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(G*) (POS-47) Navigating Radioguided Cancer Surgery Using Principles of Gamma Photon Interactions

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Breast cancer is the leading cause of cancer in women worldwide and surgery to remove the tumour and stage the cancer is a crucial component of most treatment plans. Radioguided surgery using a hand-held gamma probe that counts gamma photons is a common technique that allows surgeons to locate non-palpable, radiolabeled lesions in the operating room. While gamma probes are effective for detection of low-energy radiotracers, increased scattering at higher energies degrades the probe's resolution and limits the use of high-energy radiotracers, such as positron emitters. Understanding the physics of photon interactions and their influence on the shape of a detected gamma-ray energy spectrum, we hypothesized that a machine learning model could analyze the energy spectrum recorded by a gamma probe and predict the location from which the gamma photons originated. As such, the goal of the study was to assess how well machine learning improves a gamma probe's ability to localize high-energy radiotracers.

Using Monte Carlo simulations, we modeled a custom designed multifocal gamma probe featuring a 4-segmented collimator and detector. To simulate surgery, a 511 keV radioactive point source was embedded 35 mm below the probe in phantom breast tissue. The source was positioned at various known x, y locations and a 4-channel energy spectrum was recorded. Simulations were repeated 300 times, and the data was split using an 80:20 ratio for training and testing. A 1D convolutional neural network (CNN) was trained to analyze the recorded energy spectra and predict the x, y location of the radioactive source.

The CNN was able to effectively predict the location of the radioactive source from a 4-channel energy spectrum of a multifocal gamma probe. As desired, there was a strong linear relationship (R² = 0.93) between the true and predicted coordinate locations. The CNN had a small mean prediction error of 2.9 mm and could predict the location of the radioactive source over a large 40x40 mm field of view. The CNN predictions improved the resolution of the multifocal gamma probe by at least 10-fold compared to existing gamma probes. Overall, this work presents a new, real-time localization technique that offers higher resolution and more efficient directional guidance for detecting high-energy radiotracers with a hand-held gamma probe in surgery.

Keyword-1

radioguided surgery

Keyword-2

machine learning

Keyword-3

gamma detector

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