Overview of State of the Art PET Image Reconstruction Technologies

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Today, iterative reconstruction has become the standard PET image reconstruction technique on all PET/CT imaging systems. This reconstruction method is based on iteratively (repeatedly) estimating the activity distribution (PET image) by maximum likelihood estimation maximization (MLEM)[1]. Typically this method is implemented by using ordered subsets (OSEM)[2]. The characteristics of the reconstructed PET image depend on the specific settings used during reconstruction, in particular the number of subsets and iterations. By increasing the number of iterations (or product of subsets and iterations) the convergence of the reconstruction increases. A ‘higher’ convergence means a ‘better’ estimate of the PET image at the cost of increased image noise. Therefore, a careful optimization of these settings for specific tasks is needed[3, 4].

Several new PET technologies have recently been introduced on clinical PET/CT systems, such as time of flight (TOF)[5] and resolution modeling[6]. These new technologies enhance PET image quality when applied during reconstructions. TOF uses information on the difference in detection time of the 2 annihilation photons which are detected along the line of response. This difference in arrival time contains information on the location of the positron emission along the line of response. By including this information during reconstruction, the convergence of the reconstruction is enhanced resulting in images with better contrast to noise properties. Resolution modeling is a reconstruction technique that uses information on the spatial image resolution, expressed by a so-called point spread function[7]. Use of resolution modeling enhances spatial image resolution and thereby enhances the contrast-to-noise ratio as well. However, resolution modeling also results in artificial edge enhancements, known as Gibbs artifacts[8], which may cause bias in image quantification, particularly when based on the maximum SUV[9].

In this lecture the principles of data collection and (iterative) image reconstruction will be explained, including an overview of PET image reconstruction terminologies that are frequently used. The effects of changing reconstruction settings, such as iterations and subsets, on the quality and quantitative image characteristics will be detailed. In addition, the principle of both TOF and resolution modeling will be explained and their effects on image quality will be illustrated. After this lecture, the attendees will have gained a better understanding of the principles of PET image reconstruction, of new technologies and how these impact PET image quality.

References

