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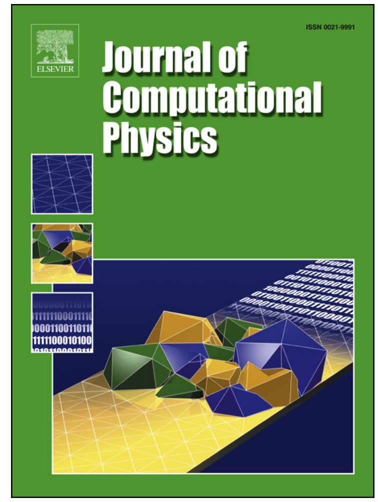

Impact of parametric uncertainty on estimation of the energy deposition into an irradiated brain tumor

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Impact of parametric uncertainty on estimation of the energy deposition into an irradiated brain tumor

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Abstract

Predictions of the total energy deposited into a brain tumor through X-ray irradiation are notoriously error-prone. We investigate how this predictive uncertainty is affected by uncertainty in both location of the region occupied by a dose-enhancing iodinated contrast agent and the agent's concentration. This is done within the probabilistic framework in which these uncertain parameters are modeled as random variables. We employ the stochastic collocation (SC) method to estimate statistical moments of the deposited energy in terms of statistical moments of the random inputs, and the global sensitivity analysis (GSA) to quantify the relative importance of uncertainty in these parameters on the overall predictive uncertainty. A nonlinear radiation-diffusion equation dramatically magnifies the coefficient of variation of the uncertain parameters, yielding a large coefficient of variation for the predicted energy deposition. This demonstrates that accurate prediction of the energy deposition requires a proper treatment of even small parametric uncertainty. Our analysis also reveals that SC outperforms standard Monte Carlo, but its relative efficiency decreases as the number of uncertain parameters increases from one to three. A robust GSA ameliorates this problem by reducing this number.

Keywords: brain tumor, radiation therapy, radiation diffusion, nonlinear diffusion, uncertainty quantification

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