Investigation of image quality optimization in list-mode particle imaging without front tracker

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Abstract

The accuracy of the most likely path estimate (MLP) of each particle's trajectory through the patient is imparative to the spatal resolution in particle list-mode imaging. For high path estimation accuracy, the MLP requires two sets of position sensitive trackers, one preceding and one following the patient. In this work we investigate single-sided particle list-mode imaging, i.e. omitting the front trackers and still reconstructing each particle's MLP. Based on the recently extended MLP formalism, we propose a method to optimize the image quality for such a setup. The GATE Monte Carlo toolkit was used to simulate a field of pencil beams and simple phantom geometries as well as a anthropomorphic pediatric head phantom were investigated. The missing front tracker information was substituted with the known pencil beam information which the extended MLP formalism can take as input. A smaller spacing in between the pencil beam spots did have no effect on the image quality if the extended MLP formalism was used. In general, the removal of the front trackers comes at the cost of reduced spatial resolution due to the deterioration of the MLP accuracy in the beginning of the particle path. However, during the image reconstruction proceude, the less accurately estimated first half of the particle trajecotry can be omitted and only the half of the ppath where the path estimation accuracy is better is used to redistriibute the particle information. The missing informtaion is obtained by filling in an opposing projection. An improvement in spatial resolution compared to the original single-sided particle imaging was observed. However, redistributing the particle information only using the last half of the particle trajectory degrades the image quality for objects closer to the object entrance. Hence, in a next step, we will investigate, if the image quality could be further improved, if the feature of interest location relative to the tracker is known.

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