Improving Positron Emission Tomography Imaging Using Normalized, Corrected Inter-Detector Scatter Data
Technology #15769-16136

Applications
This technology is an apparatus, method, and calculation that increases the sensitivity of Positron Emission Tomography (PET) scanners by isolating and correcting inter-detector scatter (IDS) events. This invention improves PET image quality and can be applied in preclinical and clinical settings to perform functions such as the detection of solid tumors.

Problem Addressed
Positron Emission Tomography (PET) scans are frequently used in the early detection of solid tumors, as well as for evaluating heart disease and multiple neurological disorders. In PET, the patient is administered a radioactive tracer that accumulates in metabolically active tissues, such as tumors. The radioactive tracer emits photons which are detected by the scanner. Specifically, PET scanners are optimized to detect double coincidences, which occur when two photons emitted from the same annihilation event encounter opposite block detectors within a specific coincidence time window. Double coincidences provide valid, meaningful information.

Scattered coincidences are also detected by the PET scanner and produce distorted information that decreases the sensitivity of PET scanners. Scatter coincidences occur when at least one of the emitted photons undergoes scattering and loses a fraction of its total energy before its detection, and the event is then detected by a pair of detectors that are non-collinear with the originating annihilation. Current methods for correcting inter-detector scatter (IDS) coincidence data involve sorting a given IDS coincidence event to the appropriate line-of-response (LOR) by determining the most likely order of detection of an IDS coincidence from the initial annihilation event. The sorted IDS coincidence data set and double coincidence data set are then merged and normalized solely based on information from the double-coincidence data set. However, this approach produces artifacts in resulting PET images, thereby reducing the sensitivity of the scanner in preclinical and clinical applications.

Increasing the sensitivity of PET systems could reduce scan time and reduce the amount of radioactive compound injected to the patient to obtain similar quality images. This invention corrects and normalizes IDS information to generate more accurate PET images.

Technology
This technology is a strategy to improve PET scanner sensitivity by normalizing and correcting sorted IDS events. The correction calculation, determined during a calibration step, can then be applied to a coincidence data set generated by the scanner to yield meaningful coincidence information.

In calibration, a radiation source is uniformly exposed to all detector pairs in a PET scanner. Double coincidences and IDS coincidences are acquired until enough measurements have been collected to achieve statistical significance in both data sets. IDS events are then sorted and represented, for
example, in an LOR histogram. The number of IDS events sorted to a particular LOR is then divided by the average number of IDS events for all of the LORs in the scanner to calculate IDS normalization values for each LOR. In contrast to other normalization methods, which only generate normalization value for double coincidences, this method provides a second set of normalization values for IDS events. During the PET scan, sets of double coincidences and IDS coincidences are collected and stored as separate LOR histogram. The corresponding normalization (from calibration) will be applied independently to each data set. After correction, the data sets are added together to provide normalized information for accurate image reconstruction.

**Advantages**

- Utilizes IDS events, which are usually discarded because they produce noise in PET images, to improve PET scanner sensitivity and image quality
- Appropriately corrects and normalizes double coincidences and IDS coincidences generated by a PET scanner
- Improves sensitivity of PET scans by up to 20%, which will improve diagnostics and reduce the amount of radioactive tracer required
- Inexpensive to implement because technology only requires a software modification to the PET scanner

**Categories For This Invention:**

Life Sciences  
Clinical Applications  
Oncology  
Diagnostics  
Imaging  
X-ray, CT, PET

**Intellectual Property:**

Normalization correction for multiple-detection enhanced emission tomography  
Issued US Patent

Inter-detector scatter enhanced emission tomography  
Issued US Patent

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**Publications:**

Simulation of Triple Coincidences in PET  
Phys Med Biol
Recovery and Normalization of Triple Coincidences in PET
Medical Physics
2015 Mar;42(3):1398

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Research Laboratory of Electronics
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