1988, *The British Journal of Radiology*, 61, 869–872

Proceedings of The British Institute of Radiology

The clinical usefulness of nuclear medicine image processing

Abstracts of papers presented at the above joint meeting of the IPSM Radionuclide Topic Group and the British Institute of Radiology, held at the BIR Lecture Theatre, 36 Portland Place, London W1N 4AT on Tuesday, February 9, 1988

Session 1

Chairmen: Dr J. Hannan and Dr A. H. Smith

Perspectives on nuclear medicine image processing, by P. Vernon (abstract not received)
Nuclear image processing: a radiologist's view, by P. J. Robinson
The assessment of single- and multiple-valued indices, by D. C. Barber and W. B. Tindale
Condensed dynamic images in radionuclide oesophageal scintigraphy, by G. C. Hart and A. J. Mearns
Quantification of hepatic uptake of DISIDA: a measure of hepatic dysfunction, by D. N. Taylor, I. Fraser and J. Barham

Nuclear image processing: a radiologist's view

P. J. Robinson
St James's Hospital, Leeds

We need to ask how (and if) image processing helps us to reach a diagnosis or clinical decision. To answer this, we have to try to define what images are, what factors influence our extraction of diagnostic data from them, and how manipulation of the image may improve this process. Images are generally two-dimensional representations of data which in reality is four-dimensional, *i.e.* images are usually summated in two spatial dimensions and in time. They show the distribution of a particular combination of structure, function and transport, being z-modulated by count rate or other predetermined factors. We extract diagnostic information from images by a process of visual and mental analysis which can be subdivided into phases of perception, recognition and interpretation, but these stages are not clear-cut and the division is an oversimplification. The extraction of diagnostic data is affected by the physical characteristics of the image, *e.g.* structured noise, unstructured noise, contrast range and spatial frequency spectrum. ata extraction is also influenced by a number of factors within the observer which are much more difficult to define and investigate; these include preconceptions, "pre-attentive" visual processing and the effects of training the observer. Image processing can enhance the diagnostic value of digital images in three ways: firstly, by quantifying the spatial distribution of data (*e.g.* split renal function with DMSA) or by quantifying the temporal distribution of data (*e.g.* a renogram curve); secondly, by displaying complex functional data which are otherwise difficult for the observer to assimilate (*e.g.* cardiac phase and amplitude images); thirdly, the effective signal-to-noise ratio of images may be improved by compensating for the instrumental degradation of raw data (*e.g.* non-uniformity correction), by spatial filtering to improve the conspicuity of the signal (*e.g.* suppression of unstructured noise), by the removal of structured noise (*e.g.* image subtraction), or by manipulation of the dynamic range of the image. Assessment of the value of processing in imaging procedures is heavily dependent upon clinical objectives and the end-point by which the success or failure of the test is to be judged. For imaging tests where the outcome is a straight positive or negative result (or an estimate of probability), the effect of image processing can be assessed by comparing areas under ROC curves. Where the objective of the test is to contribute towards a clinical decision (*e.g.* whether to remove or reconstruct a diseased kidney), we need to estimate the reduction in clinical uncertainty which results from the test. Where the results of image processing are judged in terms of clinical interpretation, observer effects need to be considered. The magnitude of both intraobserver and interobserver variation in the interpretation of some clinical images is striking; subjective variations may overshadow the more subtle improvements in the diagnostic "quality" of images which are produced by processing.

The assessment of single- and multipe-valued indices

D. C. Barber and W. B. Tindale
Department of Medical Physics, Royal Hallamshire Hospital, Sheffield S10 2JF

A numerical index determined from a radionuclide dynamic study seeks to provide a measurement of some aspect of physiology. A single-valued index can, under ideal conditions, provide a unique value for the physiological signal being measured. In contrast a multiple-valued index can take on more than one value for the same physiological signal, even under ideal conditions—it has no unique correct value for a given physiological signal. In spite of the obvious theoretical disadvantages of multiple-valued indices, several such indices are in common use. Examples include Hilson's index for the assessment of renal transplant perfusion and the hepatic perfusion index for the characterization of relative arterial and portal flows. An example of an index which comes close to being single-valued is the recently proposed renal perfusion index described by Peters et al. Clearly, a multiple-valued index can only be of clinical use if the range of values it can take in practice is small compared with the expected variation in the change of index with changing physiology. On the other hand, single-valued indices generally require more computation than multiple-valued indices. Addition of extra computational stages increases the error of an index and it is possible that the overall accuracy of a single-valued index may be less than that of a multiple-valued one. For example, attempts to eliminate the effects of attenuation and cross-talk may reduce rather than increase the accuracy of an index. In this paper the relative merits of multiple-valued and single-valued indices are discussed, with particular reference to the assessment of renal and hepatic perfusion.

11 doubtful and 25 positive on the analogue images. After computer subtractions 13 were negative, five doubtful and 60 were positive. Subsequent results, which are presented, have confirmed this. The technique has only been used with ^{81}Kr and depends on good control of patient position on the gamma camera.

Digital image registration techniques applied to radioaerosol imaging in nuclear medicine

P. A. Kenny, D. J. Dowsett, *D. Vernon and J. T. Ennis
*Institute of Radiological Sciences, Mater Misericordiae Hospital, Dublin 7, and *Department of Computer Science, Trinity College, Dublin 2, Ireland*

This paper describes the application of digital image processing and analysis techniques to an image realignment problem in nuclear medicine. The use of ^{99}Tc^{m}-labelled aerosols as a pulmonary ventilation agent immediately after perfusion with ^{99}Tc^{m}-labelled macroaggregated albumin involves computer subtraction of the perfusion image from the composite image of perfusion overlaid by the radionuclide distribution from inhalation of aerosol. The two images to be subtracted must be correctly aligned, otherwise the ventilation image obtained will not accurately describe the pattern of ventilation, and subtraction artefacts are produced. These artefacts are usually caused by patient movement during inhalation of aerosol between image acquisition. The use of non-linear spatial warping to realign the images is described. The user manually locates corresponding sets of image control points, usually at edges in the images. These are used to calculate the two-dimensional mapping required to reconstruct the perfusion image spatially coincident with the composite aerosol image. Polynomial approximations to the required transformation are used as they can be implemented without prior knowledge of the types and magnitudes of displacements between the images. The actual spatial mapping, which is unique to any pair of images, is characterized by its polynomial coefficients.

Assessment of thallium–technetium subtraction scanning in chronic renal failure

W. B. Tindale, N. A. T. Hamdy, J. L. Williams and J. A. Kanis
Departments of Medical Physics and Human Metabolism, Royal Hallamshire Hospital, Sheffield S10 2JF

Thallium–technetium subtraction scanning is an established non-invasive method for the localization of parathyroid adenomas in primary hyperparathyroidism. Its use in the secondary and tertiary hyperparathyroidism of chronic renal failure and transplantation is controversial and doubts have been expressed concerning its role in these conditions. We have evaluated the technique in 81 patients with chronic renal failure with established secondary or tertiary hyperparathyroidism as judged by biochemical, radiographic and/or histological parameters. Fifty-six patients were on renal replacement therapy (38 haemodialysis, 18 continuous ambulatory peritoneal dialysis (CAPD)), 17 had functioning renal transplants and eight had impaired renal function not requiring dialysis. Patients were further classified according to the presence or absence of hypercalcaemia (serum calcium >2.63 mmol/l). Parathyroid scanning was performed using a modified thallium-first technique, with image subtraction being carried out using a method previously optimized by computer simulation studies. In the absence of hypercalcaemia, scans were consistently negative in all patients except those on haemodialysis. In this group, 75% of hypercalcaemic patients had a positive scan, but 39% of the normocalcaemic subjects were also positive. There was a high yield of positive scans (42–67%) in the remaining three groups in the presence of hypercalcaemia. We conclude that contrary to current belief, this technique is effective in localizing hyperplastic parathyroid glands in the secondary and tertiary hyperparathyroidism of chronic renal failure. Its use is not indicated in the presenc of normal serum calcium levels in patients with impaired renal function not requiring dialysis, in those on CAPD or post-transplantation.

Session 3

Chairmen: D. J. Sumner and L. K. Harding

The effect of background activity correction on the diagnostic performance of thallium-201 scintigraphy for the detection of ischaemic heart disease

J. A. Mills, S. Choraria, D. N. Taylor, J. Flint, J. McIntosh and J. Pilcher
Department of Clinical Physics and Bioengineering and Department of Cardiology, Walsgrave Hospital, Coventry

Background activity correction images using the Watson technique were generated from the rest and stress scintigrams of 10 normal volunteers and 10 patients with coronary artery disease confirmed by angiography. The amount of correction was varied through five levels, from none to the full background image. These corrected images were presented to two experienced observers and the sensitivity, specificity and diagnostic accuracy determined for each level of correction. The sensitivity improved from 0.7 to 0.85 while the specificity remained around the 0.9 level until full correction, when it dropped to 0.7. The diagnostic accuracy remained unaltered. Bayesian analysis was applied in order to assess the way in which such variations would affect the value of the test. It was concluded that background subtraction should not be used in an automatic processing protocol without operator intervention.

VOL 61 NO 729 SEPTEMBER 1988

The British Journal of Radiology

Contents