Chapter XXXI
Telepathology and Digital Pathology

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ABSTRACT

The present chapter deals with state-of-the-art topics related to the application of information and communication technologies to the field of pathology, in particular for what regards telepathology and the so-called digital pathology. A classification of telepathology techniques is provided together with their typical applications. Starting from a definition of virtual or digital slide, digital pathology techniques and issues are then discussed.

INTRODUCTION

In pathology, the sample subject of analysis by the doctor is most often a biological tissue specimen cut in very thin sections, disposed over a glass slide, and coloured with suitable stainings in order to make morphological structures and biochemical components visually apparent. Such a specimen is observed by means of an optical microscope with resolutions up to 0.2 micron.

In the last 40 years, first morphometry (i.e., image analysis applied to the recognition and quantification of biological shapes) and then telepathology have been the two forces driving pathology toward the use of digital images.

In particular, telepathology has been traditionally constituted by the set of techniques for remotely transmitting images acquired from a glass slide through a microscope. The term telepathology was first referred to by R. Weinstein in 1986; he defined it as the "practice of pathology over a long distance," thus encompassing almost every possible application of digital images, including distant diagnosis, expert consultation, distant education, and remote image processing and analysis.

The two usual telemedicine categories of real-time and store-and-forward systems apply to telepathology, too, with the same cost and practical consequences but with peculiar aspects given by the features of the material to be represented by means of digital images.

In the very few last years and thanks to the innovations in the information technology field, a novel acquisition technique has been created that makes it possible to fully digitize a specimen, resulting in billions of pixels. The resulting image is called a virtual slide, virtual microscope, or digital slide, and can be used for most of the usual telepathology applications plus others. This innovation led to the creation of a somewhat new discipline, that is, digital pathology, where the emphasis is no more on the transmission of images, like in telepathology, but more generally on digital-image use.

In the next section, a brief overview of telepathology and digital pathology techniques and applications will be provided.

TELEPATHOLOGY TECHNIQUES: APPLICATIONS AND ISSUES

The approaches to telepathology are classically divided into two categories: store-and-forward and real-time telepathology, respectively based on the asynchronous delivery of images and real-time transmission. Another classification, often used in place of the former but with a slightly different meaning, is such between static and dynamic telepathology, respectively based on still images and live video.

In store-and-forward telepathology (Della Mea, 1999), the sender pathologist is supposed to select some representative image from the specimen to be delivered or simply made available to a remote recipient. Delivery may occur by means of standard e-mail (Della Mea et al., 1996), proprietary systems (Klossa, Cordier,

Flandrin, Got, & Hemet, 1998), or Web-based applications like iPath (Brauchli et al., 2000). Store-and-forward telepathology is the least expensive approach as it can be implemented with very basic technology, and thus it is the most diffused one despite some concerns on the bias inducted by the image selector (Mairinger, Netzer, Schoner, & Gschwendtner, 1998).

In real-time telepathology, a robotized microscope that can be remotely controlled is needed. In this case, the remote user may move the stage, change objectives, and so forth, receiving either still images (Demichelis, Barbareschi, et al., 2001) or live video (Dunn et al., 1997; Nordrum et al., 1991). As live video has lower quality than still images, hybrid approaches have been reported (Della Mea, 2000). Due to the need for quality of service, transmission often occurs through ISDN lines; however, in the past, attempts have been made to use Internet protocols (Wolf, Petersen, Dietel, & Petersen, 1998), which are at present more easily usable.

From the diagnostic point of view, telepathology might be useful in two main areas: second-opinion consultation and intraoperative diagnosis. In the former case, an expert is requested for an opinion regarding a difficult case with loose time constraints. While ordinarily the expert will receive a glass slide by post, with telepathology, he or she may receive a set of selected images (store and forward; Raab et al., 1997) or access to a real-time system (Dunn et al., 1997). In fact, store and forward is mostly used for expert consultation as it overcomes limitations due to different time zones when requesting and consulting pathologists are remotely separated (Della Mea & Beltrami, 1998). In the last years, two official services have been founded for providing consultation through store-and-forward systems: the Armed Forces Institute of Pathology

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