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Clinical Diagnosis of Various Cancer Patients using PET/CT Fusion Imaging Techniques

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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 where as CT provides morphological, anatomical information that uses X-ray beam which helps in determing 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: *Cancer, PET, CT, X-ray, diagnosing*

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.

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.

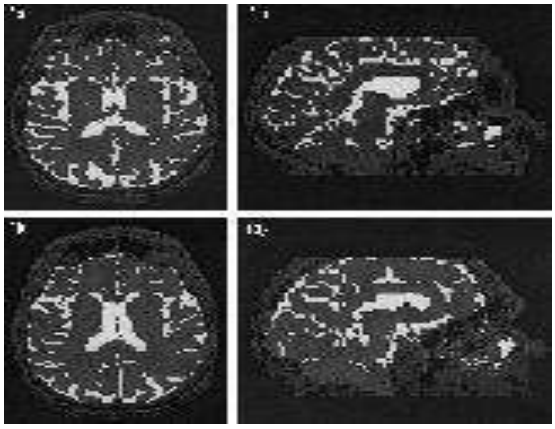


Fig. 1 a: *Coronal b. Lateral Segmented Sections of Brain Images by SOFM Algorithm.*

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, non linear 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 resulted that, after successful training the system is able to diagnose the unknown cases with predictions [3, 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.

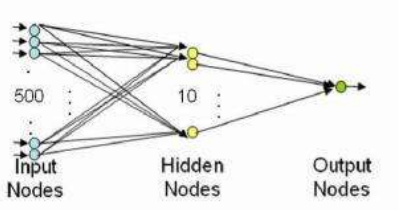


Fig. 2: *Feed Forward Neural Network.*

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.

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

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 [7–11].

Fig. 3 (a): *PET Image*

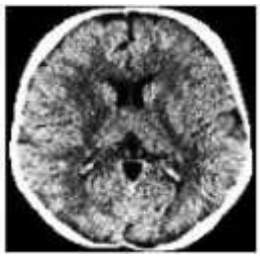


Fig. 3 (b): *CT Stretched Image*

Fig. 3 (c): *SPM-Seg Algorithm*

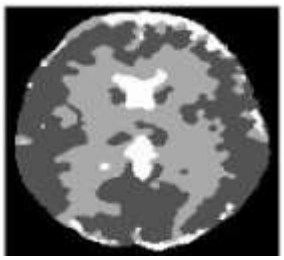
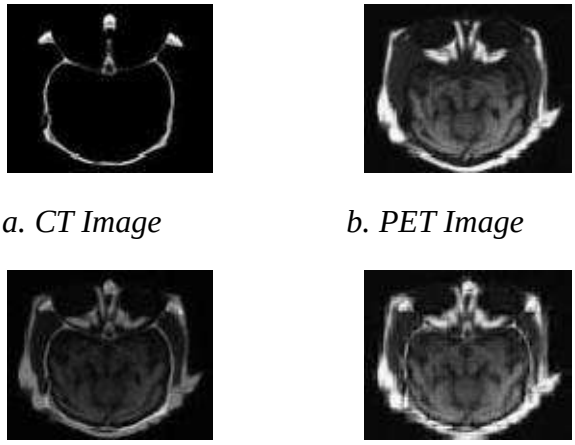


Fig. 3 (d): *FCSP-Seg Algorithm.*

While T. Logeswari in 2010, described segmentation method using Hierarchical self organizing map (Hsom) which classifies the image row by row [12, 13].

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 Image *d. Wavlet based*

Fig. 4: *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].

Application Areas of Cancers

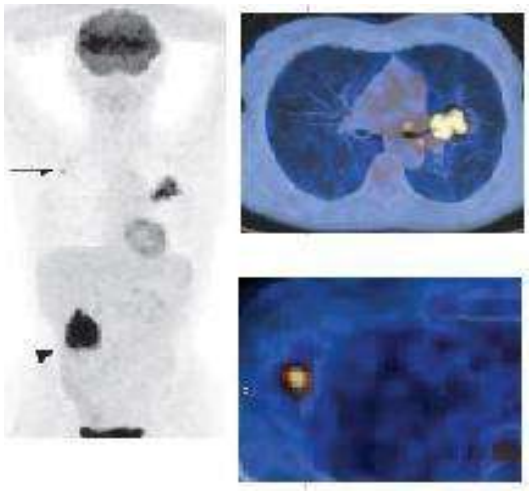
In 2006, Gustav k.studied the use of integrated PET/CT and discussed given applications. Once the PET/CT image data is obtained malignant lesions identified by PET are marked and framed in the CT's anatomic references. These imaging studies
are categorized under different body regions and are concluded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

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. 5: *Lung Canrcinoma.*

intrahepatic metastasis and local recurrence of the colorectal site .

Blood Lymphoma

PET/CT scan helps to diagnose the swlleon lymph node contains Hodgkins Disease and also the status of treatment. Also, these scans help to point out the correct place of the lymphoma.

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 [14, 15].

Below Fig. 6: *Results of PET/CT in a Patient Suspected of having Breast Carcinoma*

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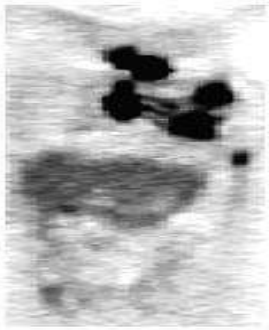
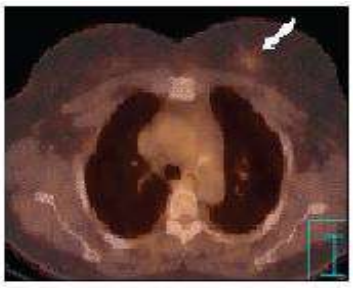
a.sigaittal fusion



b. coronal fusion

c. mamograph of breast canciroma left breast left breast



d.PET/CT of focal uptake in left breast

While in 2007,Sang Kyu Yang found that a potential advantage of PET/CT is to evaluate

Radiation Therapy

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

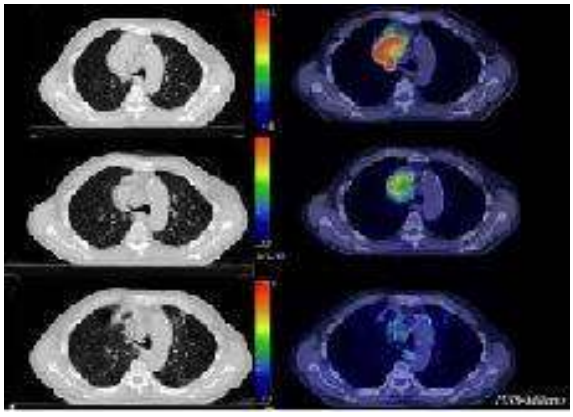
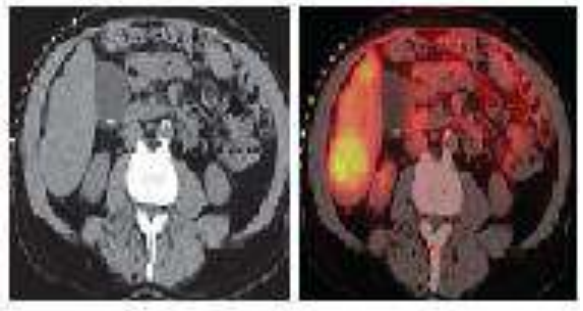


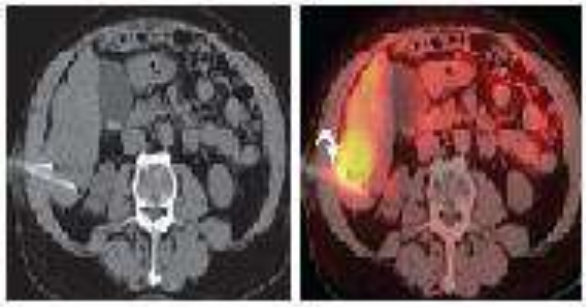
Figure 7 shows the study of FDG PET/CT that performed before the radiation treatment and after the end of ration treatment of 3 months with dose of FDG

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. Axial 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.*

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 of PET as areas of mild hyperglycolytic action is assigned to normal or abnormal anatomical structures [16, 17].

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

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 plan 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.

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