Optimization of Optical Dosimetry in a Water Phantom by Exploiting Cherenkov Radiation Polarization Imaging

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Introduction: Cherenkov radiation occurs when a charged particle travels through a dielectric medium at a speed greater than that of light [1]. This phenomenon generates polarized light, which can be utilized to detect and quantify radiation dose distributions in medical applications such as radiotherapy [2]. By using Cherenkov light emitted from the irradiated medium, this promising method allows real-time assessment of dose distribution [3]. Building upon previous research [4, 5], this study aims to validate optical dosimetry methods in a water phantom through polarization of Cherenkov radiation while enhancing their precision and introducing a novel polarizer system.

Methods: Cherenkov emission is captured using a camera equipped with a charge-coupled device (CCD) image sensor during the irradiation of a water tank with dimensions of $15 \times 15 \times 20\,\mathrm{cm}^3$ by photon and electron beams of varying energies, namely 6 MV, 18 MV, 6 MeV, and 18 MeV. Analysis of Cherenkov radiation polarization is performed using a rotating linear polarizer and an innovative polarization modulator developed by PATQER Photonique. This approach allows extraction of the polarized component of the signal, the average polarization angle, and the non-polarized portion of the signal. Radiochromic films and data from a treatment planning system are used for reference.

Results: The measurements yield the normalized dose profile relative to the maximum irradiation dose (d_{max}) and the depth dose profiles (PDD) of the ionizing beam. These results confirm the feasibility and relevance of this approach for accurate real-time assessment of dose distribution in radiotherapy.

Conclusion: Further studies could explore the application of this dosimetric method in clinical scenarios, including evaluating the FLASH effect [2]. Moreover, a hybrid approach, combining the advantages of optical dosimetry with other dose measurement modalities, could be developed for comprehensive and precise dose distribution assessment in radiotherapy. These prospects pave the way for continuous improvement in treatment techniques and better personalization of cancer treatments for patients.

Références

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