Sparse dose painting based on a dual-pass kinetic-oxygen mapping of dynamic PET images.

Abstract:

Development of molecular imaging such as positron-emission tomography (PET) offers an opportunity to optimize radiotherapy treatment planning by conforming the dose distribution to physiological details within tumors, so called dose painting. Quantification of the acquired images and an efficient and practical dose prescription remain two key questions in this field. This paper proposes a novel framework to optimize the dose prescription based on dual-pass modeling of dynamic $^{18}$F-FMISO PET images. An optimization algorithm for sparse dose painting (SDP) is developed by minimizing a linear combination of two terms corresponding to the efficiency and total variation of the dose distribution with the constraint of a constant mean dose. Dose efficiency is defined using the linear-quadratic model. The radiosensitivity given by the oxygen tension is estimated using a dual-pass kinetic-oxygen mapping strategy. This is achieved by integrating a realistic $^{18}$F-FMISO PET imaging simulation model, which can simulate the distribution of oxygen and tracer under the same tumor microenvironment setting. The algorithm was compared with a typical dose painting by number (DPBN) method in one data set of a patient with head and neck cancer.