A comparison of direct reconstruction algorithms in proton CT

Feriel Khellaf*[1], Nils Krah[2], J.-M. Létang[3], and Simon Rit†[4]

[1]CREATIS – Univ Lyon, INSA Lyon, Université Claude Bernard Lyon 1, UJM-Saint Etienne, CNRS : UMR5220, Inserm : UMR1206 – France

[2]CREATIS – CNRS – France

[3]Univ. Lyon, INSA-Lyon, Université Claude Bernard Lyon 1, UJM-Saint Etienne, CNRS, Inserm, CREATIS UMR 5220, U1206, F69621, VILLEURBANNE (CREATIS) – CNRS : UMR5220, Inserm – 7 Avenue Jean Capelle 69621 Villeurbanne, France

[4]CREATIS – Univ Lyon, INSA Lyon, Université Claude Bernard Lyon 1, UJM-Saint Etienne, CNRS : UMR5220, Inserm – France

Abstract

Several analytic algorithms have been proposed to incorporate the non-linear path of protons in the reconstruction of a proton CT (pCT) image. This paper presents a comparison between four direct algorithms used in pCT, in terms of spatial resolution and relative stopping power (RSP) accuracy. We have simulated a pCT set up which registers protons individually using Gate, a Monte Carlo simulation tool, with a 200 MeV proton source and two position, direction and energy detectors upstream and downstream from the object. A Catphan 528 phantom and a spiral phantom were imaged to take into account the spatial dependency of the spatial resolution. Each proton's trajectory was estimated using a most likely path (MLP) formalism. The spatial resolution was evaluated using the frequency corresponding to an MTF value of 10%, and the RSP accuracy as the mean value in a homogeneous region. Our results show that methods performing
the backprojection before the filtering offer a better spatial resolution (up to +36%) since each proton is directly binned in the image grid according to its MLP. However, this improvement is minor (+2%) at the center of the object, where the intrinsic uncertainty on the MLP estimate is dominant. Regarding the RSP accuracy, all algorithms but one show equivalent results.

*Corresponding author: feriel.khellaf@creatis.insa-lyon.fr

†Speaker