A computerized score for the automated differentiation of usual interstitial pneumonia from regional volumetric texture analysis

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Idiopathic pulmonary fibrosis (IPF)

• Most **common** type of interstitial lung disease (ILD)
• Confounding diagnoses of ILDs: >150!
  – Sarcoidosis, non-specific interstitial pneumonia, ...
• **Multidisciplinary** approach between experts in pulmonology, chest radiology and pathology [1]

• Often requires a surgical **biopsy**
  – Costly, invasive and risky:
    • **Hemorrhage, lung collapse**
    • **Acute exacerbation of the lungs** [2]

Radiology: usual interstitial pneumonia (UIP)

- Lung biopsy can be obviated when the clinical and radiographic (CT) impression are clearly suggestive of UIP [1]

<table>
<thead>
<tr>
<th>Classic UIP (all required)</th>
<th>Inconsistent with UIP (any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral, basal predominance</td>
<td>Upper or mid–lung predominance</td>
</tr>
<tr>
<td>Reticular abnormality</td>
<td>Peribronchovascular predominance</td>
</tr>
<tr>
<td>Honeycombing with or without traction bronchiectasis</td>
<td>Extensive ground glass abnormality (extent &gt; reticular abnormality)</td>
</tr>
<tr>
<td>Absence of features listed as inconsistent with UIP pattern</td>
<td>Profuse micronodules (bilateral, predominantly upper lobes)</td>
</tr>
</tbody>
</table>

A) tissue type

- normal
- ground glass
- reticular
- honeycombing

B) tissue location

- peripheral
- basal

Objectives and experimental setup

• **Computer-aided diagnosis for identifying classic UIPs:**
  – No biopsy required for them!

• Derive a score from regional volumetric texture analysis
  – 3-D texture analysis
  – Basic anatomical atlas

• **33 patients with biopsy proven IPF**

• Volumetric multiple detector CT (MDCT)
  – Acquired within the year of the biopsy

• Gold standard: consensus of two thoracic radiologists with more than 15 years of experience with ILDs
  – 15 patients with classic UIP versus 18 patients with atypical UIP
Simple 3-D digital atlas of the lungs

- The lungs are split perpendicularly to 4 axes [3]

<table>
<thead>
<tr>
<th>⊥ vertical</th>
<th>⊥ axial</th>
<th>⊥ coronal</th>
<th>⊥ sagittal</th>
</tr>
</thead>
<tbody>
<tr>
<td>apical, central, basal</td>
<td>peripheral, middle, axial</td>
<td>left, right</td>
<td>anterior, posterior</td>
</tr>
</tbody>
</table>

Intersections: 36 subregions

Regional features and score

- **Texture**: 3-D Riesz filters [4]
  - quantify the local amount of directional image patterns at multiple scales:

- **Intensity** hist. in \([-1000; 600]\) Hounsfield Units
  - 15 hist. bins

- **Feature aggregation and score** \(f(v_i)\):
  
  \[
  f(v_i) = \langle w, v_i \rangle + b
  \]

  - \(f(v_i) > 0\): classic UIP
  - \(f(v_i) < 0\): atypical UIP

Results and discussion

- **ROC analysis** of the score and **comparison** with two fellows

- Importance of **regional volumetric texture analysis**
- Performance is **comparable** to cardiothoracic fellows (1 year spec.)

- **Demonstrate the potential benefits of our approach in centers without access to ILD experts to avoid unnecessary biopsies**

- **Limitations:** 33 cases and requires a volumetric CT
Results and discussion

• Optimization of SVMs: 3-D Riesz

- The performance is stable and generalizes well.