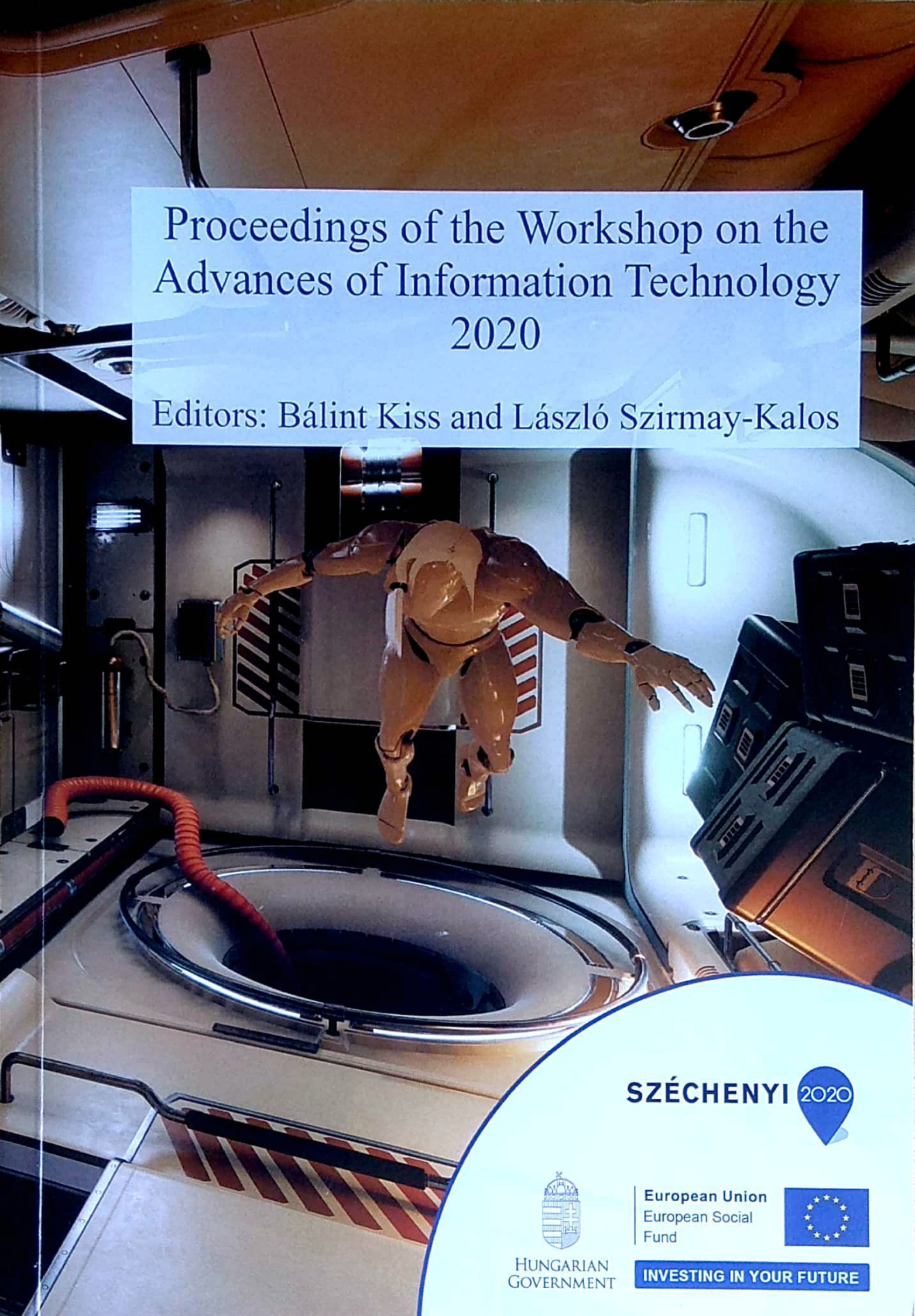


Proceedings of the Workshop on the Advances of Information Technology 2020

Editors: Bálint Kiss and László Szirmay-Kalos



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The image shows the interior of a confined space, likely a spacecraft or submarine. On the left is a large, curved metallic door with two horizontal handles. To the right, there are rows of storage bins. The upper row consists of smaller, brownish-tan bins with square openings. Below these are larger, cream-colored bins with dark brown handles. Black cables are bundled and run vertically along the side of the larger bins. The ceiling is curved and metallic, with a circular light fixture visible. The overall lighting is somewhat dim, with a blueish tint on the left side.

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Preface

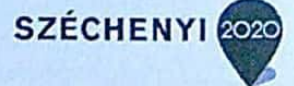
This book is the proceedings of the *Fifth Workshop on the Advances of Information Technology* (WAIT 2020), which is organized as an annual conference by the *Department of Control Engineering and Information Technology (IIT)* of the *Budapest University of Technology and Economics (BME)*. The presented papers of the conference cover the fields of research of this institution, including autonomous and assisted driving, robotics, computer graphics and virtual reality, medical imaging, embedded systems, and hardware synthesis, with special emphasis on emerging newer technologies, like deep learning.

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The cover image was rendered by Máté Hagyák. László Szécsi prepared the proceedings for printing.

Budapest, January 31, 2020.

Bálint Kiss and László Szirmay-Kalos
WAIT 2020 chairmen



Guided Filtering and Partial Volume Correction for Positron Emission Tomography

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Abstract

Positron emission tomography (PET) is a nuclear medicine imaging technique that is used to observe tissue metabolism by reconstructing the spatial distribution of the injected radioactive tracer. Due to constraints on the time and the radiation dose of the examination as well as limited scanner sensitivity, PET images usually suffer from a high level of noise. This paper focuses on the application of the guided filter for PET image denoising. After proposing several different guidance images, guided filter variants are compared with the median, the Gaussian and the bilateral filter in terms of image quality and speed. For dynamic PET reconstructions, a new approach, the parametric filtering is conceived, in which filtering is performed on the parameters of the kinetic model describing the radiotracer concentration. Finally, an efficient, guided-filter-based partial volume correction (PVC) method is proposed to restore accurate activity values that are blurred due to the partial volume effect.

Categories and Subject Descriptors (according to ACM CCS): I.4.3 [Image Processing and Computer Vision]: Filtering

1. Introduction

Positron emission tomography (PET) reconstructs the spatial distribution of the radiotracer injected into the patient. The tracer gets absorbed by tissues in proportion to their metabolic rate, therefore regions with fast metabolism such as the brain, the heart or malignant tumors appear bright in the image.

During reconstruction, the measured volume is divided into a 3D grid of homogeneous voxels. The task is to determine the amount of radiotracer in each of the voxels based on the emission detected by the tomograph. This is accomplished by the maximum-likelihood expectation-maximization (ML-EM) iterative procedure [13], which alternates forward projections and back projections to find the voxel activities that have the highest probability to have generated the measured data.

There are two types of PET reconstruction, static and dynamic. With a static reconstruction, the goal is to visualize a single snapshot of the patient's body, whereas dynamic reconstructions focus on monitoring biochemical changes taking place in the body, such as the progression of a disease or the absorption of a certain drug in the organs.

In dynamic PET, the space-time dependence of the tracer concentration is reconstructed. The measurement time is divided into independent time frames. Radiotracer concentration is described by a kinetic model of a predefined algebraic form that assigns a parameter vector to each voxel. The goal of the reconstruction is to calculate these parameter vectors [16, 19]. In this paper, the two-tissue compartment model [20] and the spectral model [18] are examined.

1.1. Previous work

PET images generally suffer from high noise due to constraints on the time and the radiation dose of the examination as well as limited scanner sensitivity, which can result in misdiagnosis. Noise can be suppressed by introducing a regularization term into the target function of the ML-EM optimization [10], but defining the right parameters is challenging because their optimal values depend greatly on the measured data and the reconstruction settings. Also, if the regularization term is not convex, optimizing the modified target function becomes difficult [22]. Alternatively, noise can be reduced by early stopping [5] or by filtering [6, 10]. In case of early stopping, the signal has not yet converged to