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Searching for most useful metrics in automatic comparison between radiotherapy treatment plans and high-definition 3D gel dosimetry images

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Radiotherapy works by killing tumor cells with radiation while sparing healthy cells, incl. organs at risk. Structures to be treated and to be avoided are distributed in a 3D space within a patient's body (a 3D, moving, deformable object). Tumor control and normal tissue complication probabilities are functions of several biologically-relevant variables, such as radiation dose (energy absorbed per unit mass), dose rate (dose per unit time), and linear energy transfer (average energy lost by ionizing particles per unit length of their track). Therefore, radiotherapy treatment planning involves a multidimensional problem. Verification of treatment delivery requires special dosimetry equipment with adequate sensitivity to those variables in a 3D space with adequate spatial resolution. Among many dosimetry systems, gel dosimetry is unique in its ability to generate accurate 3D data with millimeter spatial resolution. Gel dosimetry images are generated by transmission laser tomography (laser CT) or MRI scans of ,,treated" gel phantoms, i.e. tissue-equivalent patient-mimicking 3D objects where radiation triggers measurable material changes. Due to massive amount of data and high level or responsibility for treatment outcome, quantitative comparison of gel dosimetry data with an individual patient's treatment plan is normally a very time-consuming process, which is why this very promising approach has not yet been widely accepted in clinical practice. Any significant reduction of this time without sacrificing quality (or with improving it!) can improve outcomes by routinely detecting and correcting currently undetectable errors. This includes developing and establishing proper metrics in automatic comparison between treatment plans and 3D gel dosimetry images. The authors are inviting mathematicians to a scientifically exciting and clinically important collaborative effort in this direction.