A New Interval-Based Algebraic Reconstruction Technique for error quantification in SPECT

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Abstract:
Aim: Comparison of activities within two regions of interest in a slice is of prime importance in nuclear medicine. To ensure the reliability of such comparisons, a full knowledge of the statistical properties of the noise in the slices is mandatory. As reconstruction algorithms do not preserve the Poisson distribution, this information is not straightforward. Computationally expensive algorithms are available to predict the variances of pixel values, but they remain hardly compatible with the clinical settings. We have shown recently that the use of multi-scaled tilings in the slices allows the computation of a projection procedure that takes into account all the projection schemes associated with various geometrical models including the concave disc or the spatial dependent Gaussian projection. This approach leads to projection and backprojection algorithms whose outputs are interval-valued. The lengths of these interval-valued projections are highly correlated to the variances of the distribution of the corresponding usual (non interval-valued) backprojection.
Materials & methods: Using interval arithmetic operators, the interval-valued projection procedure is used to create an interval-based version of the usual SIRT algorithm. 100 noisy projections of a Zubal phantom were used to reconstruct 100 interval-valued slices using this modified SIRT algorithm. Similarly, a cylindrical phantom filled with 740 MBq of a technetium 99m solution was used to reconstruct 25 interval-valued slices. For each pixel location, we have computed the length and the median value of the reconstructed interval, and then we have compared the mean of these lengths and the standard deviation of these median values over the 100 or 25 reconstructions.
Results: Using the Zubal and the cylindrical phantoms, the lengths of the interval-valued reconstructed activities increased with the iteration number. When convergence is reached, the mean lengths were highly correlated with the standard deviations of the median values (Pearson correlation coefficient = 0.85 and 0.84 respectively for the Zubal and the cylindrical phantom). **Conclusion:** These first experimental results showed that interval-valued projection and backprojection procedures can be used in the core of algebraic reconstruction algorithms to provides tomographic reconstructions in which the reconstructed pixel activities are computed together with an information that is correlated to the their noise levels. Further studies are now necessary to check if this additional information can be used to decide

whether activities reconstructed in two regions of interest are significantly different.
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