Dual Modality Ultrasound-SPECT Detector for Molecular Imaging

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In the last few years, integrated dual-imaging system has emerged as a new modality for the detection and staging of cancer in medicine with the aim to combine both functional and anatomic information for a more reliable diagnosis. We present an innovative compact dual-modality detector, which integrates an ultrasound probe with a scintigraphic single photon emission gamma camera for molecular imaging. The image quality and quantitative accuracy of radionuclide imaging often lack anatomic cues that are needed to localize or stage the disease and typically has poorer statistical and spatial characteristics than anatomic imaging methods, such as MRI, X-rays or ultrasounds (US). Among these techniques, US are a cost-effective and reliable method and the US-probes represent an easy way to assemble portable devices. These issues have motivated the development of a new research approach that could combines functional data from compact SPET gamma cameras with structural ones from US equipments.

The aim of this work is to describe the detector design and preliminary phantom analysis of a compact dual-imaging device and to provide a tri-dimensional US/SPECT fused images. The scintigraphic camera is based on a four segment slant-hole collimators, which provide four projections of the object (one for each segment) for each position of the camera. More projections are gained by rotating the small gamma camera around the vertical axis (z). This approach permits to recover the depth of a lesion, without the need of rotating the camera around the investigated object. Each segment of the collimator is coupled to a high-resolution compact gamma camera as a detection module. It consists of a multi-anode Photo Multiplier Tube (MA-PMT) Hamamatsu Flat Panel H8500-Mod8 series and a 50x50x4.0 mm3 continuous LaBr3(Ce) crystal which are also tested. The final configuration of the detector is planned to be a 2x2 modular assembly with 64 independent read-out electronic channels and a FPGA based control board per module (256ch in total). A single segment of the camera provides a partial field-of-view (FOV) of the investigated object. As a consequence, the total FOV is determined by the volume intersected by all projections and it consists of a figure of rotation created from the rotation of the rhombus. In the first step, a linear US piezoelectric probe, inserted between the front of collimation zone and the object, will allow to carry out the volume of morphological image including, by image fusion techniques, the tissue functional characteristics contained in the reconstructed rhombus. The advantage of this device is the intrinsic possibility to be positioned close to the object to be imaged, carrying out a volume image of the object that contains both functional and morphological information. It can overcome the intrinsic limitations in spatial resolution arising from the geometry of SPECT/CT gantry.

Simulation and experimental results confirm that the US/SPECT hybrid imager is the first device able to carry out fusion of morphological and functional contents for many molecular imaging applications. Furthermore, the scintillation detector will be able to reconstruct volume image without the use of any tomographic ring by using an advanced reconstruction algorithm of tomosinthesys.