Biomedical Signal Processing and Control 46 (2018) 131–144

Contents lists available at ScienceDirect

Biomedical Signal Processing and Control

journal homepage: www.elsevier.com/locate/bspc

Review

Post-reconstruction-based partial volume correction methods: A comprehensive review

Hajer Jomaa[a,*], Rostom Mabrouk[b], Nawres Khlifa[a]

[a] *Laboratoire de Biophysique et Technologies Médicales, Université de Tunis El Manar, Tunis, Tunisia*
[b] *Brain Research Centre, University of British Columbia, Vancouver, Canada*

ARTICLE INFO

Article history:
Received 23 December 2017
Received in revised form 1 May 2018
Accepted 28 May 2018

Keywords:
Positron emission tomography
Partial volume effects
Partial volume correction

ABSTRACT

The vital role of positron emission tomography (PET) image is to provide an accurate quantitative information. Nevertheless, the partial volume effect (PVE) can easily alter the quantification. This effect is a consequence of the limited spatial resolution in PET which is due to the non-collinear and/or inherently random photon. For several years, great effort has been devoted to study the partial volume correction (PVC) and improve the quality of the image. At first stage, only PET modality was used and then, further study of the issue involved anatomic information from high resolution modalities in the correction process. Clearly, this regularization using segmentation, correlation and the registration step between the two modalities enhanced the performance of these techniques. These methods can be, mostly, divided into two main approaches: reconstruction-based methods and a post-reconstruction-based methods. In this paper the focus of attention was to present the most used post-reconstruction PVC methods developed in the literature. We will introduce the principal of each method, its extension and their applications in different domains.

Contents

1. Introduction

PET is a nuclear medical imaging which can provide quantitative measures of physiological processes. The principle of PET is based on the detection of two simultaneous gamma photons resulting from the annihilation events. The two gamma photons emitted during annihilation are detected by the PET scanner through a set

* Corresponding author.
E-mail address: jomaahajer@gmail.com (H. Jomaa).

https://doi.org/10.1016/j.bspc.2018.05.029

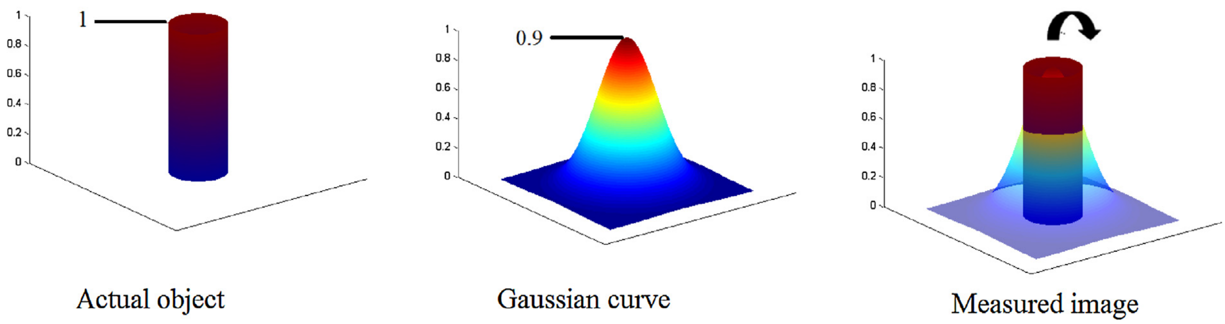

Fig. 1. Limited spatial resolution in PET images caused a reduction in measured image.

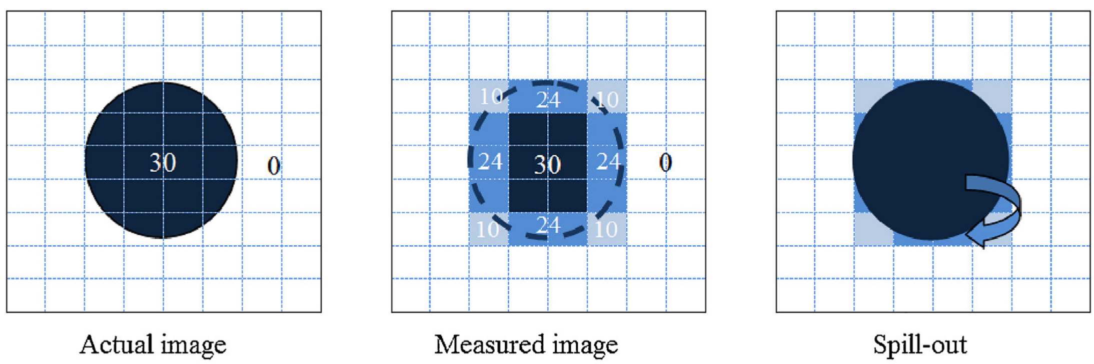

Fig. 2. The effect of spill-out on the measured mage.

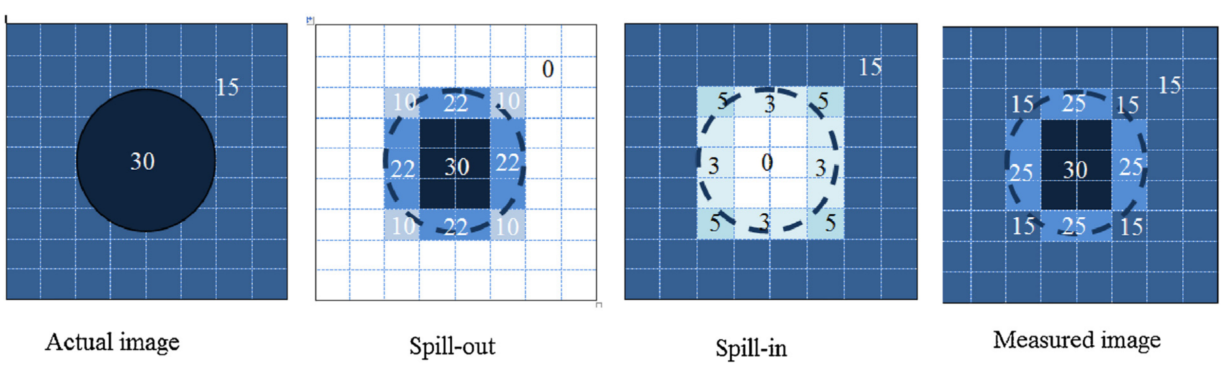

Fig. 3. The result of spill-in and spill-out of a measured image.

of detectors arranged in a ring around the target organ. The PET scanner detects the true annihilation events, but also can detect non-collinear or inherently random photons. These two false events are considered as physical limitations that affect the spatial resolution of PET. As a consequence of these physical limitations and the scanning system impact, the true concentration issued from a target is cross-contaminated with the vicinity regions. This effect so-called the partial volume effect (PVE) leads to an impairment of both spatial location and signal magnitude as represented in Fig. 1. In a deeper sense, the higher activity concentration of some regions misattributed to the adjacent regions of lower radioactivity (spill-out effect) and simultaneously radioactivity of surrounding regions scatters on the target creating hence a blur (spill-in effect) [1]. The Spill-out effect causes an underestimation of the tracer activity in the related region and the spill-in, however, appears when the region of interest (ROI) has a lower radioactivity concentration than the surrounding regions. The target region hence comprises extra-activity which causes an overestimation of the ROI concentration. Figs. 2 and 3 illustrate these effects in the measured image. The activity's spread around the small structures is described by a physical low known as point-spread function (PSF) of the system which illustrates the degree of spillover between the different regions [2–4]. This function represents the spatial distribution of the intensity in the imaging system, formed from an object source point. The principle is to realize a series of measures using source points placed in a few positions in order to measure how well the scanner can distinguish between two small objects placed closely together. To model the PSF function, it is frequently approximated by a 3-dimensional Gaussian function with full-width at half-maximum (FWHM) depending on the position. A common correction technique used a PSF was previously tested for correcting the PVE. Indeed, the early intuitively methods developed to overcome this issues were based on the mono-modality PET where a deconvolution framework [5,6][7,8] and a simple recovery coefficients [2,9] were employed to recover the true activity of the different tissue structure. Another category of correction techniques used high resolution anatomic images from the magnetic resonance imaging (MRI) or the computed tomography (CT) imaging to provide a priori information of the tissue of interest. These methods have gained popularity in the last few years and have been appearing in many