Medical Image Processing
Useful Tool in Cancer Diagnosis

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Abstract: - An accurate diagnosis, nowadays, supposes sophisticated procedures to corroborate outstanding medical techniques, in the patient interest. This is due to the fact that different physical phenomena are giving different anatomical or physiological relevant details. Nuclear medicine, nuclear magnetic resonance or noninvasive microwave procedures are giving different aspects that are completing each other, more than superposing. The problem to find a reliable, repeatable, reference, using artificial intelligence procedures, applied in biomedical imaging. Our attempt is to make an aggregated decision based on information obtained by different methods of medical imaging. These gathered data come to form a whole amount of details, meant to precisely establish, in a record time, the diagnosis. A high-quality image and a fine, interactive interpretation, in a semi-automatic, human-assisted, procedure, obviously might save lives reinforcing an early cancer diagnosis. While nuclear medicine is an invasive investigation technique, microwave body emission registration is a completely non-invasive technique, meant to be used as often as necessary, in order to detect the evolution of a certain (surveyed) inflammatory process, previously detected by using the scintigraphy results.

Key-Words: - nuclear medicine, weighted decision, medical image processing, cancer detection, non-invasive procedures.

1 Introduction

The nuclear medicine imaging techniques - scintigraphy, highlights the degree of normal/or abnormal physiological body functioning of certain organs, researched using specific molecules, radioactive tracers, able to be up-taken by the target organs. Specifically, certain organs in the body, after the vein radioactive tracers injection (radionuclides or radioisotopes), accumulates them inside the tissues.
Therefore, these tracers contain radionuclides, or atoms that emit energy through radioactive decay to attain a more stable state. Although radioactive decay may occur in one of several forms, the type detected in nuclear medicine is gamma ray emission, which is sensed by a gamma scintillation camera and is expressed as an intensity of radiation called a count. Once an adequate sample of counts is obtained, this information is relayed to a computer that generates a corresponding image [1]. The respective radioactive tracer helps to make the tissues visible on the scanning pictures.
Each type of tissue that may be scanned (including bones, organs, glands, and blood vessels) uses a different radioactive compound as a tracer.
The radiotracer remains in the body temporarily and the radioactivity usually diminishes in 6 hours.
In whole body scintigraphy as well as in brain image made by nuclear medicine, diagnosis is connected with the symmetrical uptake of the radio-tracers.
Thus, there are some diagnoses (for example in rheumatic affections, or when characterizing brain normal functioning) that suppose that radio-tracer uptake symmetry has to be observed.

2 Principle of Scintigraphy Method

The principle of the scintigraphy method is briefly illustrated in the following diagram, for the case of thyroid scintigraphy, using $^{99m-}$Tc, each organ having its special dedicated uptake products.

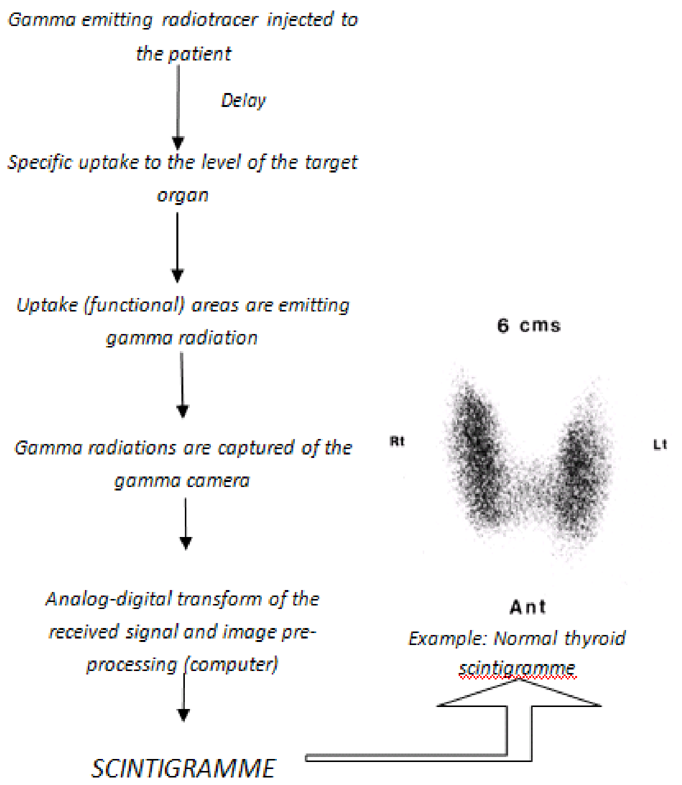

Fig. 1. Principle of the radioisotopes images

In Fig. 1. the black points show the regions with a low nuclear radiotracer uptake, while the bright ones show the maximum uptake. Due to the thyroid organ form, the normal image is usually similar to the presented display. The physician fine estimation is a subjective expert approximation, generally valuable due to the great number of years and cases experienced.

3 Bone Scintigraphy

Bone scintigraphy is usually obtained by the same prototype mechanism described before, injecting ^{99m}Tc methylene diphosphonate, ^{99m}TcMDP, in order to obtain a relevant bone image. A bone scan is a nuclear scanning test that identifies new areas of bone growth or breakdown [2]÷[6]. It can be done to evaluate damage to the bones, detect cancer that has spread (metastasized) to the bones, and monitor conditions that can affect the bones (including infection and trauma).

A bone scan can often detect a problem, days to months earlier than a regular X-ray test. For a bone scan, a radioactive tracer substance, injected into a vein in the arm, travels through the bloodstream and into the bones. Areas that absorb little or no amount of tracer appear as dark or "cold" spots, which may indicate a lack of blood supply to the bone (bone infarction) or the presence of certain types of cancer.

Areas of rapid bone growth or repair absorb increased amounts of the tracer and show up as bright or "hot" spots in the pictures.

Hot spots may indicate the presence of a tumor, a fracture, or an infection.

A bone scan may be done on the entire body or just a part of it being particular relevant to:

(a) Determine whether a cancer from another area, such as the breast, lung, kidney, thyroid gland or prostate gland has spread (metastasized) to the bone;

(b) Help diagnose the cause or location of unexplained bone pain, such as ongoing low back pain. A bone scan may be done initially to help determine the location of an abnormal bone in complex bone structures such as the foot or the spine. Follow-up evaluation then may be done with a computed tomography (CT) scan, magnetic resonance imaging (MRI), or, *our proposal here, noninvasive, measuring the bone microwave radiation, detecting its amount variations in time.*

(c) Help diagnose broken bones, such as a hip fracture or a stress fracture, not clearly seen on X-ray.

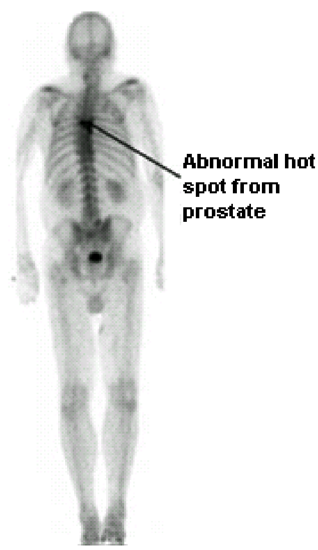

Fig. 2. Abnormal (cancer detected) bone scan.

Fig. 2. illustrates the bone scan showing the spread of prostate cancer to the spine.

It is proven that using a single method the tumors size might be under or super estimate.

For example, in comparative studies, it is shown that (generally, in living bodies) the use of radiographic evaluation alone could result in underestimation of the extent of a primary bone tumor, with risk of incomplete resection, while bone scan images tend to overestimate tumor length and, therefore, may provide safer resection guidelines [2], [4].

The initial bone scintigramme is transformed by pre-processing stages [7], [8],that suppose histogram reinforcement, segmentation, and special computing,

successively enhancement, in order to obtain the best gray levels image [9], [11].
It is useful to formulate rules for diagnose estimation, scaling the uncertainty degree in an attempt of managing heterogeneous information in decision making due to the fact that two or three nuclear medicine physicians might be asked to give an opinion on the same case, followed in time, and the surgery or the medical interventions done are registered in order to verify the given opinions.

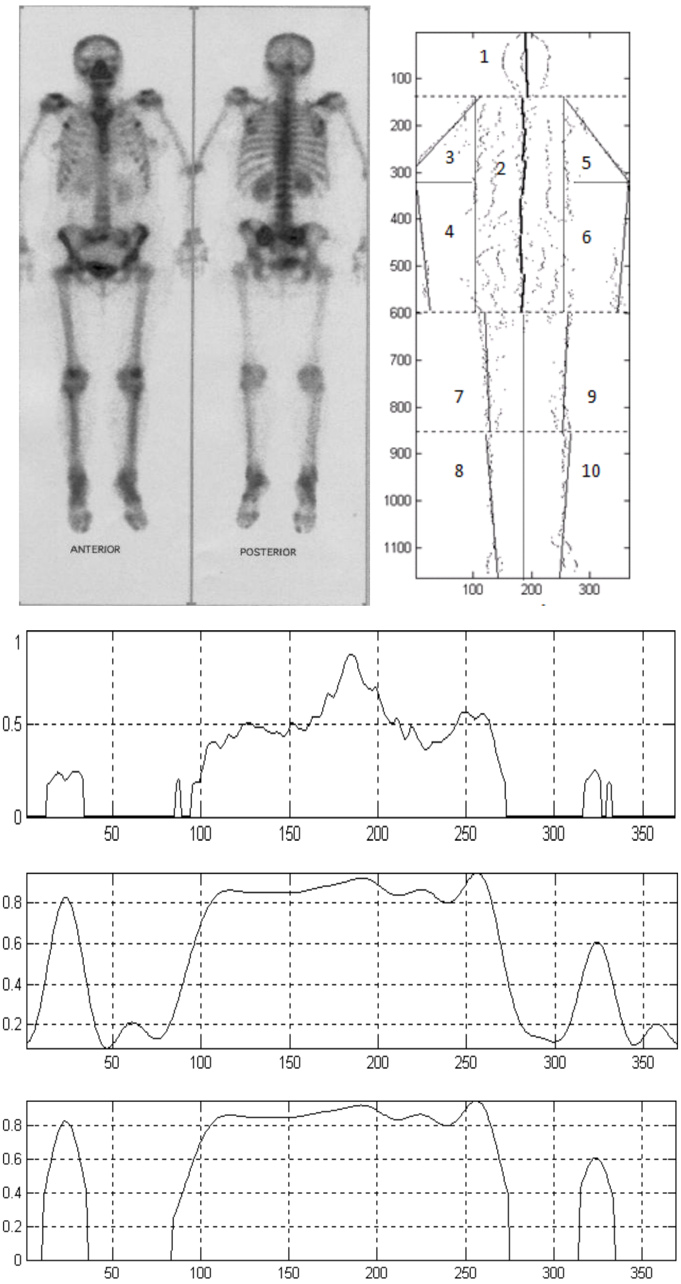

Fig. 3. Pre-processed bone-scan image, segmentation, intensity detection in sectioned areas: different lines intersecting the body image

In fact the physician opinions are often slightly different. Herrera in IPMU 2002 [11] is proposing an interesting method of managing heterogeneous information.

Bone metastasis detection usually presents in terms of likelihood related to the number of pathological uptake sites of the radiotracer [2]÷[4].
Both in the evident hyper-fixation or hypo-fixation cases, the sites diagnosis is a simple task for the physician, But, when the pathological uptake degree raise *slightly relative to the normal,* or when there is only an *uptake heterogeneity of the radiotracer* in an area where normally the uptake has to be homogenous, the diagnosis establishment may become a real problem depending both on the expert eye sensibility and on the physician experience. These very refined particularities are difficult to implement in computer-assisted diagnoses, too. This implies a tremendous responsibility as the physician has to decide in a vital paradigm if the uncertain areas are incipient metastasis lesions:

- the correct classification would permit the institution of early radio and/or chemo-therapy treatment, with evident positive effects on the metastasis disease prognosis;
- ignoring them causes loose of a very important time in therapy [3], [4].

The situation becomes doubtful when such radiotracer uptake areas are relatively numerous, without existing patent pathological uptake sites; the physician is unfortunately facing the dilemma: “bone metastasis or not?”.
An accurate automatic counting, evaluation of the doubtful pathologic areas could be a solution in such a case, reporting them to the normal range, uptake regions [9], [10]. Fig. 3. is highlighting the differences in intensity on left versus right side, along with the body scan in up-down detailed analyze.

4 Bone microwaves radiometry

Digital infrared imaging has already well-proved to be the frontline of early breast cancer detection.
As an extension microwave emission body detection [12]÷[15], might constitute a method of abnormal activity tissue detection.
By this non-invasive method it is possible to monitor the evolution of a malignant process at very short time intervals, in an incipient stage. Images with microwaves obtained for abnormal areas evolution detection are distribution maps of electrical properties in tissues [12].
One of microwave image application is represented by hyperthermia, which indicate a change in electrical properties of interest tissue depending on tissue warmth.
The main advantage of using microwaves is to avoid ionization radiation, using instead a faster and cheaper method.
To detect microwave radiation we use a microwave receiver low-noise converter (LNC) in 10-12 GHz band,

for wavelengths of 3 cm, thus being able to give information about tissue, up 3 cm depth.
The own noise is less than 0.2 dB. Each stage of the installation is generating noise which contribute on the whole noise fitting. Therefore, the installation output contains both its own noise and the thermic noise received by antenna. Choosing of the operation frequencies depends on the intensity of electromagnetic whose resolution scales up with the frequencies augmentation. A suggestive diagram of microwave and infrared waves distributions [12], [13], comparing their wave intensities reported to wavelengths (black body radiation) is presented in Fig. 4.

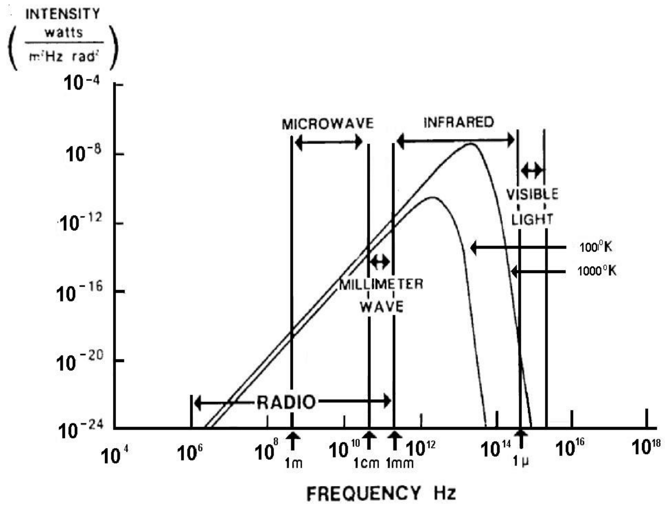

Fig. 4. Black body radiation

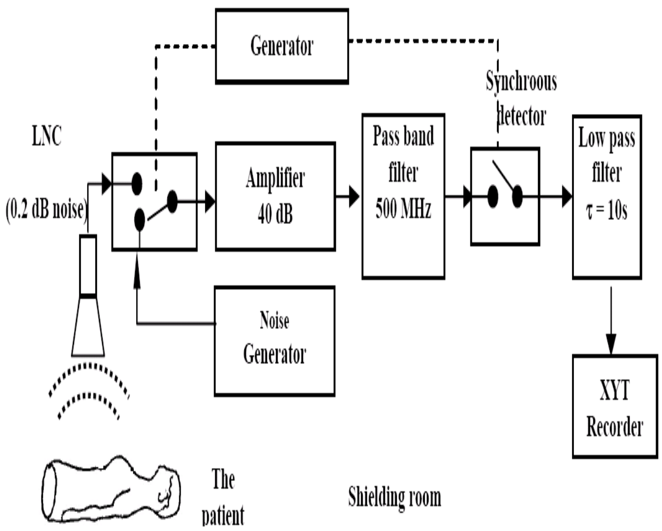

Fig. 5. Radiometer in an experimental approach

Fig. 5. presents the block schema of the radiometer [12]. To measure the differences of temperature, the radiometer antenna is positioned upon the studied area. The temperature differences are of maximum 2.5^0C.

An important problem constitutes the spatial positioning of the 3D malignant area detected, in a virtual reconstruction and this will be treated with the results of a further research.

5 Symmetry estimation

Sometimes diagnoses are based on the symmetrical proprieties of the radioisotopes fixation in bones, brain, or other parts of the body. In order to estimate such subtle aspects, fuzzy systems [9], [10] intricate with a technique of handling heterogeneous information in weighted decision are really helpful tools.

6 Decision Reinforcement by a Second Noninvasive Method

Usually, in medical practice, the final stage is the biopsy, which is invasive and traumatizing but is not ambiguous, being a clear, incontestable, diagnosis method.
We propose to use a second noninvasive detection stage that will enhance massively the certitude on the supposed diagnoses. Therefore, two methods have to reinforce each other results sustaining the diagnosis.

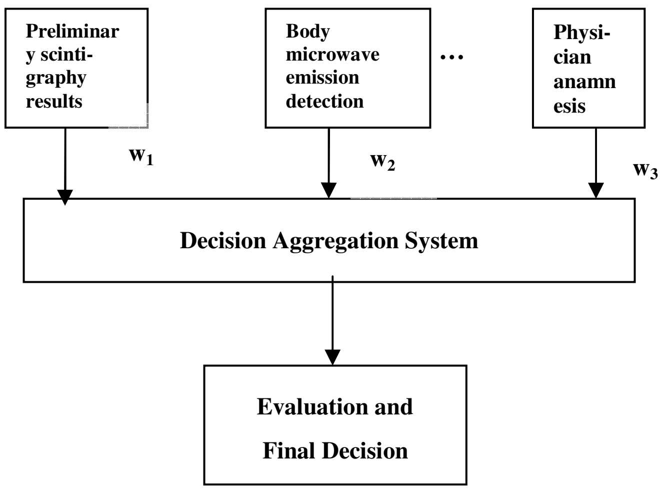

Fig. 6. Decision system based on multi-criteria aggregation

As a result, the certainty of the final decision is greater, even before the biopsy examination. This leads us to an uncertainty corroborate method of data aggregation [11]. In order top manage this, in a decision system dedicated to cancer diagnosis, a rule-base and an inference are accomplished.
The general schema proposed here is meant to reinforce the recognition coefficient obtained by particular methods, on malignant area positioning.

Multi-criteria aggregation systems use a number of modules, with different confidences (weights, wi).

7 Results concerning bone metastases distributions

Bone scintigraphy is very relevant on incipient metastasis detection(see Table 1, Fig. 7). Our method propose a non-invasive radiometric measuring technique for bone microwave radiation detection, in a constant following manner, on a precise survey timing of the abnormal, pathologic or healing process evolution.

Bone region		Metastases Multiple (%)	Metastases Solitaire (%)	Metastases distribution region (%) - total
Cranium		46 (4.52)	32 (3.15)	7.67
RACHIS	cervical	60 (5.9)	-	5.9
	dorsal	170 (16.72)	18 (1.77)	18.49
	lumbar	143 (14.06)	14 (1.37)	15.43
Ribs – stern		124 (12.2)	64 (6.3)	18.5
Clavicle – homoplat		60 (5.9)	-	5.9
Humerus		32 (3.14)	9 (0.9)	4.04
Pelvis		166 (16.32)	-	16.32
Femur		78 (7.67)	-	7.67

Table 1.
Results concerning bone metastases distributions

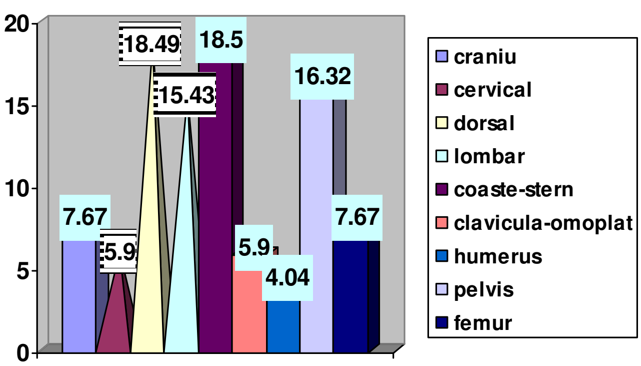

Fig. 7. Results concerning bone metastases distributions obtained on the surveyed lot of patients

8 Aggregation in the Decision System

Situated in the context of the belief functions we realize a weighted aggregation [16]÷[20].

The universe of discourse or the domain of reference (also named frame of discernment), on which evidences induce some beliefs is constituted of a number of areas, initial surfaces supposed to be abnormal: Si, i=1,...N.

It is induced a priori evidence on so-called focal elements on which our belief is focalized in order to group them. The different modules exposed give the "experts" different opinions on detected areas. If an aberrant result is obtained, then the conflict has to be managed (re-evaluation on the basis of more criteria).

The importance of each "expert module" is different.

A total mass of belief is calculated for each detected speaker according to the Dempster's rules [17]: "In the belief and plausibility models each time one of the functions m (mass), bel (belief), pl (plausibility) or q (communality function), is introduced. The declaration of one of them automatically implies the others".

There are two critical and related issues concerning the combination of evidence obtained from multiple sources: one is the type of evidence involved and the other is how to handle conflicting evidence. We usually have to consider four types of evidence from multiple sources that impact the choice of how information is to be combined: *consonant evidence, consistent evidence, arbitrary evidence, and disjoint evidence*

Consonant evidence is obtained from multiple sources (mass of belief successively included). Consonant evidence represents the situation where each set is supported by the next larger set and implies an agreement on the smallest evidential set; however, there is conflict between the additional evidence that the larger set represents in relation to the smaller set.

Consistent evidence results from multiple sensors (only one mass of belief is common) and it implies an agreement on at least one evidential set or element.

Arbitrary evidence is obtained from multiple sensors (there is some agreement between some sources but there is no consensus among sources on any one element).

Disjoint evidence is also obtained from multiple sensors but has no common points and all of the sources supply conflicting evidence.

Each of these possible structures of evidence rules from multiple sources has different implications on the level of conflict associated with the situation.

Given two belief functions bel1 and bel2 induced by two distinct pieces of evidence on the event A, the belief function bel12 that results from their combination is obtained by Dempster's rules of combination [16]÷[20]. and expressed with communality functions they become:

$$q_{12}(A) = q_1(A) q_2(A) \quad (1)$$

In the previous relation, the communality function is a function q : Ω -> [0,1], such that, for two events A and B we have:

$$q(A) = \sum_{B \to \neg A} m(A \vee B) \quad (2)$$

We stated that in medical decision, hierarchical structuring of the information, according to the weighted expert's opinion on the malignant area positioning is a very useful tool.

9 Conclusion

Non-invasive methods in cancer diagnosis are presenting incontestable advantages. The wave length we are using The microwave range, very subtle to be detected, raise problems of real spatial malignant tissue positioning. The results obtained in contouring the coordinates of a suspected malignant region are compulsory to be compared with the results given by another parallel method, the two methods reinforcing each other, and influencing the expert's opinion on the diagnosis.
The research is continuing due to the very complex aspects implied.

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