AN AUTOMATIC METHOD TO SELECT A NOISE THRESHOLD IN THE SINGULAR-VALUE DOMAIN FOR RECONSTRUCTION OF PARALLEL PLATE NON-CONTACT FDOT IMAGES

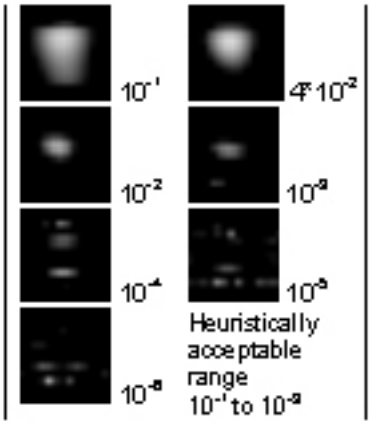
Poster no: 004

Chamorro-Servent J[1], Aguirre J[1], Ripoll J[2], Vaquero JJ[1], Desco M[1]
1Unidad de Medicina y Cirugía Experimental, Hospital General Universitario Gregorio Marañón, Madrid, Spain
2 FORTH, Institute of Electronic Structure Laser, Heraklion, Crete, Greece.

Introduction: Fluorescence Enhanced Diffuse Optical Tomography (FDOT) retrieves three dimensional distributions of extrinsic fluorophores in small animals, non-invasively and in vivo. The FDOT problem can be formulated as a system of equations, d=Wf, where W is a weight matrix that couples the measurements (d) to the unknown spatial distribution (f) of the fluorophore concentration (forward problem). To solve the inverse problem (image reconstruction), the Singular Value Decomposition method (SVD) of W has been previously employed[1-4]. To obtain a good quality image it is necessary to determine the useful singular values to retain. We present an automatic method that analytically calculates a threshold to select the significant singular values. We assess the validity of the calculated threshold by inspecting the noise level of the reconstructed images.

Methods: We used the U-curve algorithm[5] to find a threshold . The U-curve is a plot of the sum of the reciprocals of the regularized solution norm against the corresponding residual norm, in a doubly logarithmic scale. Experimental FDOT data collected with different experimental parameters for a slab-shaped phantom containing a capillary tip filled with Alexa Fluor 700, were reconstructed by SVD, using Tikhonov regularization with parameters in the 10-1 to 10-6 range. To confirm the sensitivity to the U-curve cut-off value, we verified that it falls into the experimentally relevant range that produces reconstructions with a reasonable amount of noise, and simultaneously fulfills the Picard's condition[6]. Thus, we verified that singular values above the automatically calculated cut-off decay to zero slower than the correspondent Fourier coefficients of d when they are expressed in terms of the left singular vectors of W.

Results: The figure depicts FDOT reconstructions with parameters in the 10-1 to 10-6 range and U-curve cut-off parameter =4*10-2 . lies into the heuristic range of 10-1 to 10-3 that produces images with acceptable noise levels. We also confirm that these useful singular values fulfill the Picard's condition.Acquisition parameters are: 20x20x10 voxels for a 1.5x1.5x1.5 cm volume of interest (VOI), with 12x12 detectors and 10x10 sources equally spaced in the FOV.



Conclusions: The automatic U-Curve algorithm provides a suitable regularization for SVD reconstruction of FDOT that fulfill Picard's condition. Although it is not the best of all the possible regularization parameters, it is within the heuristical range that yields reconstructions with a reasonable amount of noise. Within this range the main difference between reconstructed images remains in the low frequency noise, which can be easily eliminated by thresholding the images.

Acknowledgement: This work is supported in part by Fundación Caja Navarra (#12180), Ministerio de Ciencia e Innovación (TEC2008-06715 and TEC2007-64731) and EU-FP7 project FMTXCT-201792.

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