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#9-201 The POSiCS handheld gamma-ray camera for radio-guided surgery

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At the frontier between research and innovation, POSiCS is a project aiming to build a scalable and handheld gamma-camera for radio-guided surgery. The project is shared between three partners: the University of Geneva, the University Hospital of Geneva and the Fondazione Bruno Kessler. These consortium of institutions have been granted an European grant for innovation and have filled together a patent for this innovative technology and are starting to develop business activities for the European market.

Targeting the imaging of lymph nodes for biopsies in the context of breast cancer and cutaneous melanoma, the camera aims at reducing the invasiveness of the sentinel lymph node biopsy procedure by imaging above the skin while improving the surgery success probability. Patients undergoing sentinel lymph node biopsy are injected a pharmaceutical radio-tracer that binds to the cancerous cells. The radio-tracer used is technetium-99m and produces distinct 140.5 kilo electron-volt gamma-ray emission line via isomeric transition.

For such an application, we designed and produced a wireless handheld gamma camera, based on an innovative position-sensitive linearly graded silicon photo-multiplier technology. By using an array of 3x3 tiles of linearly graded silicon photo-multiplier, the position of a beam of light can be reconstructed with a sub-millimeter resolution over a large area of nine 10x10 mm2 chips for a total area of about 9 cm2 with only 8 readout channels. The 140.5 kilo electron-volt gamma-rays are converted to optical photons by a lutetium–yttrium oxyorthosilicate pixelated (30x30) 1.1 mm pitch and 2 mm thickness scintillator. A parallel-hole tungsten collimators is used to assign each pixel position a dedicated gamma-ray direction. Two types of collimators a high-resolution collimator and a high-sensitivity collimator can be interchanged depending on the imaging application. With only 8 channels and weighting less than 1 kilogram for 900 pixels, the power consumption and size of the camera is minimized thus making it a portable wireless device and operable on a battery.

Small non-linearity in energy and position reconstruction of the acquisition chain as well as the non-uniformity in the trigger response require a proper calibration of the camera. In order to correct the end-user image for these effects as well as rejecting background. The calibration of the camera that will be presented. In particular we will present the measurements and corrections of non-linearity as well as energy calibration based on a technetium-99m flood of the camera.

The images are cleaned from the Compton-scattered gamma-rays and from intrinsic radiation of the scintillator. The full reconstruction pipeline from the raw data to the graphical user interface will be presented. All computing and displaying can be performed on a standard laptop and the reconstruction pipeline is able to display without perceived latency the camera recordings even at high trigger rates of about 40 kHz.

From the final images, the position resolution and sensitivity of the device are assessed with phantoms and are compared to Monte-Carlo simulation. We evaluated the spatial resolution, across the camera surface, using an source placed behind a block partially covering the camera. The edge spread function of the block allowed us to measure a resolution of 5.5 mm with a source positioned 15 mm for the high-sensitivity collimator in agreements with our simulations. Additionally, we measured the photo-peak energy resolution of 18% at 140.5 kilo-electronvolts.

The results of an on-going clinical evaluation of the device with mice experiments will be shown. In this study, 10 mice were injected with malignant cells. After a couple of weeks, to let the cells grow, each mouse is injected with a technetium-99m pharmaceutical radio-tracer. Shortly after the injection, the mice are imaged with an animal single-photon emission computed tomography scanner and compared to the images from the POSiCS camera.

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