

Purpose: Bioluminescence tomography (BLT) is a promising approach to guide focal irradiation of pre-palpable tumors in small animals, but is limited in resolution. In this study, we investigate the use of x-ray and diffuse optical tomography to provide spatial and optical information about the object to improve BLT reconstruction.

Methods: In a 3-step approach, x-ray CBCT is used first to provide the anatomic spatial information about the object. Secondly, photons of different wavelengths are transmitted through the object for detection by a CCD camera. The optical properties of the anatomic regions are then found by solutions of the diffuse optical tomography problem. In the final step, the anatomic and optical “priors” are employed in BLT reconstruction, where optical filters are used again to extract the multi-spectral information required to derive the position and power of the internal source. The approach was tested in an experimental setup where a 1.5 mm diameter (dia) optical fiber light source was inserted at 5 different lateral positions in a 12 mm dia optical heterogeneity within a 25 mm dia cylindrical tissue-mimicking phantom. The reconstructed positions and powers were compared with the known inputs.

Results: The average error in locating the source centroid was 0.13 mm, range 0.3 mm to 0 mm. The average error in source power estimations was 9%, range 14% to -1%. The results are an improvement over commercial systems that typically have an average localization uncertainty of 1 mm and error in power estimation of more than 20%.

Conclusions: The spatial and spectral prior information provided by x-ray CT and diffuse optical tomography improves the accuracy of BLT. Integrated x-ray/BL tomographic capability on board new small animal radiation research systems can contribute significantly to accurate biological targeting in realistic animal models.

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