded tissue can become brittle and difficult to work with, which can lead to degraded image quality.

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