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Toward Reconstruction-Free PET: Progress in Direct Positron Emission Imaging (dPEI)

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Three-dimensional biomedical imaging techniques, such as X-ray computed tomography (CT), single-photon emission computed tomography (SPECT), and positron emission tomography (PET), acquire one- or two-dimensional projections of the object of interest. These projections are subsequently reconstructed into cross-sectional or volumetric images using analytic computed tomography algorithms. In all these modalities, each measured data point does not correspond directly to a specific point in image space; instead, the spatial distribution of the signal must be inferred through a reconstruction process. Furthermore, accurate tomographic reconstruction requires adequate angular sampling of the data. Positron-emitting radiotracers used in PET have the unique property of producing a pair of 511-keV annihilation photons that travel in opposite directions after each radioactive decay. This property allows for the possibility of obtaining cross-sectional or volumetric images of the radiotracer distribution directly, by measuring the difference in arrival times of the two photons—without the need for an image reconstruction step. The first demonstration of this reconstruction-free approach, referred to as direct positron emission imaging (dPEI), was accomplished using two gamma-ray detectors with ultrahigh timing resolution in combination with convolutional neural networks. By eliminating the constraints imposed by conventional tomographic sampling, dPEI creates new opportunities for innovative imaging system designs. This presentation will focus on the current progress and technological roadmap for developing dPEI scanner systems.

Workshop topics

Applications

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