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Simulation of Positron Emission Tomography Tumor Images using MRI and CT

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Abstract:- **MRI and CT are commonly used for disease detection. A new technique is introduced in this area – Positron Emission Tomography (PET) image analysis. This is able to detect most of the diseases and most appropriate treatment can be provided to the patients. Tumor goes more deeply, PET image is more used in the diagnoses of tumors. Now, some simulation programs such as GATE (Geant4 Application for Tomographic Emission) exist, but too complicated and more time consuming. This work proposes a new method to simulate the PET image of the brain with Monte Carlo simulation in Matlab. . For the simulation, a high resolution, MRI and CT based, segmented image, is used as the original image. In MRI segmentation intensity non - uniformity (INU) artifact present.Hence, Adaptive Spatial Fuzzy Center means segmentation is used. It is based on fuzzy C - means that address both INU artifact and local spatial continuity.**

Key word:- INU artifact,FCM,ASFCM, membership values, clusters, fuzziness factor

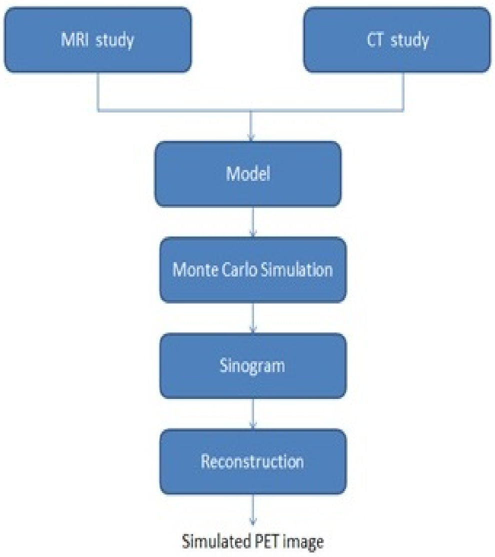
I. INTRODUCTION

A wide range of different image modalities for medical imaging are available at present, which provide view of internal organs of the human body such as brain, kidney, liver etc. Among these medical image modalities, Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) imaging are commonly used for disease diagnosis. Another technique used in this area is Positron Emission Tomography (PET). Unlike earlier radiotracer techniques PET can quantitatively measure biochemical and physiological processes. PET scans are more accurate in detecting tumors that are smaller or less aggressive than other imaging techniques.

For clinical PET scanning, positron emission radioactive isotopes are injected into the human body. The following are the major drawbacks of this type of scanning: (1) radio active isotopes have side effects on patients and (2) PET scan is expensive. For these two reasons, PET simulators are needed for physical and clinical research. Here a new method is proposed to simulate the PET tumor image of the brain using analytical information from CT and MRI images with Monte Carlo Simulation in Matlab. For the simulation, MRI and CT based segmented image is used as the original image. The main draw back of the MRI scanning is that it cannot provide clear information of hard tissues such as bones and skull while CT scan provides this information. A combination of CT scan and MRI scan is used in this work.

In neuroimaging, Monte Carlo Simulation has been applied in several fields such as the evaluation of reconstruction methods ,statistical toolkits, quantification methods, registration algorithms, segmentation methods, etc. Monte Carlo is a numerical calculation method in which random variables play an important role. Random numbers are used to simulate the transport of particles from its emission site for either its detection in the detector or its absorption in the medium in PET simulation.

II). METHODOLOGY



For the simulation of PET image MRI and CT images are used as initial maps.from these attenuation and activity maps are created .MRI images are segmented to 1) extracted brain image, 2) outskin image, and 3) brain tissue segmented image . Brain tissue segmented image means separate grey matter , white matter and cerebrospinal fluid(CSF). Thresholding methods is used for bone tissue extraction from the CT image.From the combination of the bone tissue and outskin image attenuation maps were created. Information from all images are requird for generate the activity maps.MC code was used to simulate PET image.

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III). SEGMENTATION

MRI and CT data were used to generate the initial images. MRI studies were brain extracted and segmented to obtain the image set 1) extracted brain image, 2) outskin image, and 3) brain tissue segmented image (grey matter , white matter and cerebrospinal fluid(CSF) separately). Bone tissue was extracted from the CT image by thresholding.

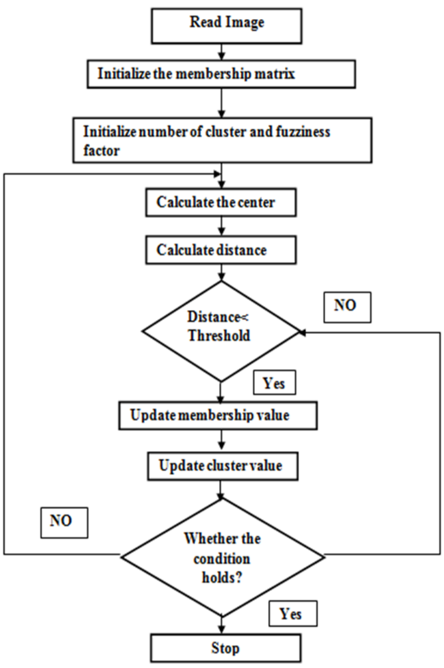
Segment the MRI image into extracted brain image and outskin image by linear thresholding. Brain tissue segmention is done by Adaptive Spatial Fuzzy center mean algorithm (FCM)[16]. Adaptive Spatial Fuzzy C-means clustering is a data clustering method .In which each data point belongs to a cluster to a degree specified by a membership value.

3.1 Adaptive Spatial Fuzzy C-Means Clustering

- Membership matrix U randomly select according to the size of the image.
  U=$[U_{ij}]$, $1 \le i \le c, 1 \le j \le n$
  It satisfies the following condition:
  $$\sum_{i=1}^{c} U_{ij} = 1 \quad \forall j = 1,2,\ldots\ldots,n$$

Where U_{ij}- membership grade ,n- number of samples c-number of clusters

- Then calculate the Cluster center
  $$c_i = \frac{\sum_{j=1}^{n} U_{ij}^{m} . x_i}{\sum_{j=1}^{n} U_{ij}^{m}}$$
  Where m ∈ [1,∞] is the weighting exponent xi is the data point
- Calculate distance between the pixel and center
  $$d_{ij}^2 = \|x_i - c_j\|^2$$
- If the distance is less than the threshold 1e-5 then update the membership matrix
- The new membership matrix is
  $$U_{ij}^{m} = \frac{1}{\sum_{k=1}^{c} (\frac{d_{ij}}{d_{ik}})^{\frac{2}{m-1}}}$$
- Terminating condition: Aims at minimizing the desired function
  $$J_{ASFCM} = \sum_{i=1}^{c} \sum_{j=1}^{n} U_{ij}^{m}\, d_{ij}^2$$



SFCM Segmentation algorithm :
(1) Read the MRI image
(2) Assign number of clusters
(3) Assume the fuzziness factor
(4) For i=1:max_iter
i)Distance between pixel and centroid is calculated
ii) Membership values are calculated
End for
(5) If distance less than threshold
i) Membership values are updated
ii) Update cluster centroid
(6) Do the Segmentation

IV). EXPERIMENTAL RESULTS

MRI studies were brain extracted and segmented to obtain the image set 1) extracted brain image, 2) outskin image, and 3) brain tissue segmented image (grey matter , white matter and cerebrospinal fluid(CSF) separately). Bone tissue was extracted from the CT image by thresholding.The attenuation maps were generated from a combination of the bone tissue and outskinimage.To generate the activity maps, information from all images was taken into account.

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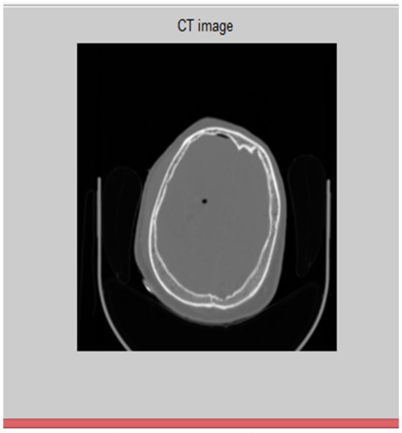


Fig 8.1 Input CT image

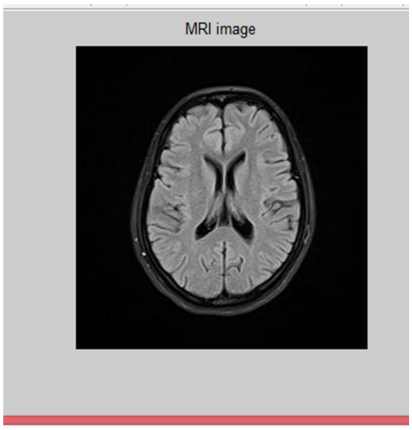


Fig 8.2 Input MRI

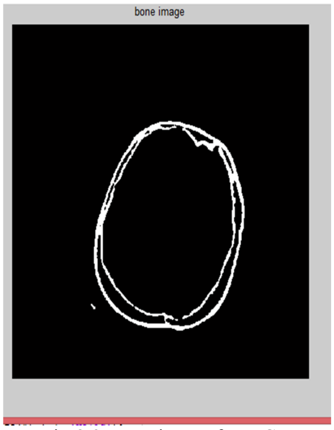


Fig 8.3 Bone image from CT

Fig 8.4 Extracted brain image from MRI

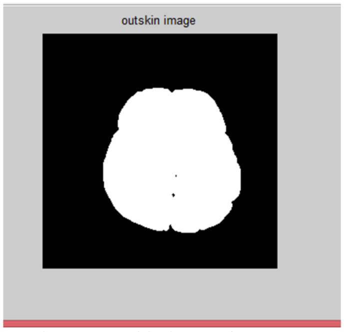
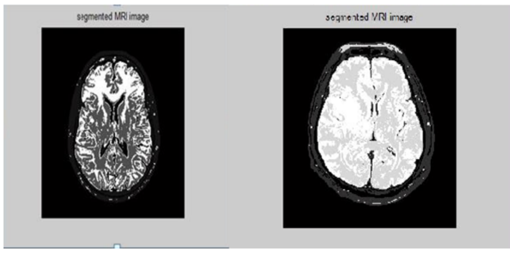
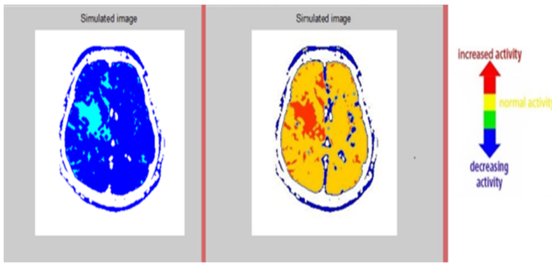


Fig 8.5 Outskin image from MRI



a)Using FCM b)Using ASFCM

Fig 8.6 Segmented MRI



a)Using FCM b)Using ASFCM

Fig 8.7 Simulated PET

CONCLUSION

In this work ,the efficiency of the PET simulation is demonstated by FCM and ASFCM segmentation.In this method first assign the membership marix and fuzziness factor.From these values update the membership value according to the distance.Hence brain tissue segmentation is obtained correctly.

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