Spatial Distribution of Adipose Compartments Size, Shape and Orientation in a CT Breast Image of a Mastectomy Specimen

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Abstract

- High resolution anthropomorphic software phantoms have been developed to assist pre-clinical validation of breast imaging systems [1].
- The simulation algorithms require input parameters such as number of compartments, distribution, and size and shape of adipose compartments.
- To obtain more realistic phantoms the above parameters need to be inferred from clinical images.
- This work investigates the distribution and spatial placement of adipose compartments in reconstructed CT images of a Mastectomy Specimen.

CT Scanning Parameters

- Multi-slice CT system (Sensation 64, Siemens Medical Solutions USA, Malvern, PA).
- Tube Potential: 120 kVp.
- Tube Current: 400 mAs.
- Slice Thickness: 0.6 mm.
- In-slice Resolution: 0.72 mm x 0.72 mm.
- Acquisition Protocol: Head.
- Exposure Time: 1000 ms.
- Focal Spot Size: 1.2 mm.

Adipose Compartments Segmentation

- The adipose tissue compartments in the reconstructed high intensity CT slices were segmented manually using ITK-SNAP [2].
- We segmented 142 adipose compartments from the 619 slices of the mastectomy specimen.
- The compartments span 2863 slice segments in total and more than 20 slices on average.
- The segmented adipose tissue compartments covered approximately 14% volume of the total mastectomy specimen.

Results and Discussion

- We observed a significant correlation between compartment sizes and the barycenter y-coordinate (p-value ≤ 0.02), but not with x- and z-coordinates (p-value>0.05).
- The ellipsoidal semi-axes ratios ranged between 1.24 to 6.70 inclusive and were not correlated with the compartment sizes (p-values=0.56).
- The compartmental orientations And positions were not correlated since the p-value (>0.05) was not significant.

Future Work

- Automatic segmentation of adipose compartments would be preferred to accelerate the analysis and reduce operator bias.
- The extracted shape parameters of the compartments may be utilized to inform the simulation.
- The shape analysis in this work could be used as a benchmark in extracting the compartment parameters from clinical breast images.

Conclusions

- We successfully demonstrated a Proof Of Concept for segmentation and ellipsoidal fitting of adipose compartments from CT images of a mastectomy specimen.
- Since the mastectomy specimen does not fully reflect the real breast, this analysis would be required for clinical images of Healthy Breast Anatomy.
- Further, potential development of automatic tissue segmentation would provide a more objective and accelerated analysis.
- Finally, a similar approach to the analysis of the size, shape and orientation may be developed for other 3D Imaging Modalities.

References


Acknowledgements

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Extracted Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td># Compartment Slices</td>
<td>(6, 59)</td>
</tr>
<tr>
<td>Shape Ratio</td>
<td>(1.24, 6.70)</td>
</tr>
<tr>
<td>Size</td>
<td>(0.065, 3.97) cm³</td>
</tr>
<tr>
<td>Compartmental</td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td>(-178, 178) deg</td>
</tr>
<tr>
<td>Ellipsoidal Fitting</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>(56, 88) %</td>
</tr>
</tbody>
</table>

Ellipsoidal Fitting

- Each compartment was characterized by its volume and the coordinates of the barycenter.
- An ellipsoid centered at the barycenter with the same moments of inertia as a compartment was determined [3].
- The goodness of elliptical fitting was assessed by Dice score measuring the overlapped volume between the fitted ellipsoid and each compartment.

Size, Shape and Orientation Distribution

- Fitted ellipsoids were characterized by the size and orientation (Euler’s angle) of their semi-axes.
- The ellipsoid shapes were quantified by the ratios of the largest and the smallest semi-axes.
- The sizes of the segmented compartments were measured by their volumes.
- The Adipose compartmental orientations were characterized by the Euler angles of the ellipsoid axes.
- The positions of the segmented compartments were determined by the coordinates of compartmental centers.

Future Work

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