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High Resolution Brain SPECT Imaging Technologies and Clinical Performances

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Abstract. High resolution SPECT imaging has great impact in the diagnosis of functional abnormalities in deep brain structures and always appeared as a high priority demand. Short summary and overview will be presented about the various functional imaging technologies with their physical and clinical performances including the available methods to improve the image quality on the particular imaging system. It is well known, till nowadays the vast majority of the applied imaging systems are conventional general purpose large field of view (LFOV) systems using parallel projection. The main problem of these systems is the high level image blur and the low sensitivity i.e. there is a contradiction between the system resolution and the sensitivity. One way to improve simultaneously the resolution and the sensitivity is to create imaging geometry to adapt suitably to the size, location and the shape of the investigated organ, especially to the brain. XRing/4R four head (cylinder symmetric appr.) dedicated brain SPECT system (Mediso Ltd.) with extra high intrinsic resolution (<2.2mm in 230*220mm UFOV) NaI(Tl) based detectors as well as LEHR/UHR collimator set deliver a feasible solution with Tc-99m/I-123 isotopes for brain SPECT. 2mm isotropic voxel-size is used for both phantom and clinical studies by MTF-1 based 2D pre-filtering on the projection data and FBP reconstruction method. The system produced morphologically highly detailed images reflecting the brain anatomy by the patient studies. The gyruses and the grey matter along the gyruses are well delineated. 3D ordered subset expected maximization (OSEM) iterative reconstruction method has been developed for general purpose LFOV parallel projection based imaging systems in order to reduce the image blur effect and simultaneously compensate the photon absorption. The non-linear image blur distortion is originating from the distance dependent spatial resolution (DDSR) of the parallel projection. Dedicated calibration procedure has been worked out for the point spread function (PSF) modeling of DDSR and the photon attenuation map is determined by co-registered and resampled CT imaging. Forward projection step of the 3D reconstruction method includes both the PSF modeling and the photon absorption effect. High performance computing method has been also developed due to the intensive computation demand algorithm. The implementation has been carried out by novel nVidia based GPU's being much faster than the conventional multi-core CPU's (Central Process Unit). AnyScan™ SC (SPECT/CT, Mediso Ltd.) was considered for physical phantom and patient studies. The 3D iterative reconstruction method also was possible to apply on the retrospective studies of XRing/4R dedicated brain SPECT systems without CT based attenuation correction (only the conventional Chang method was applicable in this particular case). The 3D iterative reconstruction method was a part of the research project to be supported by TECH_08_A2-TeraTomo (NKTH) and TÁMOP-4.2.1/B-09/1/KMR-2010-0002 grants.
The novel 3D GPU based reconstruction algorithm resulted significant improvement in the image contrast and spatial resolution. The reconstructed images showed clear-cut better spatial activity distribution. Considering the speed of the implemented reconstruction method is suitable for daily clinical application too (running time is less than 10min. with nVidia 480GTX GPU in case of 128x128x128 volume sampling rate, and less than 23min. in case of 256x256x128 volume sampling). The processed brain SPECT studies showed surprisingly good and artifact free result for both modalities (AnyScan™ SC and XRing/4R) with significant improvement of the image contrast and signal/noise ratio both by ˜2mm and ˜1mm voxel size samplings.

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