

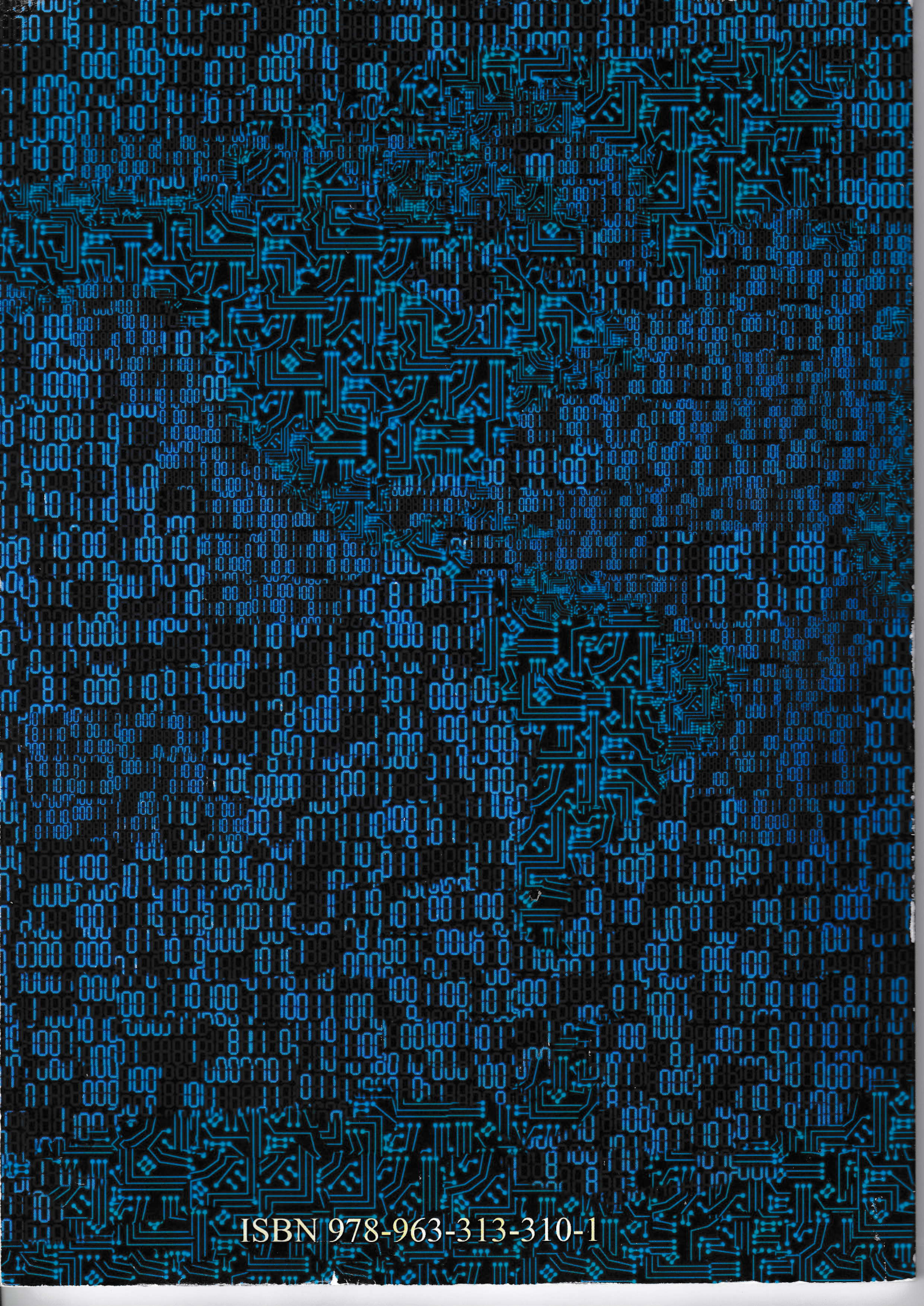
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Preface

Lectori salutem! You are reading the proceedings of the *Fourth Workshop on the Advances of Information Technology* (WAIT 2019), which is organized as an annual conference by the *Department of Control Engineering and Information Technology (IIT)* of the *Budapest University of Technology and Economics (BME)*. The focus fields of the conference cover the classical fields of research of this institution, including control engineering and robotics, image processing, machine vision, computer graphics, medical imaging, software technology, and hardware synthesis, with special emphasis on emerging new technologies, like virtual reality and deep learning.

The cover image is designed by Tamás Umenhoffer and rendered by his texture synthesis program. László Szécsi took the responsibility of preparing the proceedings for printing, and supervised the process.

Budapest, January 19, 2019.

Bálint Kiss and László Szirmay-Kalos
WAIT 2019 chairmen

Motion Compensation on the GPU for Emission Tomography

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Abstract

The self-motion of the examined patient often cannot be avoided during tomography, which may destroy the examination. Thus, the motion should be measured and this information should be incorporated into the reconstruction process. It would be possible to decompose the measurement time into small intervals, called frames, and consider each frame as a static reconstruction with frame dependent position and orientation of the object. However, higher speed motions, which occur when studying neurological disorders like epilepsy, require very high number of frames, which leads to unacceptable reconstruction times proportional to the number of frames. To attack this problem, we re-formulate the classical Maximum Likelihood Expectation Maximization (ML-EM) scheme to incorporate continuous motion during the frames that are defined according to the tracer dynamics. We conclude that inside frames we should apply 3D motion blur, which needs to be executed before forward projection and during back projection once for the numerator and once for the denominator. For the efficient implementation of the 3D motion blur, the paths of object-space voxels are approximated by polylines and anti-aliasing line drawing methods are adopted to efficiently calculate the blurred result. The 3D motion blur is executed on the GPU exploiting the trilinear interpolators of its texturing units. Having executed the continuous motion blur on the voxel array before the forward projection and during the back projection, all other components of the simulation can be reused from a dynamic reconstruction system developed without motion compensation.

1. Introduction

In dynamic Positron Emission Tomography (PET), we analyze the accumulation and emptying of drugs in organs^{10,9,10}. Direct dynamic tomography algorithms usually iterate two steps, first an ML-EM⁶ static forward and back projection are executed for each frame, then the parameters of a time function of pre-defined algebraic form are fit in each of the voxels¹⁴. Thus, the number of projections is proportional to the number of frames, which should be kept under control to avoid prohibiting reconstruction times and memory requirements.

The self-motion of the examined patient often cannot be avoided, e.g. when studying neurological disorders like epilepsy, thus the motion should be measured and taken into account during the reconstruction process⁴. Accurate reconstruction requires projections that simulate all relevant phenomena, including positron range, gamma-photon scattering and absorption both in the measured object and in detector crystals, etc., which are all affected by the motion of the body. Classic forward and back projections should be executed for the transformed data of each frame if we can as-

sume that inside a frame, the subject movement is negligible, i.e. the motion is slow. However, this is usually not the case when neurological disorders are examined, object motion has much quicker dynamics than the tracer diffusion. Gated approaches^{12,3} keep hits close to discrete time samples to solve the problem of motion inside the frame, but they ignore significant information and thus less reliable for low statistics or low dose experiments.

The other option is to re-bin the list-mode data and find another event list that would be measured if the subject did not move, and execute a conventional reconstruction for the modified sinogram^{5,1,2}. This implements a general idea of compensating certain effects by transforming the measured data to show what the measured data would be if this effect had not been happened. Such measured data, also called sinogram filtering techniques are simple to implement and efficient, but cannot be applied for effects happening in the detectors. They either add noise or result in filtered measured data that are not of Poisson distribution, and suffer from the missing or lost data problem. To illustrate this missing data problem, let us follow an event on a pair of detec-