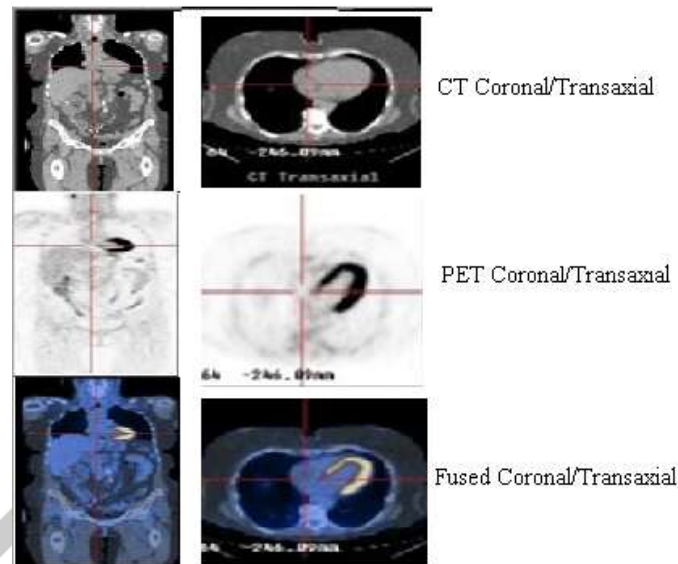# Review article on Clinical diagnosis of various cancer patients   using PET / CT fusion Imaging techniques

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Aim: To review the applications of different techniques applied to PET, CT and integrated PET/CT modality resulting in good quality image.

Materials and methods: This paper represents different techniques, methodologies, algorithms that are introduced, developed, applied, tested and published in various Journals, books, articles of engineering, technology, medicine, medical, nuclear medicine, and radiology departments by various research scholars. These methods include neural networks, segmentation techniques, reconstruction techniques and wavelet transforms methods.

Results: These methods and algorithms results in quality image resolution, brightness contrast and remove different types of noises as well as artifacts.

Conclusion: The resulting fused images which are processed by different algorithms and filtering techniques helps e physician and radiologist to diagnose the cancer/tumor staging, restaging and treatment monitoring of whole patient's body.

Review article

Clinical diagnosis of various cancer patients using PET / CT fusion Imaging techniques

Purpose: This article presents the results of evaluation of fused PET/CT images and individual PET, CT images of different malingnated parts of human body using MATLAB and various image processing techniques.

Abstract: Many types of cancers begin because of out of control growth of abnormal body cells and it is named for the site where it get started and spread. Growing rate of these cells is different and they are diagnosed as well as treated differently. Positron Emission Tomography (PET-Radio tracer) and Computed Tomography (CT) are two different diagnostic modalities in which PET provides, functional and physiological computer generated images obtained from a detection of photon annihilated radionuclide ^{18}F-FDG(Fluro deoxy glucose- radioactive tracer)i.e. Distributed in tissues, decays in the body to release positrons whereas CT provides morphological, anatomical information that uses X-ray beam which helps in deterring site with extent of malignancies. Thus combined PET/CT modality provides metabolic functions and anatomical functions in single detection of whole body. This paper describes various image processing application techniques that are introduced and developed to minimize artifacts and enhance the required feathers for correct diagnosing which will help the radiologist as well as the physician to decide the way of treatment with medications for curing cancer patients.

Keywords: FDG, radiation, fusion, biopsy

Introduction

^{18}F-FDG radionuclide PET/CT modality is increasingly used for staging, restaging and medication monitoring for head and neck cancers, lung cancer, breast cancers, colorectal cancers, urogential cancers, gastrointestinal cancers, lymphoma and unknown primary cancers. Reconstruction of image takes place after the acquisition of CT modality before PET acquisition which provides overlaying of high resolution anatomical image with functional images .This results in precise localization of hyper metabolic activated tissue region. In order to improve microscopic lesion delectability different filtering techniques, algorithms, extractions, neural network techniques are applied which results in image reconstruction with removal of blurring, artifacts and different noises. This paper represents 4 different sections which gives review of such a methodologies of past, present and possible future role for the same.

Section I-Neural Network Applications

In 1996, Cheng derived a parallel and unsupervised approach with the use of Hopfield neural network (CHNN) incorporating the winner takes all (WTA) learning mechanism for medical image segmentation based upon the global information of the gray levels distribution. [1]

While In 1997, Ahmed and Farag experimented performance of SOFM (self-organizing feature map) with Hopfield network and ISODATA algorithm for segmenting PET/CT volume and found that accuracy of SOFM is superior to that of Hopfield network and ISODATA algorithm. [2]

Figure a and b shows the results of the application of our volume segmentation technique to a 256×256×50 image volume. Colors in the segmented images refer to regions in the brain.
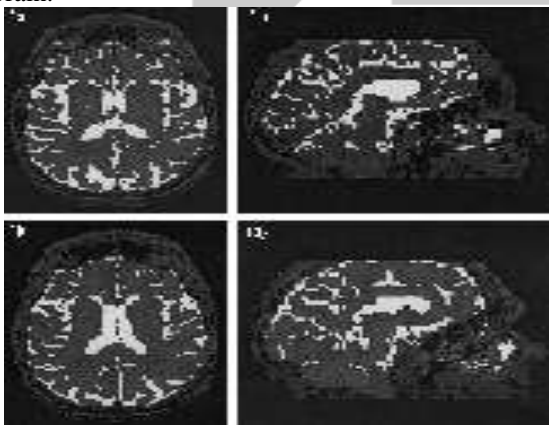

Fig.1a. Coronal   b. lateral segmented sections of brain images by SOFM algorithm.

In 2002, M.Petersen reviewed more than 200 applications of neural networks in which he discussed image reconstruction, restoration, enhancement techniques with its applicability in preprocessing, data reduction, feature extraction and image compressions. He concluded that ANNs are usable in image processing as nonparametric classifiers, nonlinear regressions functions and unsupervised feature extraction. S.M. Kmruzzaman in 2004, with his coauthors developed a modified feed forward NN constructive algorithm for medical diagnosis which starts with minimal number of hidden layers; additional units are added to it at a time to improve accuracy of the network. It results that after successful training the system is able to diagnose the unknown cases with predictions.[4]. In 2012, K. Khart proposed two approaches for brain tumor detection based on ANN which were categorized into back projection NN and feed forward NN.
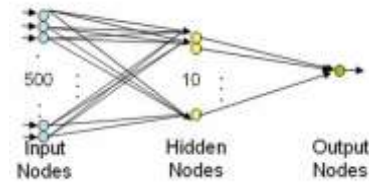

Fig. Feed forward neural network

This helped him for discriminating malignant tumors from benign ones assistant decision making in clinical diagnosis. [5]

Section II- Reconstruction Techniques

In 1998, K.Erlandsson developed a 3D reconstruction method based on back projection and filtering (BPF) technique (ATRAX) which makes a combination of analytic and algebraic techniques resulting in improved resolutions and contrast recovery. In 2003, Tobias presented a projection based approach for noise suppression in projection reconstruction in which the filter can directly be applied after the acquisition of each projection. The filter algorithm was implemented on an ADSP-21060 DSP which allows real time processing. It results in speed optimizing adaptation. [6]. In 2012, Prabhat P. developed a user friendly GUI using MATLAB and JAWA AWT to compare the performance of various filters like Hann, cosine, Shepp-Logan and concluded that Hann filter gives superior performance for select images as compared to all.

Section-III-Segmentation Techniques

In 2008, Yong Xia applied a fuzzy clustering of spatial patterns algorithm(FCSP) to the PET/CT image with 3 steps, first is contrast stretching, second is delineating CSF from other structures and third by differentiating gray from white matter and proved that the incorporation of the anatomical information improves the performance of brain image segmentation.[11]

Fig.2 (a).PET image image

Fig.2 (b)CT stretched
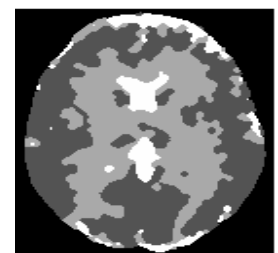

Fig.2(c).SPM-Seg algorithm

Fig.2(d).FCSP-Seg

Algorithm
While T. Logeswari in 2010, described segmentation method using Hierarchical self-organizing map (Hsom) which classifies the image row by row.[13]

Section IV-Wavelet Transform
Wavelet transform theory plays important role especially in multiscale analysis. Its representation provides directional information in the high-low, low-high and high-high bands. In 2005, A.Ben Hamza calculated a biological wavelet transform of each source image and divergence based fusion algorithm is developed to construct composite wavelet coefficients. He successfully tested this new technique on fusion of multisensory, multi focus, multi spectral images.
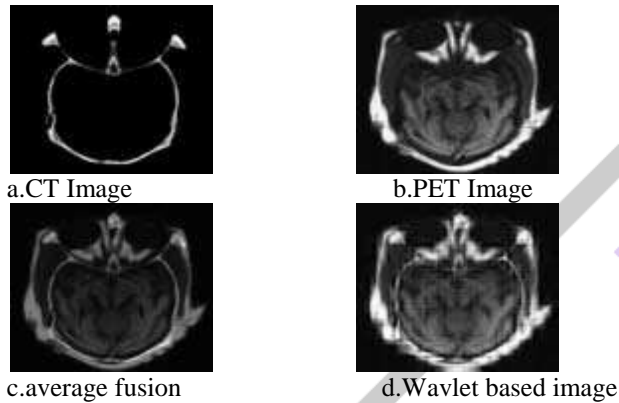

a.CT Image   b.PET Image

c.average fusion   d.Wavlet based image
Fig.3 Wavelet based trasformations

While Bahareh Shalchain in 2009,showed that the approximation image produced a better than that of the original PET and CT images by fusing PET and CT images using wavelet transform with Ma.-Min, Min-Min, Max-Mean combinations.[10].

Section V-Application areas of cancers
In 2006, Gustav k.studied the use of integrated PET/CT and discussed given applications.
Once the PET/CT image data is obtained malignant lesions identified by PET are marked and framed in the CT's anatomic references. These imaging studies are categorized under different body regions and are concluded as follows:

1. Assess the treatment response to chemotherapy
2. Diagnose extra thoracic metastasis
3. Establish mediastinal lymph node involvement
4. Document the extent of plural disease
5. Evaluate tumor extraction into lung and thoracic walls
Some of application areas and the review of their processing techniques are categorized as:

a. Role of PET/CT in abdominal tumors
This modality helps in detection as well as evaluation of intrahepatic tumor load ,extra and
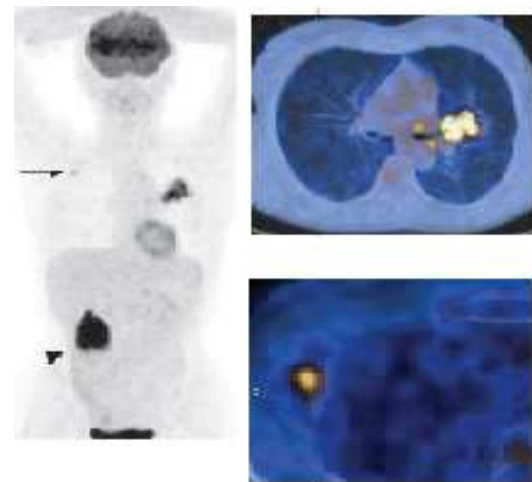
a.coronal PET   b.PET & PET/CT
Fig.4 Lung Canrcinoma
intrahepatic metastasis and local recurrence of the colorectal site .

b.Blood Lymphoma
PET/CT scan helps to diagnose the swlleon lymph node contains Hodgkins Disease and also the status of treatment.Also these scans helps to pointout the correct place of the lymphoma.

c. Breast cancer
In 2007 Eric L.Rosen found that for primary detection and diagnosis of breast cancer PET/CT provides information of distant site monitoring and staging of loco regional with the rate of the response to therapy. And also for evaluation of asymptomatic treated breast cancer patients with rise in the level of tumor markers without clinical symptoms PDG PET/CT may be helpful
As figure(a/b) shows the sigaittal and coronal fusion imaged of patients breast carcinoma which indicates that the sensitivity of PET/CT is superior to that CT in detecting nodal diseases meditational nodal basins. . [15].
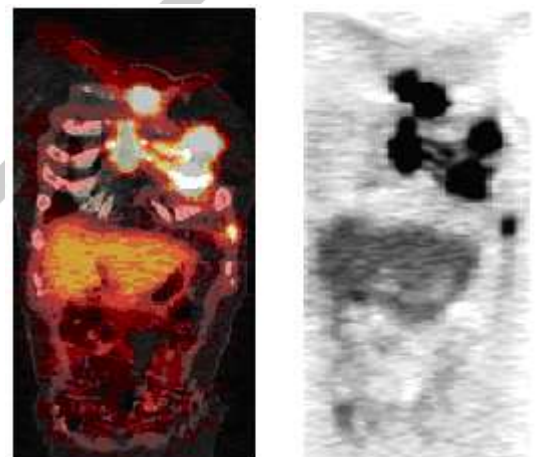
a.sigaittal fusion   b. coronal fusion
Fig.5Breast carcinoma

PET/CT is useful as it provides staging status as well as CT data can be used for radiation planning before and after the treatment. Pet has effective for decision making process prior to radiation therapy and treatment changes occur in around 25 of patients and it is found out by Gustav K. in 2006.[17].Thus PET/Ct imaging provides molecular

information about a tumor in addition to morphological information to decide planning.

Fig.6 c. mamograph of   d.PET/CT of focal uptake in
left breast   left breast

Fig.6 Results of PET/CT in a patient suspected of having breast carcinoma

While in 2007,Sang Kyu Yang found that a potential advantage of PET/CT is to evaluate small lesions that are up taken ,may be artificially lowered due to partial volume effect of PET as areas of mild hyperglycolytic action is assigned to normal or abnormal anatomical structures.[16]

d. Radiation Therapy

Cancers are treated by high dose of irradiation which precisely targets the entire tumor with minimization of radiation damage to normal tissues. With respect to radiation therapy
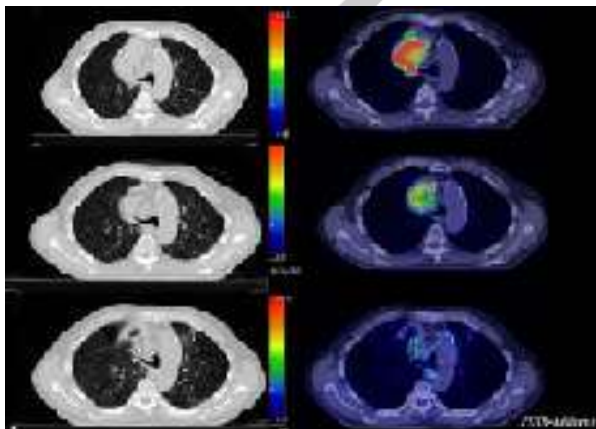

Fig.7 FDG PET/CT images

Figure.7 shows the study of FDG PET/CT that performed before the radiation treatment and after the end of ration treatment of 3 months with dose of FDG. [18]

e. Biopsy applications

PET/CT supported biopsy of abdominal cavities with use of previously acquired fused images registered is feasible. In 2010 Servet Tatil and his colleagues experimented on fused images which are converted in DICOM (Digital Imaging and Communications in Medicine) format. An image of most FDG avid portion of image was chosen and matching image from separate PET as well as CT scans was selected. The interventional radiologists who performed this biopsy procedure review the registered images and the biopsy procedure was planned**.**

The biopsy results were decided with a specified diagnosis as positive if malignant cells were present or negative if malignant cells were absent. These results were verified by means of a follow up PET/CT procedure. [8]
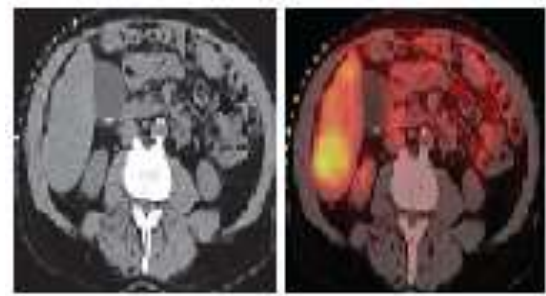
a. xial CT   b. mass with radiation
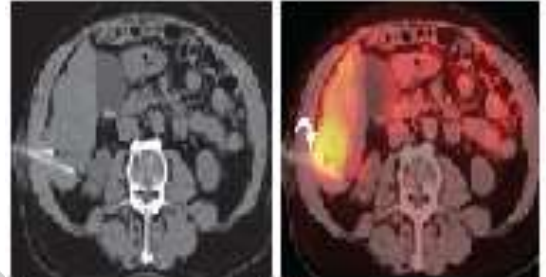
c.Axial CT   d. shows tip of one
needle   in the most metabolically active portion of the mass

Fig.8 Biopsy revealed metastatic breast cancer

Conclusion

This paper reviews the cilinal diagnosis using PET /CT imaging modality in case of head and neck or breast or ,lung,or cardiac including all types of tumors it provides anatomical, physiological as well as molecular real time information which helps a physicision to diagnose the stages and to plann the way of treatment with correct medication. This images are processed to have high resolution and high sensitivity by using different reconstruction, filtering and neural network algorithms.

References

1.Cheng, Kuo-Sheng. "The application of competitive Hopfield neural network to medical image segmentation." (IEEE Transactions on Medical Imaging) Vol.15 (August 1996): 560-566.

2.N.Ahmed, Mohamed,Aly A. Farag. "Two stage neural network for volume segmentation of medical images." Pattern Recognition Vol-18 (1997): 1144-1151.

3.M.Egmont-Petersen, D.de Ridder,H.Handels. "Image processing with neural networks-a review." Pattern Recognition,Elsevier Vol -35 (2002): 2279-2297.

4.S.M.Kamruzzaman, Ahmed Ryadh Hasan,Abu Bakar Siddiqee and Md.Ehsanul. "Medical Diagnosis using neural network." 3rd International Conference on Electrical & Computer Engineering. Bangeladesh, Dec 2004. 537-540.

5.M.B.Nagori, Kailash D.Kharat & Pradyumna P.Kulkarni &. "Brain tumor classification using neural network based methods." International Journal of Computer Science and informatics Vol-1,Iss-4 (2012): 85-90.

6.K.Erlandsson, A.J.Reader,M.A.Flower,R.J.Ott. "A new backprojection and filtering method for PET using all detected events." IEEE Transactions on Nuclear Science Vol-45, no. No.3 (June 1998): 1183-1188.

7. Tobias Schaeffter, Michael Grass,Roland Proksa,and Volker Rasche. "Real time adaptive filtering or projection reconstruction MR fluroscopy." IEEE Transactions on Medical Imaging Vol-22, no. No.1 (January 2003): 75-81.

8. Servet Tatil, Victor H.Gerbaudo, Marcelo Mamede, Kemal Tucali ,Paul B.Shyn, Stuart G.Silverman."Abdominal masses sampled at PET/CT – guided percutaneous Biopsy". Radiology.Vol-256, No.1 (July 2010):305-311.

9. A.Ben Hamza, Yun He,Alan Willsky. "A multiscale approach to pixel-level image fusion." IOS Press (IOS Press), 2005: 135-146.

10.Bahareh Shalchain, Hossein Rajabi,Hamid Soltanian Zadeh. "Fusion of PET and CT images using wavelet tranform." Hellenic Journal of Nuclear Medicine Vol-13, no. Iss-3 (December 2009): 238-243.

11.Yong Xia, Lingfeng Wen,Stefan Eberl,Michael Fulham. "Segmentation of brain structures using PET-CT images." 5th International Conference on Information Technolgy and Application in biomedicine. 2008. 86-89.

13.T.Logeswari,M.Karnan."Animproved implementation of brain tumor detection using segmentation based on soft computing".Journal of Cancer Research and Experimental Oncology Vol-2(March-2010):006-014.

14.Yves Lemoigne, Alessandra Caner,Ghita Rahal. Physics for Medical Imaging Applications. Vol-240. Springer, 2005.

15. Eric L. Rosen, William B. Eubank,David A. Mankoff. "FDG PET, PET/CT, and Breast Cancer imaging". Radiographic. Vol27 (October 2007):215-229.

16. Sang Kyu Yang, Nariya Cho, Woo Kyung Moon. "The Role of PET/CT for Evaluating Breast Cancer" Korean J Radiol .Vol8 (5):429-437.

17.Gustav K. von, Hans C. Steinert, Thomas F.Hany.(Integrated PET/CT: current applications & future directions",Radiology.Vol.238(February 2006):405-422.
18. The Role of PET/CT in Radiation Treatment Planning for Cancer Patient Treatment Austria, (October 2008)