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PET Image Reconstruction: A Stopping Criterion Based on the Updating Coefficients of the ML-EM Algorithm

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We have studied certain properties of the maximum likelihood expectation maximization (ML-EM) algorithm for iterative image reconstruction in positron emission tomography (PET). The principal aim of the work has been the development and evaluation a new stopping criterion for this algorithm. We developed and used a software platform based on Monte-Carlo techniques, which simulates the emission of gamma rays in the source and their detection in the tomograph, to compute the transition matrix and also to generate projection data for reconstruction. The digital Hoffman brain phantom was used. A single-ring tomograph has been simulated with 128 detector crystals on the ring, which has 15 cm radius and a field of view (FOV) of 20x20 cm2. The images were reconstructed over a 64x64 and 128x128 grid. In order to investigate the problem of the deterioration of the image quality after a number of iterations, we have studied the statistical properties of the updating coefficients in the ML-EM algorithm. The results of this study show that the values of the updating coefficients for the non-zero reconstructed pixels follow a distribution composed of a peak region around 1 which becomes progressively narrower as the iteration proceeds, and also a tail below 1, which corresponds to that part of the image that is far from being completely reconstructed. This tail has an exponential form and is pushed to high values as the iterations progress. We find that the minimum and average values of the tail are related to the quality of the image. In particular for optimally reconstructed image these values are independent of the number of counts and of the image size. The possibility of exploring this property in stopping the algorithm at optimally reconstructed image is discussed.

Author: Mr GAITANIS, Anastasios (Department of Medical Physics, Medical School, University of Patras, Greece)

Co-authors: Dr KONTAXAKIS, George (Universidad Politécnica de Madrid, E.T.S.I. Telecomunicación, Dpto. Ingeniería Electrónica, 28040 Madrid, Spain); Prof. PANAYIOTAKIS, George (Department of Medical Physics, Medical School, University of Patras, Greece); Dr SPYROU, George (Foundation for Biomedical Research of the Academy of Athens (IIBEAA), Soranou Efessiou 4, Athens 11527, Greece.); Prof. TZANAKOS, George (University of Athens, Department of Physics, Division of Nuclear & Particle Physics, Panepistimioupoli, Zografou, Athens 15771, Greece.)

Presenter: Dr GUERRA, Pedro

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