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Geometry of volumes in radiotherapy planning. A new method for a quantitative assessment

Stefano Tomatis[1], Mauro Carrara[1], Elisa Massafra[2], Giovanni Naldi[2], Mauro Palazzi[3], Ester Orlandi[4], and Renato Marchesini[5]

[1]Medical Physics Unit, Fondazione IRCCS Istituto Nazionale Tumori, Milan; [2]Department of Mathematics, University of Milan, Milan; [3]Radiotherapy Unit, Azienda Ospedaliera Ospedale Niguarda Ca' Granda, Milan; [4]Radiotherapy Unit, Fondazione IRCCS Istituto Nazionale Tumori, Milan; [5]Department of Physics, University of Milan, Milan, Italy

ABSTRACT

Aims and background. The purpose of the study was to develop a general method able to quantify the mutual disposition in the 3D space of critical organs with respect to the target when these structures are designed for a radiotherapy treatment plan. To that end, we introduce the "expansion intersection histogram", a function defined as the intersection between an organ at risk and the target volume, while the target is expanded in 3D.

Methods and study design. A software was developed to calculate the expansion intersection histogram of anatomical structures exported in a DICOM format from a commercial treatment planning system. A virtual phantom with spherical and cylindrical objects arranged in different dispositions in the 3D space was created for testing the software under known conditions.

Results and conclusions. Expansion intersection histogram computation was tested against reference data derived analytically for spherical volumes, with a resulting maximum error of 0.5%. Specific geometric features derived from the expansion intersection histogram, such as the distance between a selected target and each different ideal volume included in the virtual phantom, well matched the corresponding theoretical expected values. The expansion intersection histogram was evaluated also for the anatomical structures of a real patient. Data show this method as a tool to effectively take into account the mutual disposition of each critical organ with respect to the target, summarized in characteristics of distance, shape and orientation. The expansion intersection histogram method integrates and extends other preexisting modalities for evaluating the geometrical relationships among radiotherapy volumes and could be used to improve planning optimization.

Key words: geometrical features, quantification, radiotherapy volumes, treatment plan optimization.

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Correspondence to: Stefano Tomatis, Medical Physics Unit, Fondazione IRCCS Istituto Nazionale Tumori, Via Venezian 1, 20133, Milan, Italy.
Tel +39-02-2390-2192;
fax +39-02-2390-2124;
e-mail
stefano.tomatis@istitutotumori.mi.it

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