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Signal to Noise Ratio optimization for extended sources with a new kind of MURA masks

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Coded aperture imaging is a well known technique for localization of radioactive hot-spots. Its advantages are high detection efficiency and under certain configurations wide Field of View (FOV). We have used a simple assembly technique which results in coded masks with high transparency, low weight and which can be restructured easily. We present the study of the reduction of the intrinsic noise of these coded apertures, when they localize spatially extended γ-emitters. Specifically, the Modified-Uniformly-Redundant-Array (MURA) [1] coded apertures are structured by lead spheres arranged on a transparent medium such as acrylic glass. This configuration induces a systematic, element-wise, noise on the Point-Spread-Function (PSF) of the correlation matrix. In imaging of extended hot-spots with these apertures [2], a penumbra phenomenon occurs which reduces this intrinsic noise in the same way as a kernel filter does. Fast-Fourier-Transform (FFT) is used herein to analyze the effect of this phenomenon on the correlation matrix and to explain the dependence of its Signal-to-Noise Ratio (SNR) on the dimensions of the hot spot. The SNR maximization is achieved for certain combinations of geometrical characteristics of the source and of the coded aperture camera. Simulations have been used for the detailed study of the SNR as a function of the dimensions of the hot-spot, while experiments with two 99mTc cylindrical sources with 11mm and 24mm diameter, respectively and 1.5 MBq activity each, confirm the reduction of the intrinsic noise. The results define the way of optimization of the imaging setup for the detection of extended hot-spots. Such an optimization could be useful for example in the case of lymph nodes imaging in nuclear medicine. Finally, we propose a kernel filter, derived by the Auto-Correlation-Function (ACF) [1], to be applied on PSFs with high intrinsic noise, in order to eliminate it.

[1] S. R. Gottesman and E. E. Fenimore, "New family of binary arrays for coded aperture imaging.,"Appl. Opt., vol. 28, no. 20, pp. 4344–4352, 1989.
[2] I. Kaissas, C. Papadimitropoulos, C. Potiriadis, K. Karafasoulis, D. Loukas, and C. P. Lambropoulos, "Imaging of spatially extended hot spots with coded apertures for intra-operative nuclear medicine applications,"J. Instrum., vol. 12, no. 1, 2017.

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