PET/CT Image Denoising and Segmentation based on a Multi Observation and Multi Scale Markov Tree Model

Medical Sensors Project Presentation

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Outline

1. Introduction
2. Registration
3. Denoising
4. Segmentation
5. Result and Discussion
6. Conclusion

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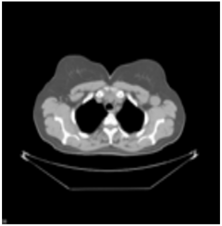
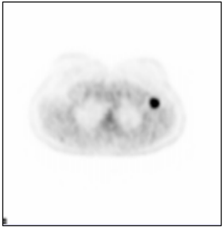
PET	CT
- High contrast - For oncology	- High spatial resolution - For anatomy
Fuse PET/CT data to provide high quality anatomical correlations with radionuclide	

Introduction

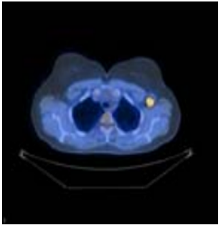
Why PET/CT



CT



PET

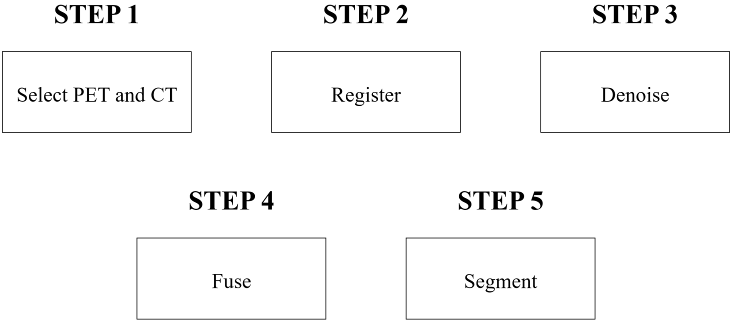


Fused Image

Fuse PET/CT data to provide high quality anatomical correlations with radionuclide

Introduction

Flowchart



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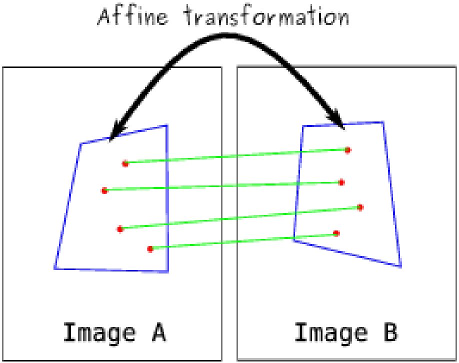
Registration PET/CT

PET/CT are acquired:

- With patient in different positions
- With different pixel sizes
- With different array sizes



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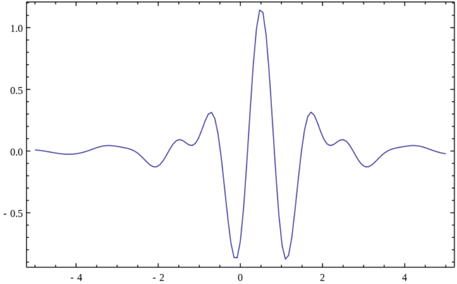
Wavelet Denoising

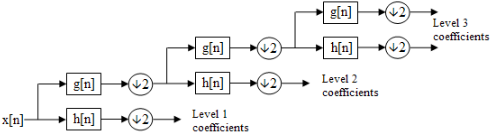
What is Wavelet

A wavelet is a wave-like oscillation with an amplitude that begins at zero, increases, and then decreases back to zero .

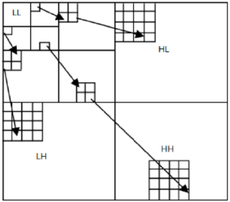


Meyer Wavelet

Wavelet transform performs a correlation analysis, therefore the output is expected to be maximal when the input signal most resembles the mother wavelet



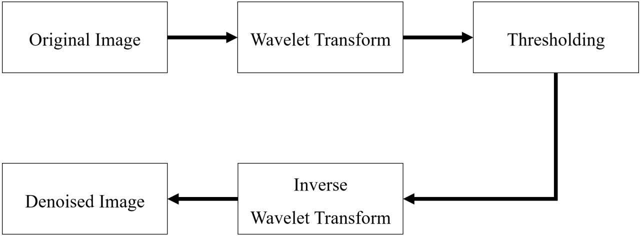
Three-level filter bank



Wavelet Coeeficient Arrangement

Wavelet Denoising

Flowchart



Optimal for isotropic structures

Contourlet Denoising

Contourlet Transform

Contourlets form a multiresolution directional to separate smooth regions with smooth boundaries.

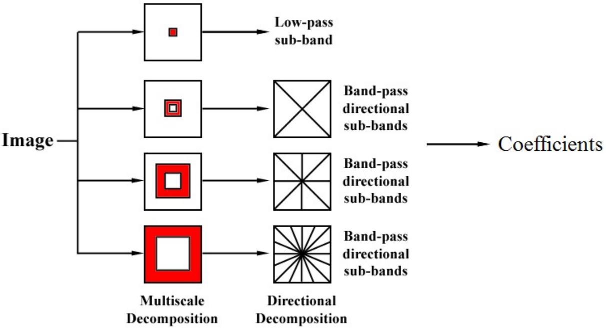
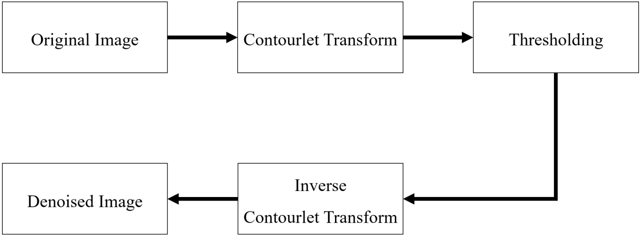


Figure: Contourlet Transform

Contourlet Denoising
Flowchart



Optimal for directional information

Wavelet-Contourlet Denoising

Isotropic structures of Wavelet

+

Directional information of Contourlet

=

Isotropic structures of Wavelet
Directional information of Contourlet

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PET-CT Image Segmentation

What is Segmentation?

Segmentation is the process of splitting an observed image into its homogeneous regions

- Extract **features** from the input image
- Define the set of **labels** for each pixel/features
- **Hidden Markov Model**

A Hidden Markov Model (HMM) is a statistical model in which the system being modeled is assumed to be a Markov process.

- Observed and Hidden States
- Hidden Markov Model:Segmentation

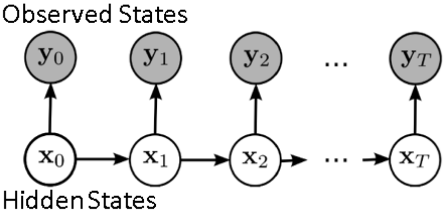

Figure: Hidden Markov model

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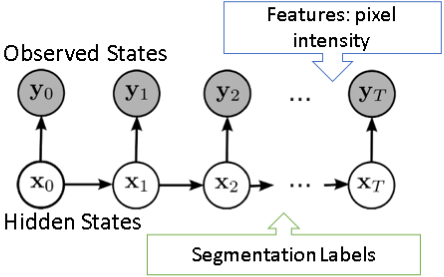

Figure: Hidden Markov model in Image Segmentation

- Given an image Y $M \times N$ lattice Ω, indexed by a pair (i, j) so that $\Omega = (i, j); 1 \leq i \leq Mand1 \leq j \leq N$
- Labeling X same size as Y
- The relationship between gray scale values and labels: Bayesian Likelihood function.
- According to the MAP criterion '

$$X^* = \underset{x}{\operatorname{argmax}}\{P(Y \mid X, \Theta)P(X)\} \tag{1}$$

Where $\Theta = \{\theta_l | l \in L\}$ is the parameter set

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Gaussian distribution function with parameters $\theta_I = (\mu_I, \sigma_I)$:

$$G(z; \theta_I) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp(-\frac{(z - \mu_I)^2}{2\sigma^2}) \tag{2}$$

1. Estimation Step: Labels know, estimate parameters

$$\mu_l^{(t+1)} = \frac{\sum_i P^{(t)}(l \mid y_i) y_i}{\sum_i P^{(t)}(l \mid y_i)}$$
$$(\sigma_l^{(t+1)})^2 = \frac{\sum_i P^{(t)}(l \mid y_i)(y_i - \mu_l^{t+1})^2}{\sum_i P^{(t)}(l \mid y_i)} \tag{3}$$

2. Maximization Step
   - Knowing parameters assign labels: Optimization problem

$$X_i^{(k+1)} = \underset{l \in L}{\operatorname{argmin}} \{U(y_i \mid l) + \sum_{j \in N_i} V_c(l, x_j^k))\} \tag{4}$$

Where U(x) is prior energy function and $V_c(X)$ is the clique potential and C is the set of all possible cliques

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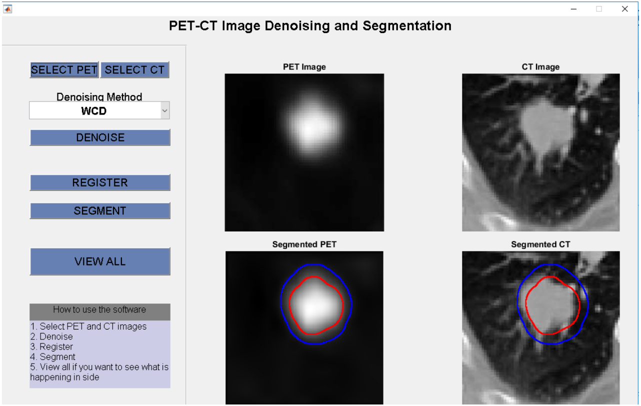

Figure: Wavelet-Countroulet denoised image. PET Image

Result and Discussion

PET Denoising

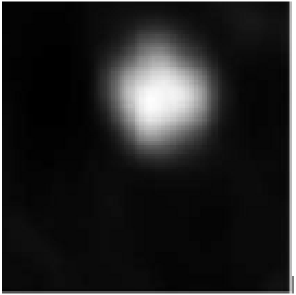

Figure: Wavelet denoised image.

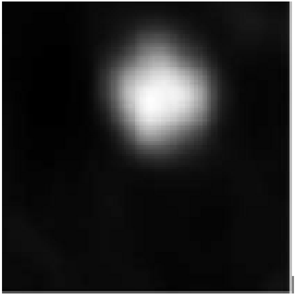

Figure: Countroulet denoised image. PET Image

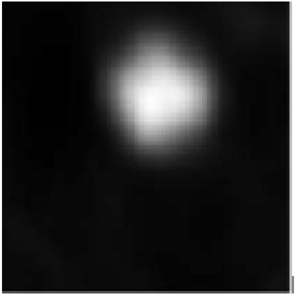

Figure: Wavelet-Countroulet denoised image

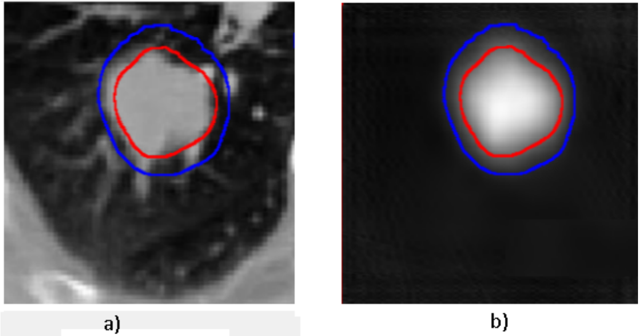

Figure: Segmented CT and Pet Images

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Conclusion

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- HMT based Image Segmentation
- Future Work
  - Extending our algorthim to PET-MRI
  - Enhancing the segmentation algorithm

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Q & A

Thank you for listening