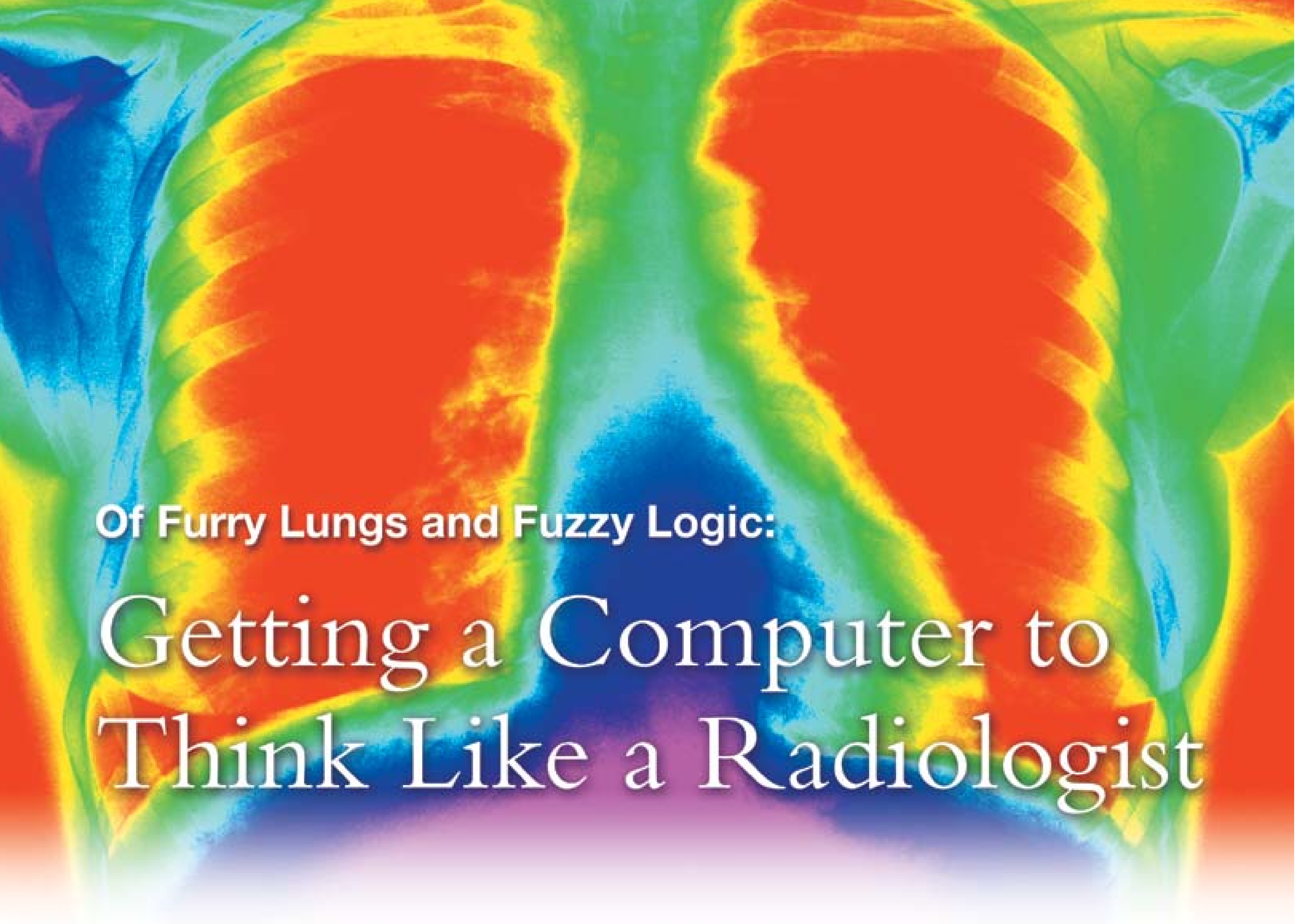


Of Furry Lungs and Fuzzy Logic:

Getting a Computer to Think Like a Radiologist

A fruitful collaboration between Dr *Jonathan Rossiter* from the Artificial Intelligence Group in the Department of Engineering Mathematics and Bristol Royal Infirmary is leading to advances in the automatic detection and diagnosis of lung disease, and helping to provide a greater understanding of how radiologists think as they do their demanding jobs.

If you have ever had a suspected medical condition that requires a radiological test – be it an X-ray, a CT scan, an MRI scan, or any of the many other tests available – spare a thought for the doctor who must then diagnose your condition from the results. These clinical radiologists are almost continuously overworked and over-stressed, a fact that is confirmed by the numerous reports in medical communications and the press about critical shortages of qualified radiologists. This problem is not confined to the UK. Indeed, such is the shortage of consultants in this field that it is not unknown for top-rate radiologists to be offered jobs in the United States with dollar salaries of seven figures! The NHS is facing a crisis in this area. Another, perhaps even more pressing problem is the shortage of trained radiology staff in developing countries. Here they may have the equipment, perhaps provided through aid and related development contracts, but a lack of qualified staff will make this equipment altogether useless.

To take the strain off radiologists there is a growing need for diagnostic aids and automated systems. The ultimate goal of research in this field is to replace the main stressful and repetitive tasks of a clinical radiologist with a fully automated 'artificial radiologist'. However, such is the fear of false diagnosis and possible medical negligence claims that no hospital will allow an automated diagnostic system to operate completely independently. Any system will only act as a diagnostic tool for the radiologists, rather than as a replacement for them.

Dr Rossiter has been collaborating on this problem with Professor Paul Goddard and his colleagues in the Department of Clinical Radiology at Bristol Royal Infirmary. Their research has focused on the detection of lung ➜

disease from radiological test data. The requirement of a tool that will be an assistant to, rather than a replacement of, senior radiologists was a key concern from the very outset.

The system being developed closely involves clinical radiologists in the development of a transparent diagnostic tool using concepts, language and reasoning processes close to those of the human radiologists. In this way a radiologist can have confidence in the system through two routes:

1 they can 'look inside' the system and examine the knowledge and the reasoning mechanisms used;

2 they can follow the reasoning steps of the system and see that they match the reasoning steps he or she would take when faced with the same information.

Recent progress has focused on providing an automated diagnosis from CT scans. At present a radiologist must examine a series of 50 or more scan images and then write a report on the diagnosis. Typically this report is only a few sentences long and contains such vague terms as 'extensive fibrosis' and 'a small amount of localised emphysema'. The diagnostic system being developed – ie the artificial radiologist – must be able to perform these complex diagnostic tasks automatically. This requires a biomimetic process – the mimicking by technology of human behaviours, perceptions and thought processes.

In the simplest analysis the radiologist's tasks can be broken down into three stages:

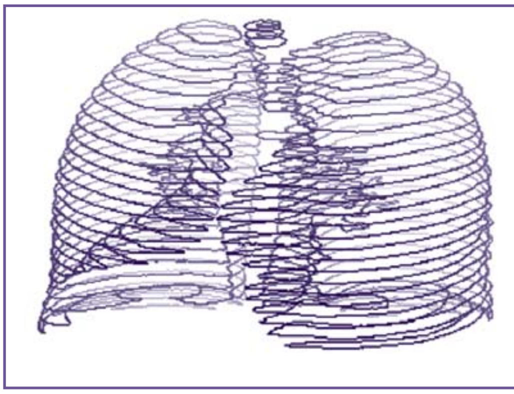
1 examining the scans requires image processing by the eyes and human visual system – the low-level compression step;

2 intermediate processing in the brain links the low-level image features to disease characteristics;

3 high-level reasoning fuses all this information together, producing the diagnosis and the written report.

Previous work on image-feature detection and automatic classification of lung disease using artificial neural networks and fractal measures has provided the low-level information-compression step, analogous to that performed by the vision system inside the human radiologist. For the higher level of biomimetic conceptual reasoning and report generation, the research team have been examining the text reports that the radiologists have written. Using techniques of natural language processing and clustering, key features have been extracted from a large body of these anonomised reports. This has supplied the important terms in a specialised language that can then be used to communicate with radiologists.

Having shown great success in processing medical information at both the high- and low-level stages, research is now concentrating on the intermediate level required to join them up. It is important to remember that this interface must also model and preserve the underlying uncertainty and vagueness of the original reports. Work by Rossiter on reasoning with uncertain information and the AI Group on fuzzy conceptual graphs is providing the lynchpin.



A 3D lung volume that has been extracted automatically from a series of CT scans

Throughout this process, the research team has been keen to ensure that the work is as transparent as possible and easily interpreted by the clinical radiologists. If the artificial radiologist can mimic how doctors think, then they should have more confidence in the system and it should perform at least as well as the doctors themselves. ■

The ultimate goal is to replace repetitive tasks with a fully-automated 'artificial radiologist'

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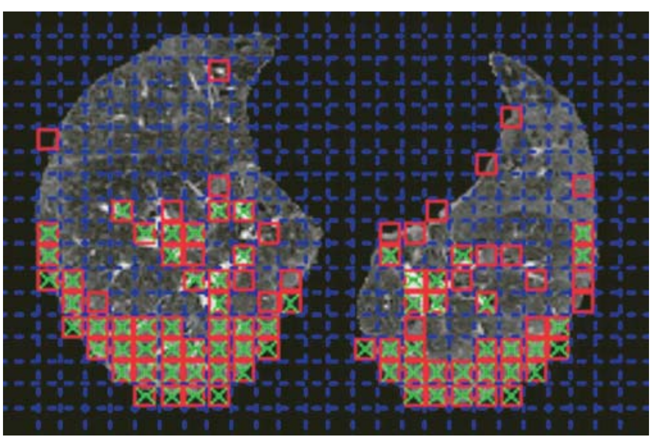
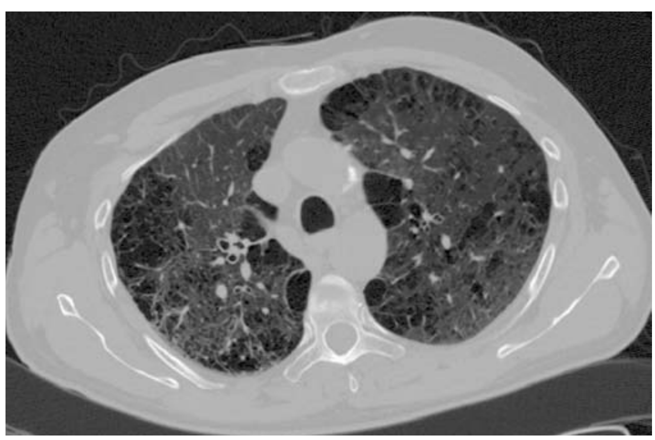


A processed CT scan showing the actual lung disease as green crosses and the corresponding computer prediction as red squares



A typical CT scan of the lungs showing extensive emphysema (the dark voids)