RAPID 3D NONLINEAR LUNG IMAGE FUSION OF CT WITH SPECT ^{81m}Kr VENTILATION and ^{99m}Tc-MAA PERFUSION USING ENERGY MINIMIZATION

Y. Ogura, K. Utsunomiya, I. Narabayashi, T. Komori, I. Adachi, A. Stundžia*, P. Dufort*, M. Ichise**.

Osaka Medical College, Takatsuki, Japan;
*Advanced Biologic Corp., Toronto, Canada;
**National Institute of Mental Health, Bethesda, USA

Objectives: We developed a rapid non-linear technique to register and fuse 3D lung CT images with SPECT ^{99m}Tc MAA perfusion, ^{81m}Kr ventilation and ventilation–perfusion normalized (V/Q) images called the LungGuide Image Fusion Method (LG-IFM).
Methods: CT, SPECT ^{99m}Tc-MAA perfusion, and ^{81m}Kr ventilation lung imaging was performed for 12 patients with suspected lung defects including embolism, emphysema, and tumour nodules. For each patient, the LG-IFM technique was applied in four stages. First, a plane of approximate left-right symmetry, labeled as the midsagittal (MS) plane, separating the left lung from the right lung, was found. This MS plane identification was performed independently for CT and SPECT image data. Second, the optimal linear match between the original lung SPECT and CT images was found by aligning the MS planes and then rigidly translating (shifting) and rotating the SPECT image in 3D such that the maximum overlap between the two images was achieved, as measured by a statistical correlation function. Third, the most probable SPECT outer lung surface was estimated and corresponding anatomic reference points on the CT and SPECT lung surfaces were respectively identified. A one-to-one correspondence between all points on the CT lung surface and all points on the SPECT lung surface was generated giving a continuous 3D vector displacement field $\mathbf{S} = \mathbf{S}(x,y,z)$ from one surface to the other. Finally, a scalar deformation energy function $E = E(\vec{\mathbf{V}})$ was constructed for a volume displacement field $\vec{\mathbf{V}} = \vec{\mathbf{V}}(x,y,z)$ defined on the interior points of the lungs, with the surface mapping $\mathbf{S}$ as a boundary constraint. Minimization of the energy function yielded a non-linear mapping of the SPECT volume onto the CT volume, or equivalently 3D nonlinear image fusion of CT with SPECT.
Results: The processing of same patient 3D LG-IFM registration and fusion of lung CT images (16 million voxels ≈ 32 MB) with SPECT ventilation, SPECT perfusion, and V/Q images (1 million voxels ≈ 2 MB) took 300 seconds on a PC workstation (Windows 2000 on a 2 GHz Pentium 4 with 512MB of RAM). The accuracy of image registration and fusion were confirmed visually for all twelve cases by 3 independent readers, using the lung defects and independent markers as reference. **Conclusion**: The LungGuide Image Fusion Method appears a rapid and accurate method of generating fused 3D images of anatomic CT and functional SPECT lung studies within the same subject, and may be a clinically useful tool.