Motion Compensated Unrestrained Awake Animal SPECT Imaging

The next generation of ... Biomedical Imaging

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Oak Ridge National Laboratory (ORNL), Thomas Jefferson National Accelerator Facility (JLab), and Johns Hopkins University (JHU) have collaborated to develop a SPECT-CT system for imaging unanesthetized, unrestrained mice. The full operational system is composed of a commercial precision x-ray CT/SPECT gantry, two high-resolution gamma cameras and an infrared (IR)-based motion tracking system. Thee Dell workstations are used to control the three sub-systems (gantry, IR tracking and gamma cameras) and record three separate data sets that are later used to correct for motion in image reconstruction. The three data sets that are time tagged via a common clock are: gantry location, mouse pose and gamma camera list mode data. A fully functional system including motion corrected SPECT reconstruction has been demonstrated. The completed system is installed and being tested on awake mice at JHU (Fig. 1).

The awake mouse is confined within a transparent burrow at the center of rotation of the gantry. The mouse head position is tracked by three infrared reflecting hemispheres attached to its head that are imaged by three CMOS based infrared cameras. Figure 2 gives the overall functional block diagram for motion measurement.

The system has been tested at Johns Hopkins University, first with moving phantoms and then with several awake mice. See Figure 3 for an example result of the tracking of an awake mouse injected with Tc99m-MDP. In this example a white female BALB-C 32.1g mouse was injected through a tail vain with 3.3 mC of Tc99m- methylenediphosphonate (MDP). Tc99m-MDP is used for bone scintigraphy where it is typically taken up by healthy bone. The resulting SPECT images are, therefore, similar to a low resolution x-ray CT of the skeleton. After about three hours after injection the mouse was anesthetized for ~10 minutes with the inhalant isoflurane to allow placement of IR reflectors with instant adhesive. The mouse was imaged ~3hr post injection using a 1 mm diameter pinhole collimator with 1.5 × magnification. List-mode data were acquired at 120 gamma stops over 360 degrees, at 20 sec/position. The list mode projection data with mouse head tracking was reconstructed using OSEM with tracking data incorporated.

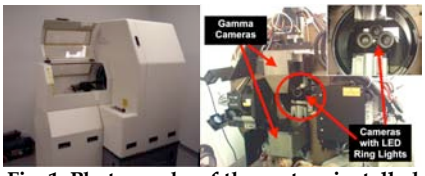

Fig. 1. Photographs of the system installed at JHU. Shown on the left is the Siemens MicroCAT II with the x-ray shield in place. The internal view on the right shows the gantry with the JLab SPECT detectors and mounted ORNL optical tracking system. Three CMOS IR cameras are seen in the enlargement.

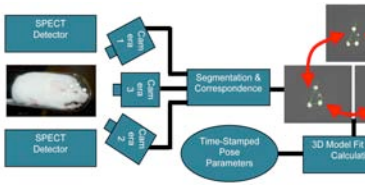

Fig. 2. Functional block diagram of optical tracking system

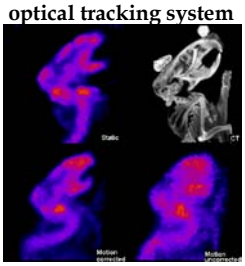

Fig. 3. Three-dimensional views from a SPECT reconstruction of a Tc99m-MDP injected mouse without motion correction (lower right); with motion correction (lower left); static (upper left); and a static CT reconstruction of the same mouse (upper right).