Optimized List-Mode Acquisition and Data Processing Procedures for ACS2 Based PET Systems

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I. Introduction

COMMONLY used PET systems like the ECAT Exact HR$^+$ PET scanner offer very limited data access methods [1]. Especially for list-mode acquisitions, where typically several gigabyte of data is produced, the hardware and software limitations of the underlying acquisition control system (ACS2) represent a severe obstacle to the utilization of potential advantages of event-based acquisition. The maximum data transfer rate in which the system can access the raw acquisition data, leads to long time delays of up to several hours until the final image reconstruction can be applied. As a result, the image data is often available only the next day, thus representing an unacceptable delay for clinical PET. Therefore, to fully utilize potential advantages of list-mode based methods, e.g. an event-driven movement correction [2], more advanced data access methods are required.

In our study we analyze, if additional hardware and software methods allow for an access to and processing of acquisition data in real-time. In addition, we will emphasize the necessity of well developed list-mode acquisition support and give suggestions for future PET scanner designs as even newer PET generations suffer from similar limitations.

II. Methods

A. Shared Data Access Method

The ACS2 uses a standard SCSI-2 hard disk for storing the raw acquisition data and allows to transfer data to other systems with a throughput of $\approx$ 0.5 MB/s only. We replaced the internal hard disk with an external dual-channel SCSI-RAID system and connected one channel to the ACS2 and the second to a separate Linux system. To access the data from the Linux system, we reverse-engineered the filesystem used by the ACS2 and developed an own implementation for the Linux operating system.

B. External DAQ-based Access Method

The raw coincidence data during a PET acquisition is routed through externally accessible data cables in the ACS2 system. This data bus consists of 32 channels and connects all main acquisition components of the ACS2 while carrying the typical list-mode data stream. To allow for an external sampling of the coincidence data, we developed a hardware adapter card. This adapter allows to sample the acquisition data via optoelectronic couplers from the data bus without imposing any risk to the standard components of the PET gantry. We connected the adapter to the external bus of the ACS2 as well as to digital acquisition cards (DAQ) installed in a Linux system. Several software components were developed for sampling the list-mode data from the bus and to distribute it in real-time to other processing workstations.

III. Results

After having verified method *A* under routine conditions, we were able to observe a 140$\times$ speed up ($\approx$ 70 MB/s). The data can be immediately transfered off the ACS2 storage after an acquisition, rather than having to wait until all critical PET operations are finished.

Due to the direct data sampling from the hardware bus, method *B* shows that an access in real-time to the raw coincidence data is possible even during a running acquisition. To verify the operation of method *B*, we constantly increased the amount of local radioactivity in several test acquisitions until we reached the maximum allowed count-rate of the ACS2. Even under high load, the drop-out rate for unregistered coincidences, due to hardware limitations in the DAQ cards, were below 0.1%, thus is applicable for clinical PET.

IV. Conclusions

The presented methods speed up the access to raw acquisition data considerably. They address long-term limitations of ACS2 based PET systems and allow to integrate list-mode acquisition into clinical PET.

Method *A* allows to immediately transfer all acquisition data with a high throughput to other workstations. This reliefs the ACS2 and also speeds up the processing of normal histogram data, thus improves also standard PET invesigations. Moreover, by implementing method *B*, event-driven processing methods can be applied during a running acquisition.

Our methods and their application do not only practically improve the flexibility of PET facilities. They also show that an integration of list-mode in clinical PET is feasible, relavtively inexpensive, and offers significant advantages.

References

[1] Langner, J.; Bühler, P.; Just, U.; Pötzsch, C.; Will, E.; van den Hoff, J. *Optimized List-Mode Acquisition and Data Processing Procedures for ACS2 Based PET Systems*, Z. Med. Phys. **16** (2006) 75-82

[2] Bühler, P.; Just, U.; Will, E.; Kotzerke, J., van den Hoff, J. *An Accurate Method for Correction of Head Movement in PET*, IEEE Trans. Med. Imag., vol.23, no.9, pp. 1176-1185, 2004.