Analysis of Proton Images from a Prototype System

Ethan Dejongh*[1], Fritz Dejongh†[1], Victor Rykalin‡[1], Christina Sarosiek[2], Mark Pankuch[3], James Welsh[4], Nicholas Karonis[2], Caesar Ordonez[2], John Winans[2], Kirk Duffin[2], and George Coutrakon[2]

[1]ProtonVDA Inc – United States
[2]Northern Illinois University – United States
[3]Northwestern Medicine Chicago Proton Center – United States
[4]Loyola Stritch School of Medicine – United States

Abstract

Purpose: A research collaboration funded by the National Cancer Institute has developed a fully functional prototype proton imaging system that is designed to be simple, cost-effective, and suitable for practical use in clinical workflow. Using a low-intensity scanning pencil beam at the Northwestern Medicine Chicago Proton Center, we have acquired experimental images for both radiography and pCT. In this study, we will present these images and evaluate them using metrics such as WET accuracy and spatial resolution. Methods: Our system consists of tracking planes before and after the patient to track the positions of individual protons and a range detector to measure residual range. We employ Most Likely Path algorithms to determine proton paths through the patient and reconstruct images using both iterative and non-iterative algorithms. Our data acquisition system and reconstruction computer automatically process the data and can produce a radiograph within one minute after the beam turns on. For our experimental images, we used phantoms which contain material inserts with known proton RSP.

Results: Our radiographs of known materials showed good WET accuracy, with range errors < 1 mm. Our preliminary pCT images also showed RSP within 1% of the correct value. In addition, radiographs taken of a head phantom with several different materials inserted into a cavity demonstrated our system's ability to detect very small (_˜0.6 mm) changes in range. Radiographs taken of a line-pair phantom demonstrated spatial resolution better than 1 mm. Conclusion: Preliminary results of our prototype proton imaging system are encouraging. The combination of image sharpness and range sensitivity, as well as fast, automatic image reconstruction capability, suggests that proton radiography will be a powerful tool for pre-treatment range and alignment verification, and that proton tomography will provide accurate 3-D RSP maps for treatment planning.

*Speaker
†Corresponding author: fritz.dejongh@protonvda.com
‡Corresponding author: