A Brief Review of Telepathology

Home Assignment of eHealth Course

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2017/05/12

1 Introduction

Telepathology, as its original definition, is a platform for pathological diagnosis at long-distance.[1] The implementation of telepathology integrates advanced computer science as well as information and communication technologies (ICT), providing more convenient and professional experts consulting services for both patients and pathologists. In this report, a brief review is described for the development history of telepathology and its current situation in industry, which attempts to build a basic understanding of how telepathology plays a part in medical domain at present and in the future.

2 Methods

To carry out the review, knowledge and information are collected from literature which can be reached on Google scholar, Chalmers library and several companies' official websites. Searching some key words, for instance "telepathology", "telecytology" and "telemedicine", are capable to offer general concept and introduction. For more technological details, key words such as "digital pathology", "whole slide imaging", "virtual slide" and "virtual microscopy" etc. are retrieved to gather relevant content. After which, interested articles are screened, keeping those which have high correlation to the topic of telepathology.

3 Results

In this section, firstly, the development history of telepathology is represented concisely. Afterwards, cutting-edge technologies are described with more specifics. Referring to implementation drivers and development trends of telepathology is carried out to catch more understanding. IntelliSite Pathology Solution (IPS), a commercial application created by Philips, is introduced about essentials of its workflow.

3.1 Historical Background

Telepathology had been demonstrated in 1960s before it was defined. In 1968, the first formal experiment was accomplished in U.S.A., in which gray-scale microscopy images of a blood smear were conveyed from an airport to a hospital.[2, 3] In 1986, it was a milestone for telepathology that Ronald S Weinstein raised the term and definition.[1] Norway implemented the National Telepathology Program for people living in frozen area in 1989, and the full-featured system was available in 1994.[3] In the year 2009, the use of digital pathology for diagnosis was approved by the Food and Drug Administration.[4] Since then, more advanced applications and services of telepathology appear in medical industry, which not only provide solutions for pathology diagnosis, but also promote the integration and management of whole system.

3.2 State-of-the-Art Technologies

3.2.1 Static Image-based System

Static images are captured and saved into storage by a digital camera which is attached to the microscope or imaging platform. These digital images are transmitted to a remote end via Internet. The static image-based system is the simplest technology of telepathology. However, its performance is undistinguished since complete information of slide image is not represented to pathologists. They make diagnosis according to discrete images which lack of correlation among neighboring structures, reducing diagnosis accuracy. It is the reason that application scenarios of static image-based system are limited.[5]

3.2.2 Streaming Image-based System

In streaming imaging system, images are captured continuously by digital streaming camera from a microscope or imaging platform. The serial transmission of these images offers more information to remote-end pathologists. Even more, remote pathologists can handle the microscope that allows them to freely select interested slides if robotic microscope is applied. In this way, the drawbacks of static imaging are avoided, increasing diagnosis accuracy and reducing labor intensity.[5, 6]

3.2.3 Whole Slide Image-based System

Whole slide imaging (WSI) is the newest and the most advanced technology applied in telepathology. WSI implements an automated microscope to scan a slide, and generates a set of images which consist of various sections of the slide. After which, all parts are spliced to form a virtual representation of entire specimen. Remote-site users are able to diagnosis on the basis of the virtual image that contains the full structure of slide. WSI affords a approach to share slide with many pathologists indefinitely. There are many challenges of WSI, such as high price, more demand for resources and slow imaging speed. [5] This branch of telepathology is also known as digital pathology (DP).

3.3 Implementation Drivers

The success of telepathology is attributed by the following two aspects. First one is the rapid development of technology. More stable and more swift communication system is the key component to speed up the transmission which enables telepathology to become a valuable application. Advanced algorithms, as WSI, image processing and image registration, constantly improve the imaging quality. Innovations on hardware, a typical sample of robotic microscope, enrich the context where telepathology can be applied. The other contributor, which is more important, is the strong market demand of this solution. People lives in the region where is far apart the pathology center is rough to obtain diagnosis in time. Accurate and quick pathological diagnoses, timely and high-quality healthcare are some of the primary causes that highlight the demand for telepathology.

3.4 Development Trends

Since it was defined in 1968, telepathology has been becoming a valuable and helpful tool for clinical and research using. It keeps developing alongside technological innovations of ICT, hardware updating

and improvement of computation power. Nowadays, DP with highly integrated system is orienting to the mainstream application of telepathology in medical using. Many healthcare providers have launched their solutions for DP, for example IntelliSite (Philips) and Sectra's DP implementation. More than assisting diagnosis, the system owns increasingly complicate and functional software, which is going to play an important part in next generation tech, namely, personalized medicine.[7]

3.5 IntelliSite Pathology Solution

In this section, an introduction to a sophisticated application of DP, IPS, designed by Philips is represented shortly. (What needs declaration is that all information about IPS is referenced from its official web page [8].) Philips IPS is not a single product but a combination of hardware and software service for DP using. It comprises three branches, which are ultra-fast scanner (UFS), image management system (IMS) and a visualization tool named IMS viewer.

UFS consists of a digital scanner which has capability to automatically focus on the slide. In the meantime of focusing, scanning process is performed. Each scanner applies a 40-time magnification on the slide, resulting in the image with superb resolution. It has a cavity that can mostly store 300 barcoded slides at one time, scanning them without manual intervention. A touchable screen is available for operators to check scanning state and modify configuration. IMS provides various storage services to clients. It has compatibility with the current image analysis software and the hospital information system. Images can be easily shared within the same system or across systems. Moreover, multiple users can work on the same image repository while they are in different sites. IMS viewer is a powerful user interface that facilitate slide sharing among pathologists and researchers. Special tools are designed for different tasks to help users focus on specific one, especially efficiently review on slides. IMS viewer is also a assistant who improves users' workflow by managing case lists. In general, the high-integrated system of IPS makes every step more convenient to render the diagnosis, allowing pathologists to concentrate on their work.

4 Discussion & Conclusion

Telepathology, in particular the DP implementation, has many advantages to optimize the process of diagnosis, and it provides a more friendly operation for pathologists. Nevertheless, DP has not been a regular diagnosis approach yet, such as IPS. Since large investments are required for its hardware and software system. The imaging time of DP is slow and some samples are difficult to be scanned. In addition to these drawbacks, pathologists also need time to learn how to proceed rendering of diagnosis by a new technology.[9] It seems that technology needs to be improved to amendment the imperfection of DP. Besides medical field, DP can also be introduced to education domain as preclinical training application. Compared with DP, though, static and streaming imaging system lack of high quality images, low cost of equipment and less required resources indicate its superiority to be applied in some developing countries.

This article carries out a brief review on conception and development in terms of telepathology, alongside historical background, state-of-the-art tech and a cutting-edge application IPS. For past decades, telepathology has been updated rapidly which benefits from technical progress and strong demands on

innovation of healthcare. Several commercial products have been launched to solve practical issues. Although telepathology still have shortages in some respects, it will gradually be refined as a practical approach that can be widely used to offer efficient healcare service.

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