Automatically Segmented CT Model for Preoperative Lymph Nodes Characterization and Staging

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Motivation

• Morphologic imaging is not always sufficient for a correct differential diagnosis between benignancy and malignancy.

• Accurate staging of the lymph nodes still relies on preoperative surgical exploration and manual palpation.

Purpose

We propose a new non-invasive diagnostic approach based on the simulated palpation of lymph nodes through virtual laparoscopic instruments.
Method

• Lymph node segmentation and data extraction on CT images.

• Lymph node reconstruction and simulation with haptic feedback.

• Discriminative extraction of the characteristics for node statistical analysis (variance, roundedness and size), and classification.
Data segmentation: initialization

- In case of simple template we use automatic initialization.
- When structures are more complex we use manually defined contours.
Segmentation is based on active contours (snakes), and specifically on B-splines. The snakes algorithm autonomously proceeds in the segmentation of the whole data set, under the supervision of the user, who is able to stop the process in order to re-initialize it or correct the results.
Data segmentation: reconstruction
We extract dynamic properties from medical images:

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
<th>Min</th>
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<tbody>
<tr>
<td>Hounsfield values from CT (HU)</td>
<td>39</td>
<td>21</td>
</tr>
<tr>
<td>Density values used for reconstruction (Kg/m$^3$)</td>
<td>1100</td>
<td>1040</td>
</tr>
<tr>
<td>Stiffness values (Young modulus) used for reconstruction (MPa)</td>
<td>100</td>
<td>5</td>
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</tbody>
</table>

To obtain a realistic model behavior.
Simulation
Results

- Malignant lymph nodes shows pixel densities 40% higher
- Benign nodes attenuation peaks during the arterial phase and rapidly decreases in the subsequent acquisitions;
- Malignant nodes attenuation peaks in the portal-venous phase, and slowly decreases in the delayed scan.

![Graph showing attenuation peaks over time](image-url)
Results

From both the morphological information and their stiffness values, obtained from the trends of pixel densities, we build complete mechanical models of the lymph nodes.
Preliminary tests have shown comparable diagnosis results with the outcome of a real surgical procedure. Therefore our first experimental results show the feasibility to improve the pre-operative diagnosis in abdominal resection surgery.
Further studies are in course to clinically validate the correlation between the results obtained by our technique and surgical and pathology findings.

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