New Technology in Medical Imaging

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Abstract

Biomedical images of the human body are an invaluable source of information that clinicians can use in order to make a correct and final diagnosis. Computer-aided diagnosis (CAD) is used by radiologists as a second opinion has become one of the major research areas in medical imaging. The computer assisted diagnosis need not be comparable to that of physicians, but is surely complementary. PACS (picture archiving and communication system) are computers or networks that present, distribute, store, and retrieve images from one or more medical imaging instruments, i.e. mammogram, ultrasound, endoscopy, magnetic resonance, etc., and are viewed on monitors along with a patient’s clinical details and radiological reports. By using PACS the medical image interpretation may be changed from conventional hard copy images to soft-copy studies and viewed on the systems workstations.

Keywords: CAD, PACS, image processing, medical imaging and multimodality.

Introduction

Today, many diagnostic protocols rely on biomedical images. Almost every examination requires the acquisition of one or more images of the human body in a single or multiple modalities. Since almost every imaging modality is able to acquire finer details of the imaged body part, a correct diagnosis requires a careful reading of the entire image dataset. Since the workload for radiologists is increasing and they must inspect several high-resolution images many times trying to merge the information extracted from the different modalities. Furthermore, the widespread use of 3-D imaging modalities requires the radiologists to inspect hundreds of images for every single examination. It is clear that reliable and specialized software programs, known as CAD tools, might be a valuable aid in the diagnostic procedure as:

(i) they can be used to get a second reading of the data and the clinicians can verify their conclusions.
(ii) They are necessary to build 3-D views of topographic examinations and to merge the views built from data acquired in different modalities.
(iii) They can provide useful tips that can greatly reduce the number of human errors. The PACS are available within a hospital allowing a global access to the medical images. PACS is a work flow-integrated system for managing medical images and related data and is designed to streamline operations throughout the whole patient care delivery process. Effective use of PACS throughout the hospital operation would shorten the time for diagnosis and thus improve the efficiency of healthcare delivery [1, 2].

PACS yields potentially more information for review and interpretation whereas images included in hard-copy studies are often cropped to the region of interest and contain only limited or no images from the localizer series. On the other hand, soft-copy studies on PACS usually include all un-cropped and unaltered images for the study. The introduction of PACS has changed the mode of interpretation of a cross-sectional image from a conventional hard-copy image to the softcopy viewing on PACS workstations. PACS has become the fundamental infrastructure for digital diagnostic imaging and information management system [3].

The remainder of this paper is organized as follows. Section 2 summarizes the current status of CAD technology and future scope of CAD in PACS environments. Section 3 provides an overview of PACS review, describes the current status of PACS technology and its applications. Conclusions are drawn in Section 4.

Current status of CAD technology

The basic objective of CAD is to provide a computer output as a second opinion to assist radiologist's image interpretation by improving the accuracy and consistency of radiological diagnosis by reducing the image reading time. A number of CAD schemes are available. These schemes include: detection and classification of lung nodules on digital chest radiographs, detection of nodules in low dose CT, distinction between benign and malignant nodules on high resolution CT, usefulness of similar images for distinction between benign and malignant lesions, quantitative analysis of diffuse lung diseases on high resolution CT and detection of intracranial aneurysms in magnetic resonance angiography. Since CAD can be applied to all imaging modalities, all body parts and all kinds of examinations, it is likely that CAD will have a major impact on medical imaging and diagnostic
radiology in the 21st century [4].

The scope of CAD in the PACS environment

Now CAD schemes are included together with other software for image processing in the workstations associated with some specific imaging modalities such as digital mammography, CT and MRI. Similarly, many other CAD schemes can be assembled and implemented as a part of PACS. Radiologists may use this type of CAD package in the work-station in two different ways. One is first to read images without the computer output and then to request a display of the computer output before making the final decision. If radiologists keep their initial findings in some manner, this mode may prevent a detrimental effect of the computer output on radiologist’s initial diagnosis such as to dismiss incorrectly a subtle lesion because of no computer output, although radiologists are very suspicious of this lesion initially. However, this mode would probably increase the time required for radiologist’s image reading, which is generally undesirable. Another mode is to display the computer output first and then the final decision by the radiologist. With this mode, it is very likely that radiologists can reduce the reading time for image interpretations, but it is uncertain whether they may miss some lesions when no computer output is shown due to computer false negatives. This negative effect can be reduced if the sensitivity in the detection of abnormalities is at a very high level, which may be possible with a package of a number of different, but complementary CAD schemes. This would be one of the potential advantages in packaging a number of CAD schemes in the PACS environment [5].

Current status of PACS Technology

PACS has become an important component of many radiology departments and the hospital around the world. Now, many hospitals are running successful PACS installations for several years. In fact, new areas of PACS development include improved reporting strategies, optimized distribution of radiological information to referring doctors and knowledge management applications ranging from e-learning to CAD. The PACS, originally implemented in the radiology department, needs to grow and has already carried well beyond departmental limits conquering all image relevant areas inside the hospital. During the past 10 years a dramatic development in imaging techniques especially within MRI emerged. Advanced 3D- and 4D-MR imaging techniques result in much more images and more complex data objects than ever before which need to be implemented into the existing PACS. These new imaging techniques require intensive post-processing apart from the imaging modality which needs to be integrated into the image workflow and the PACS implementation. Along with these new imaging techniques new clinical applications like stroke detection and research applications such as study of heart and brain function, in neurology and cardiology require changes to the traditional PACS concept. The concept of a PACS is introduced more than two decades ago and the desire to store medical images digitally stems from well-known limitations in the film-based radiology departments. A PACS acquires medical images digitally from several modalities in the radiology department, stores them in central data databases and makes them available upon request to referring clinicians. Since the medical images are now in browser-based format, they can be made available for viewing almost instantaneously throughout the entire hospital and even beyond the boundaries of hospitals to off-site radiologists and other institutions using secure broadband internet connections.

Nowadays the PACS industry is well-matured and offers archiving solutions and reading stations that fulfill the needs of the users [6]. The IHE (integrating the healthcare enterprise) also provides hospitals with a solid framework that from a technical point of view and ensures that different information systems – including HIS (health information systems), RIS (radiology information system), EMR (electronic medical record) – are well integrated. PACS are deployed in most academic centers and many private practices are joining the ranks of the digital radiology revolution. A recent survey on e-business in 2006 among 18 European countries conducted by the European Commission, posed the basic question for hospitals as to whether they use PACS or not. Large differences among countries appear from these data. Only 10% of French hospitals say they use PACS as against almost 70% of Finnish hospitals. It is difficult to discover a definite systematic adoption pattern within this list of countries in terms of their geographical location, economic position and healthcare system usage. Although some scholars consider PACS to be a mature technology, but still all the key issues have not been resolved. The systems are complex and costly to acquire, replace, maintain and repair. The performance of these systems directly affects the patient care and workflow and clinical effectiveness in the working environment. Samei et al. [7] therefore suggest that careful attention should be paid to the selection of a system that meets certain needs and
requirements. Based on the concept of IS/IT (Information systems / information technology) the six maturity stages: initiation, contagion, control, integration, data management and maturity are defined for PACS. PACS is valuable for researchers as well as consultants and medical practitioners. It can be applied as a valuable tool for organizational assessments, monitoring and benchmarking purposes [8].

**Necessity of PACS research**

Although computer scientists and radiologists are wondering whether PACS is still a hot topic for research or it is just an issue raised by vendors to update the technology for their commercial products. This is totally pessimistic opinion. There are several answers to this question probably the main reason is that when it was born, PACS was already announced as the ultimate tool. This initial bold definition granted to PACS immediate interest and it soon became a hot research topic. It is worth telling that it’s a just radiological modality. Today, PACS is beyond an e-learning and radiological tool [9].

The first PACS implementations took place in the United States in the early 1980s. Some more or less successful PACS developments also took place in Europe in the 1980s, particularly in the Netherlands, Belgium, Austria, the United Kingdom, France, Italy, Scandinavia and Germany. Most systems could be characterized by their focus on a single department such as radiology or nuclear medicine. European hospital-wide PACS with high visibility evolved in the early 1990s in London. These are followed during the later part of the 1990s by approximately 10–20 PACS installations in each of the major industrialized countries of Europe. Wide-area PACS covering several health care institutions in a region are now in the process of being implemented in a number of European countries [10]. Today more than 90% hospitals in USA are using PACS in their daily clinical practice.

**The Geneva Hospital PACS**

The university hospital of Geneva has initiated a hospital-wide PACS project with the aim of developing an integrated image management system for radiological as well as non-radiological medical images. The unit has a storage capacity of over one terabytes on optical disks as well as magnetic disk cache of several gigabytes for faster access to the recent images. The PACS developed at the university hospital of Geneva as shown in Fig.2 is based on a distributed architecture with hierarchical archive of images and related data with multiple archive and display servers. This type of architecture seems to be nowadays the only viable solution for large scale PACS where images from a variety of imaging modalities are accessed from a large number of consultation points [11].

**Conclusions**

In today’s scenarios biomedical imaging has been seen truly exciting advances in recent years. Computerized segmentation methods are now garnering the help of CADs and radiotherapy planning. It is unlikely that automated segmentation methods will ever replace physicians, but they are likely to become crucial elements of medical-image analysis. Segmentation methods will be particularly valuable in areas such as image-guided surgery, in which visualization of the anatomy is a critical component. CAD tools are a valuable support to the current radiological practice due to the increasing resolution and dimension of the data that a radiologist needs to inspect before providing a diagnosis. Their software architecture is very complex and hard to maintain and extend. In Europe and USA, CAD schemes are already incorporated into PACS and are available as a package for detection of lesions and also for differential diagnosis. In USA and most of the European countries, PACS is now recognized as a basic infrastructure for communication within hospitals.

**References**


Illustrations

Illustration 1

Figure 1

Application of PACS for CAD system
Illustration 2

Figure 2

The Geneva Hospital PACS
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