Image processing techniques in nuclear medicine

Thesis

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Figure P2.9  TV display of cardiac gated blood pool study. Acquisition was of 16 frames in a 32*32 matrix zoomed from a 64*64 matrix covering the camera field of view. The images show paradoxical motion of the left ventricular apex. The scale to the right of the images shows the assignment of the colours from maximum pixel values at top of scale to zero values at bottom. a: First frame of raw data after one nine point smooth. b: Regional ventricular ejection fraction image, defined for each pixel time–activity curve as (max–min)/max. c: Amplitude image from first harmonic Fourier analysis. d: Phase image from first harmonic Fourier analysis.
**Figure P4.1** Normal (a-d) and abnormal (e-h) hepatic flow patterns.  

**a-b:** Positioning of the three ROIs on early (a) and late (b) summed images. The left kidney ROI is defined to enclose the entire left kidney and exclude non-renal activity.  

**c:** Time activity curves from liver (heavy solid), left kidney (light solid) and right kidney (dotted). $\text{HPIR} = \text{HPIL} = 0.37$.  

**d:** Liver response curve obtained from deconvolution of liver and left kidney curves. $\text{MTT}_1 = 26.2$, $\text{MTT}_2 = 31.2$.  

**e-f:** Positioning of the three ROIs on early (e) and late (f) summed images. The left kidney ROI is defined to exclude overlapping activity in the liver and spleen.  

**g:** Time activity curves from liver (heavy solid), left kidney (light solid) and right kidney (dotted). $\text{HPIR} = \text{HPIL} = 1.05$.  

**h:** Liver response curve obtained from deconvolution of liver and left kidney curves. $\text{MTT}_1 = 14.7$, $\text{MTT}_2 = 15.2$. 

Figure P5.6 Equilibrium ECG gated cardiac blood pool imaging (MUGA).

a: Diagram showing ECG gating (Holman, 1979). b-c: End diastolic and end systolic images. d-e: Outline images showing the positions of right ventricle (RV), left ventricle (LV), right atrium (RA) and left atrium (LA), for the images shown in b, c.
Figure P6.1 Manually selected regions of interest.  a: End diastole.
b: End systole.
Figure P6.2  Interpolative background subtraction.  a: End diastolic image, showing outline of the box in which background subtraction will be performed.  b: Isolated left ventricle image, obtained by background subtraction.  c: Isolated ventricle with superimposed 10% isocount contour.  d: End diastolic image with 10% contour.
Figure P6.3 LVROI derived from 10% isocount contour. End diastolic image (as in figure P6.2) with superimposed region of interest corresponding to 10% isocount contour and automatically selected background region.
Figure P6.5 LVROIs at end diastole and end systole. 

a-b: Normal study (LVEF=57%).

c-d: Apical aneurysm with paradoxical motion (LVEF=33%).
Figure P6.6 Operation of the pseudo-Laplacian convolution filter. The user specified box enclosed the entire image in this case.  

- **a**: Four images from application of the filter in the four directions.  
- **b**: Images from (a) after local maxima search.  
- **c**: Sum of the four filter images.  
- **d**: Sum of the local maxima images.  
- **e**: Remainder after deletion of non-ventricular edge points.
Figure P6.7 Operation of the left ventricular centre search.

- a: Residual volume image.
- b: Fourier phase image.
- c: Masked residual volume image.
- d: Horizontal profile, first peak from right is in column 23.
**Figure P6.13** Effect of LVROI size on LVEF.  

- **a:** Manual ROI, LVEF = 20%.  
- **b:** Method 1, correct box size, 10% contour, LVEF = 11%.  
- **c:** Method 1, smaller box, 10% contour, LVEF = 9%.  
- **d:** Method 2, LVEF = 14%.  
- **e:** Method 1, correct box size, 20% contour, LVEF = 13%.
Figure P6.14 'Binary edges' from Method 2. a-b: 16 image frames from patients 10 and 9 (patient group A2) respectively. c-d: 16 'binary edges' from patients 10 and 9.
Figure P7.3 Normal exercise $^{99}$Tcm-tBIN study, patient 13, showing examples of slices in the planes described in the text. Reconstruction of tomographic data was performed using filter 1 (smoothed).

Upper block: planar images; centre block: transaxial, coronal and sagittal slices; lower block: oblique slices.

Line diagrams beneath the images show the myocardial zones scored by the observers, numbered as follows: 1, anterior wall; 2, inferior wall; 3, apex; 4, septum; 5, postero-lateral wall.
Figure P7.4 Normal exercise $^{99}$Tc$^m$-tBIN study, patient 13, showing the hot iron colour scale used in reporting. a: LAO planar image. b: transaxial slice. c: short axis slice.
Figure P7.5  Exercise images from patient 3 (inferior wall transient ischaemia) reconstructed with filter 1S.

Figure P7.6 Exercise images from patient 3 (inferior wall transient ischaemia) reconstructed with filter 2.

Figure P7.7 Exercise images from patient 3 (inferior wall transient ischaemia) reconstructed with filter 3.

Figure P7.8 Exercise images from patient 3 (inferior wall transient ischaemia) reconstructed with filter 5.

Figure P7.9 Exercise images from patient 3 (inferior wall transient ischaemia) reconstructed with filter 8.

Figure P7.10 Patient 5; sagittal slices from exercise (a,b) and rest (c,d) studies. Slices correspond in pairs a,c and b,d. Arrows indicate a transmural defect in the inferior wall of the left ventricle. In addition, the antero-apical wall shows reduced uptake at exercise with resting redistribution.
Figure P7.11  Patient 4; short axis slices from exercise (a,b) and rest (c,d) studies. Slices correspond in pairs a,c and b,d. Arrows indicate the expected location of a defect on the exercise image, into which redistribution should occur.
Figure P8.3 Axial slices through centre of rod phantom for the seven filters. These slices are reconstructed from the acquisition with activity concentration ratio, rods: 'myocardium' = 0:1. # = filter number, N = not corrected for attenuation, A = attenuation corrected.
Figure P8.4 ROIs used in rod phantom experiment and deviation images.

a: ROIs for computation of deviation image. The area between the two inner lines indicates the pixels used for calculation of the mean and standard deviation. The outer line indicates the area within which the deviation image is calculated.

b: ROIs superimposed on an axial image (filter 3, attenuation corrected).

c: Deviation image for filter 3, attenuation corrected.

d: Deviation image for filter 3, not attenuation corrected.
Figure P8.6 Axial slices through centre of slice phantom, experiment 1.
Figure P8.7 Oblique images in the plane of the slice, experiment 2.
Figure P8.8 Effect of ROI choice on deviation images. a: Axial slice (filter 3, attenuation corrected). b: Deviation image from slice in (a) formed as in figure P8.4. c: Deviation image from slice in (a) formed using a single ROI corresponding to the outer line in figure P8.4. d: Image (c) displayed with 5sd as the maximum display level.
Figure P8.9  Effect of non-stationary filter on reconstructions of data from patient 13.  

a: Anterior projection image, pre-filtered with SMTH. 
b: Axial slice reconstructed from projections pre-filtered with SMTH. 
c: Anterior projection image, pre-filtered with VSMO.  
d: Axial slice reconstructed from projections pre-filtered with VSMO.