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Hybrid *Vision-Fusion* system for whole-body scintigraphy

Marko Barjaktarović [a,*], Milica M. Janković [b], Marija Jeremić [b], Milovan Matović [b,c]

[a] University of Belgrade - School of Electrical Engineering, Belgrade, Bulevar Kralja Aleksandra 73, 11000, Belgrade, Serbia
[b] Clinical Center Kragujevac, Center of Nuclear Medicine, Kragujevac, Zmaj Jovina 30, 34000 Kragujevac, Serbia
[c] Faculty of Medical Sciences, University of Kragujevac, Serbia, Svetozara Markovića 69, 34000 Kragujevac, Serbia

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ABSTRACT

Radioiodine therapy in the treatment of differentiated thyroid carcinoma (DTC) is used in clinical practice for the ablation of thyroid residues and/or destruction of tumour tissue. Whole-body scintigraphy for visualization of the spatial 131I distribution performed by a gamma camera (GC) is a standard procedure in DTC patients after application of radioiodine therapy. A common problem is the precise topographic localization of regions where radioiodine is accumulated even in SPECT imaging. SPECT/CT can provide precise topographic localization of regions where radioiodine is accumulated, but it is often unavailable, especially in developing countries because of the high price of the equipment. In this paper, we present a *Vision-Fusion* system as an affordable solution for 1) acquiring an optical whole-body image during routine whole-body scintigraphy and 2) fusing gamma and optical images (also available for the auto-contour mode of GC). The estimated prediction error for image registration is 1.84 mm. The validity of fusing was tested by performing simultaneous optical and scintigraphy image acquisition of the bar phantom. The fusion result shows that the fusing process has a slight influence and is lower than the spatial resolution of GC (mean value $\pm$ standard deviation: 1.24 ± 0.22 mm). The *Vision-Fusion* system was used for radioiodine post-therapeutic treatment, and 17 patients were followed (11 women and 6 men, with an average age of 48.18 ± 13.27 years). Visual inspection showed no misregistration. Based on our first clinical experience, we noticed that the *Vision-Fusion* system could be very useful for improving the diagnostic possibility of whole-body scintigraphy after radioiodine therapy. Additionally, the proposed *Vision-Fusion* software can be used as an upgrade for any GC to improve localizations of thyroid/tumour tissue.

1. Introduction

Radioiodine therapy in the treatment of differentiated thyroid carcinoma has been in clinical practice for almost 70 years [1,2] with the aim of ablation of thyroid residues and/or destruction of tumour tissue. For the postoperative ablation of thyroid residues in the thyroid lodge, the activity of the 131I in a range of 1.11–3.7 GBq (30–100 mCi) is commonly used, whereas greater activity of 131I ranging from 5.55 to 7.4 GBq (150–200 mCi) is applied for the treatment of local or distant metastases. In some cases, lower or higher activities than those listed are also applied [3,4].

Generally, the recommended activities depend on the estimated risk, radioiodine uptake in the thyroid/tumour tissue, and the volume of thyroid rest or tumour tissue [5–8].

After applying radioiodine therapy, the patient must be isolated in a premise specially designed for radionuclide therapy because the radioactivity in his/her body does not fall to the level that is determined by the appropriate legal regulation. In Serbia, a patient can be released from the hospital if the remaining radioactivity in their body is below 400 MBq [9]. The hospitalization period usually lasts 3–5 days. The scintigraphic visualization of the spatial 131I distribution is performed by a scintillation camera and is a mandatory and standard procedure before releasing the patient from the hospital [5,6,10]. Scintigraphy is usually conducted in the whole-body mode, and if necessary, the image acquisition of chosen regions is conducted in the static mode.

A common problem is the precise topographic localization of regions where radioiodine is accumulated, whether it is a thyroid rest in a thyroid lodge or pathological accumulation of radioiodine in the rest/recurrence of the tumour or regions of its metastatic spread. The basic question is where the iodavide tissue is located: in which or near which the anatomical structure is placed. This problem is more pronounced if the volume of the iodide tissue is greater and its radioiodine binding is more

* Corresponding author. University of Belgrade - School of Electrical Engineering, Belgrade, Serbia, Bulevar kralja Aleksandra 73, 11000, Belgrade, Serbia.
E-mail addresses: mbarjaktarovic@etf.bg.ac.rs (M. Barjaktarović), piperski@etf.bg.ac.rs (M.M. Janković), marijafiz@yahoo.com (M. Jeremić), mmatovic@medf.kg.ac.rs (M. Matović).

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intensive when it is practically impossible to perform precise topographic localization of such regions (Fig. 1).

A more precise localization of thyroid/tumour tissue can be achieved using SPECT modality for image acquisition, although difficulties can sometimes arise in practice due to the problems with the rotation of detectors, which contain a high weight of a high energy collimator (necessary for detection of 364 keV 131I photons). Even better results can be achieved using the SPECT/CT acquisition modality, but it is often unavailable, especially in developing countries because of the high price of the equipment (based on the results from the Nuclear Medicine Database project (NUMDAB), International Atomic Energy Agency, Vienna, Austria) and only 17% of gamma cameras are SPECT/CT. Better results could be expected by simultaneous image acquisition of the same regions in the gamma and some other parts of the electromagnetic spectrum and by overlapping the images obtained from multiple modalities. Other authors have obtained a more accurate detection of tumour tissue (although in other tumour locales) using multimodal fluorescence imaging (Near Infrared Fluorescence Imaging, NIRF) [11,12]. However, these studies were mainly performed on patients with ovarian cancer or on animals.

Simultaneous recording of scintigraphic and optical images in patients is not a familiar method. Two publications by Lees and co-authors [13,14] describe small, specially constructed handheld multimodal devices for intraoperative imaging in the gamma and visible part of the electromagnetic spectrum. However, in the papers that have been published, we did not find articles regarding the usage of bimodal imaging in the gamma and optical spectrum during whole-body imaging by a gamma camera (GC). We decided to perform whole-body image acquisition for the same geometry both in the gamma and in the visible part of the spectrum. We developed a low-cost *Vision-Fusion* system for simultaneous web-camera image acquisition with routine scintigraphic whole-body acquisition including the algorithm for image fusion of both

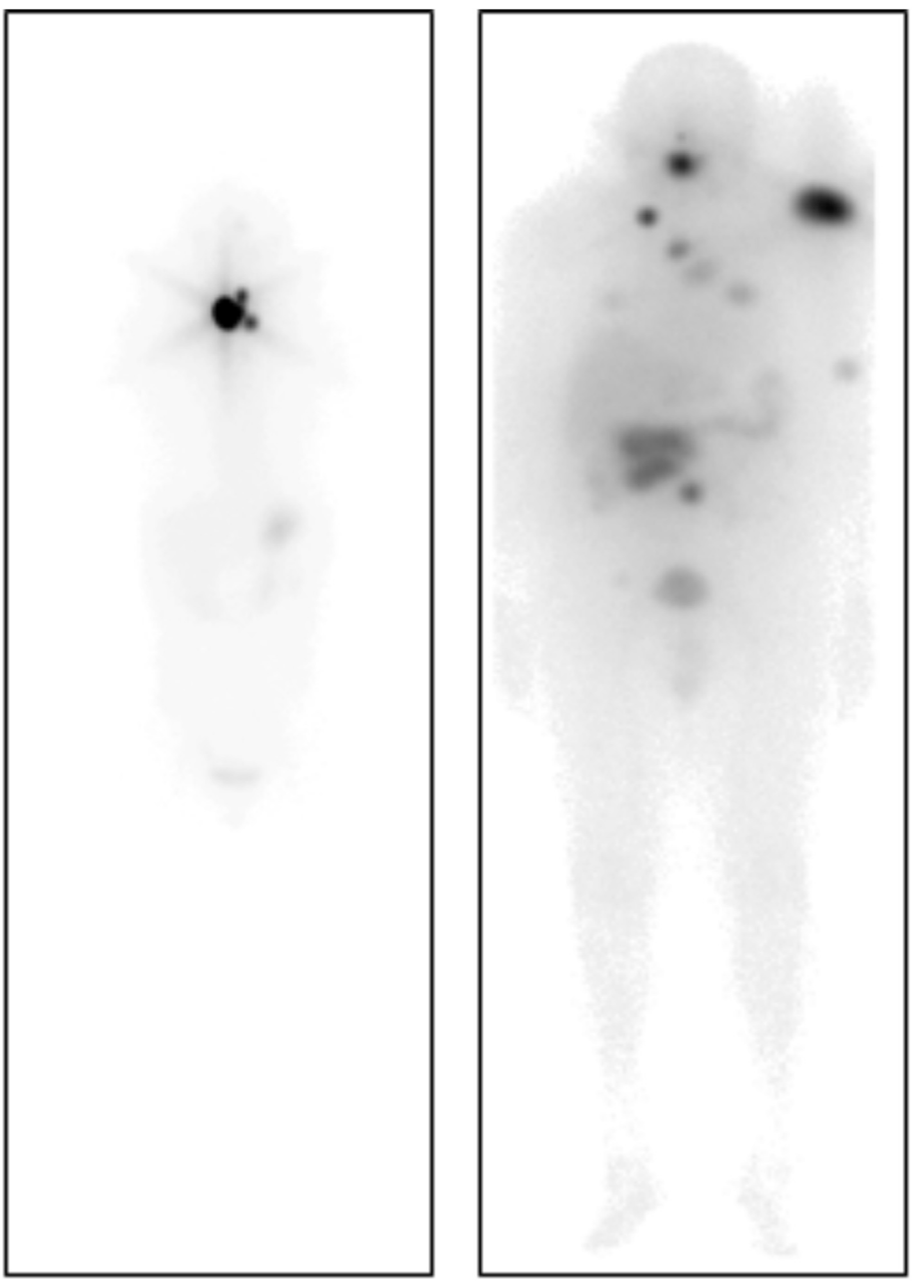

Fig. 1. A patient with large thyroid rest (left) and a patient with metastatic disease from papillary thyroid carcinoma (right).