Benefits of Texture Analysis of Dual Energy CT for Computer–Aided Pulmonary Embolism Detection

A. Foncubierta Rodríguez, O. Jiménez del Toro, A. Platon, P.A. Poletti, H. Müller, A. Depeursinge
Pulmonary Embolism

• Obstruction of arteries in the lungs
• Unspecific symptoms
• **High mortality rates:**
  – 75% (initial hospital admission)
  – 30% (3 years after discharge)
• Delays in diagnosis increase the risk
• But **easily treated** with anticoagulants
PE Imaging

Conventional CT images
- Wedge shaped regions
- Heterogeneous attenuation
- Correlation with vascularization and ventilation

Dual Energy CT images
- 4D Data
- X,Y,Z
- Energy level
- Different materials: different attenuations

Material Attenuation Coefficient vs keV

Photon Energy (keV)

Iodine
Water

m(E) (cm²/mg)

Iodine
Water

80 keV
140 keV

40 50 60 70 80 90 100 110 120 130 140
Dataset

- 25 patients
- Image resolution
  - 0.83mm/voxel (axial plane)
  - 1mm inter-slice distance
  - 1.25mm slice thickness
- 11 energy levels
- Manually segmented lobes
- Qanadli index
Pipeline

3D Analysis
- Automatic regions of interest
- Region-level features: energy of wavelets
- Lobe-level descriptors: Bag of visual words
- One vocabulary per energy level

4D data integration:
- Histogram of visual words for all energy-level vocabularies
- Find optimal combination of energy-level vocabularies
Automatic ROIs

• Saliency-based:
  – 3D Difference of Gaussians
  – Multiple scales
  – Geodesic regional extrema

• Data-driven region shape

• Local to global analysis of the lobes
Region-level Features

- 4 dimensional feature vector per region

- 4 scales
- 3D DoG
- Energy in Regions
Bag of visual words

- BOVW allows data-driven features:
  - Patterns actually occurring in the data
- Vocabularies
  - K-means clustering
  - 5 to 25 words
  - One vocabulary per energy level
  - Lobe specific: lobes are not directly comparable
- Each lobe described by 11 histograms of VW
Evaluation

• Classification based on 1-NN
  – $Q_i > 0$
  – $Q_i < 0$

• Leave One Patient Out

• Combinations:
  – From 1 to 11 energy levels
  – 5 to 50 visual words per energy level

• Reference: 70 KeV for conventional CT
## Results

<table>
<thead>
<tr>
<th>Lobe</th>
<th>4D Analysis Accuracy</th>
<th>Energy levels</th>
<th>Visual words</th>
<th>Conventional Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Right</td>
<td>84%</td>
<td>50+130 KeV</td>
<td>5</td>
<td>52%</td>
</tr>
<tr>
<td>Lower Left</td>
<td>84%</td>
<td>100+140 KeV</td>
<td>5</td>
<td>48%</td>
</tr>
<tr>
<td>Middle Right</td>
<td>80%</td>
<td>40+50+130+140 Kev</td>
<td>5</td>
<td>52%</td>
</tr>
<tr>
<td>Upper Left</td>
<td>76%</td>
<td>40+70+80+90 Kev</td>
<td>25</td>
<td>60%</td>
</tr>
<tr>
<td>Upper Right</td>
<td>80%</td>
<td>90+120 KeV</td>
<td>25</td>
<td>56%</td>
</tr>
</tbody>
</table>
Conclusions

• Using 4D analysis of DECT outperforms conventional CT: 36% accuracy increase
• Consistent results among all lobes
• Lobe specificities:
  – No optimal parameters for all lobes
  – Methods need to be optimized per lobe
• Satisfactory results for integration of automatic ROI detection
Future work

Larger database
• Ongoing process

Similarity-based retrieval
• Qanadli index as metric

Optimize BOVW
• Synonyms
Thanks for your attention!
Questions?