ABSTRACT

Computer-aided diagnosis (CAD) is a rapidly expanding area of medical image analysis that aims to help clinicians in making a proper diagnosis by, for example, detecting abnormalities, classifying and diagnosing these, and quantifying the spread of disease. The largest efforts in CAD, both commercially and academically, have been aimed at mammography, but chest imaging is the second major area.

Historically, diagnosing lung cancer with chest radiographs is even the oldest CAD application, pioneered in the 1960s. Spotting lung nodules on chest x-rays is very difficult, because of superimposed structures. Several companies now offer nodule CAD for chest x-rays and many systems have been described in literature. Although the sensitivity of the best commercial systems is impressive, they usually provide several false positive marks per image, and because lung nodules are a relatively rare finding, the vast majority of markers are false positives. The radiologist is faced with the task of picking out the few true positives among all these markers. Recent observer studies show that this is very difficult for them, and the benefit of current CAD systems is therefore limited. Substantial reductions in the number of false positives are needed, and different paradigms of using CAD that may help the radiologist in correctly interpreting the CAD findings should be investigated.

One way to do this might be to filter the radiographs in such a way that the normal anatomical structures are suppressed. Highly effective algorithms to remove bony structures have recently been presented. Another technique in development is temporal subtraction. The underlying registration problem is complex, because a 3D deformation should be estimated from 2D projection images. But a subtraction of even an imperfectly registered pair may reveal subtle changes.

For over a decade now, routine CT scanners can image the lungs isotropically with sub-millimeter resolution in a single breath hold. Nodule detection has been the most researched application for chest CT as well as chest x-ray. Over five systems are commercially available. With CT much smaller nodules can be identified. This application is quite different from nodule detection in x-rays. Dismissing false positives is relatively easy, and it is easy to miss a nodule when scrolling through a 3D data set so the classical paradigm of CAD as a tool to avoid oversight seems applicable. Still, the best algorithms produce a large number of marker that, to a human observer, are obviously incorrect. There appears to be ample room for improvement. How to achieve this?

In addition, many other applications for chest CT are under development, including detection of pulmonary emboli, interpretation of nodules (benign or malignant?), nodule volumetry to assess tumor growth, analysis of the lung parenchyma, quantification emphysema and airway abnormalities, automating scoring systems for diseases such as cystic fibrosis, asthma and interstitial lung disease, and so on. There are many different clinical indications for chest imaging. In that respect, developing software to analyze these images is a much more diverse task than for example in CAD for mammography screening. All these chest CAD applications require segmentation, image standardization and other common elements. The same holds for chest x-ray CAD. Groups in this area are reinventing the wheel many times. How can this process be streamlined?

Comparing algorithms in a standardized manner on a common database is a good way to identify promising approaches for CAD. Results will be presented from the ANODE09 study (http://anode09.isi.uu.nl), established to compare CAD systems for nodule detection in chest CT. A next step in this approach would be to standardize the evaluation and dissemination of common elements in applications that address a particular modality, in this case chest CT or chest x-ray. The EXACT09 study (http://image.diku.dk/exact) will be discussed that was aimed at one such element, namely the segmentation of the airway tree in chest CT. For both studies an interesting result was that combining algorithms yielded substantially better results than using individual systems, even the best ones.

It might be worthwhile to set up libraries of validated algorithms that address one step in the pipeline of CAD applications for a particular modality. If these building blocks are readily available, rapid development of many high quality CAD applications would be possible.