THE USE OF A STOPPING RULE IN ITERATIVE IMAGE RECONSTRUCTION

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ABSTRACT

During a study of the characteristics of the Maximum Likelihood Estimator (MLE) method of image reconstruction from Positron Emission Tomography (PET) data, we have found that the requirement that the reconstructed image, if it were a source, could have generated the original data imposes the stopping of the iterative procedure at some point. This requirement appears to be in contradiction with the concept of a maximum likelihood estimator until one realizes that maximizing the likelihood results in reaching for the top of the measurement probability distribution $P(g|f)$ in Bayes' formula:

$$P(f|g) = P(g|f)P(f)/P(g)$$

where the results measurement vector g can be described by $g = Hf + n$, with f being a source, H the response matrix of the measurement system and n the noise vector in the measurement.

From a Bayesian point of view, we should maximize the Maximum a Posteriori Probability (MAP) $p(f|g)$, i.e., the probability that the source be f given a measurement g, and for that purpose one needs to have the *a priori* source distribution $P(f)$, which is not usually available with any degree of reliability.

The use of the stopping rule does not reach for the MAP solution but it uses some important physical prior information: it requires that the iterations stop as soon as the image obtained has a characteristic that we call "feasibility". We define a feasible image as one that could have given the original data by the physical process that governs the measurement.

We show that MLE reconstructions started from a uniform image field pass through a region of feasibility in which the images represent a good compromise between sharpness and smooth regions of high activity, without the "noise artifact" having yet set in. The shape and characteristics of the region of feasibility are described and implications for future work are described.