

Introduction

Interstitial lung diseases

- **Interstitial lung diseases** (ILDs) regroup more than 150 pathologies that can be characterized by the gradual alteration of the **lung parenchyma** leading to breathing dysfunction.
- When the synthesis of physical examination, laboratory tests, pulmonary function testing as well as visual findings on chest X-ray arouses suspicions toward an **ILD**, **high-resolution computer tomography** (HRCT) imaging of the chest is often required to acquire a rapid and accurate visual assessment of the lung tissue.
- **Interpretation of HRCT** is often challenging and time-consuming with numerous differential diagnoses and a large number of images to screen. It is currently reserved to experienced radiologists.

Goals

- Bring in **image-based computer-aided diagnosis** (CAD) to aid little experienced radiologists and clinicians consisting of (see Figure 1) :
 - **3D categorization of the lung tissue** in HRCT using texture analysis and a selection of clinical parameters.
 - **Content-based retrieval** of similar ILD cases from a multimedia database.

Methods

Multimedia library of ILD cases

- Each case contains annotated HRCT images series and 99 clinical parameters.
- 133 cases and 92 HRCT image series representing 7 of the most frequent ILDs are captured.

Automatic 3D categorization of the lung tissue

- **Texture analysis** is based on grey-level histograms in Hounsfield Units (HU) and a custom-tailored wavelet transform.
- A Support Vector Machine (SVM) classifier is used to predict the class of lung tissue from texture features.
- Classification results are displayed in three dimensions to the clinician.

Content-based retrieval of similar cases

- An inter-case **multimodal similarity measure** based on the volumes of each class of lung tissue as well as clinical parameters is used for retrieval.
- Full details (including annotated image series) of the retrieved cases can be viewed with a web-based interface.

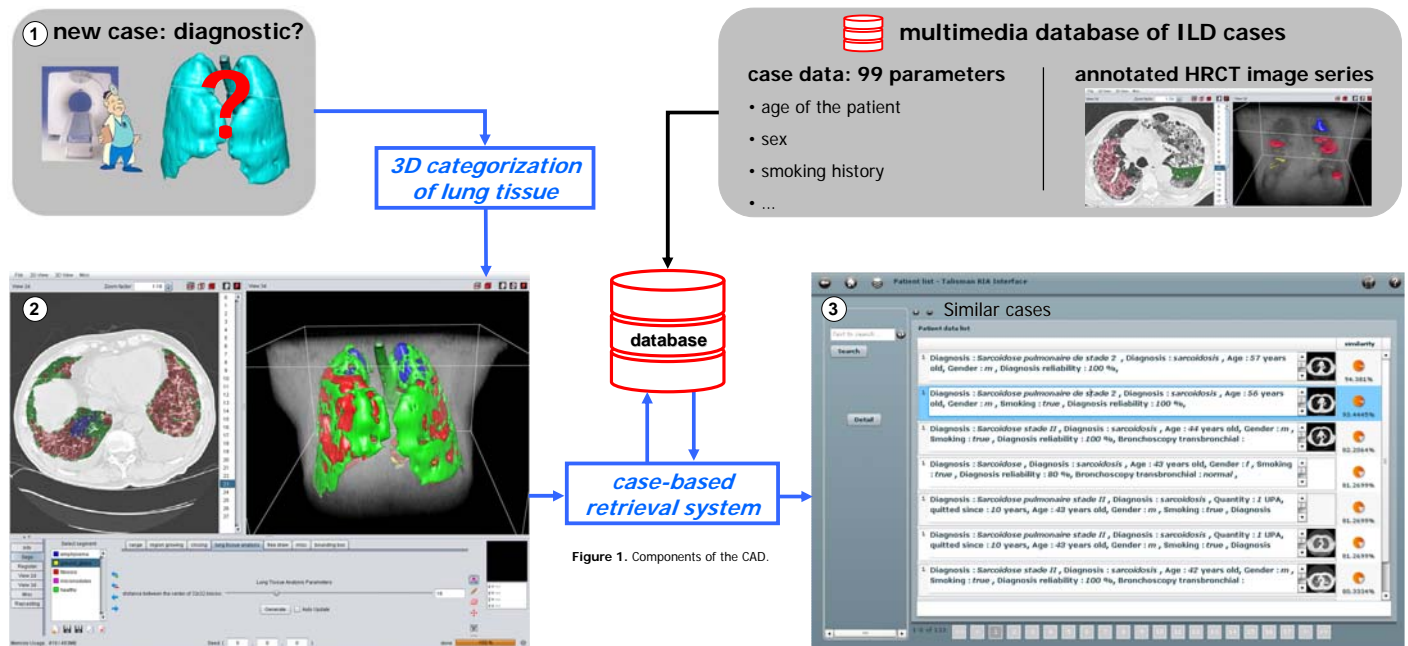


Figure 1. Components of the CAD.

Results

3D lung tissue categorization

- Table 1 shows the confusion matrix of the classification of the lung tissue patterns obtained with a **leave-one-patient-out (LOPO) cross-validation** of 69 cases.

	healthy	emphysema	ground glass	fibrosis	micronodules	N_{case}
healthy	78.1	2.8	0.7	0.2	18.1	63914
emphysema	0.9	70.1	0	4.7	24.2	61578
ground glass	4.6	1.6	70	14.7	3.1	644814
fibrosis	2.3	1.9	17	73.5	5.3	860474
micronodules	13.7	1.8	2.2	6.7	75.7	1436055

Table 1. Confusion matrix. N_{case} denotes the number of manually segmented voxels used for evaluation.

- Recurrent confusions between *healthy* and *micronodules* patterns are observed.
- The integration of clinical parameters allowed significant improvements of the classification accuracy.

Multimodal case-based retrieval

- The mean retrieval precisions P at ranks 1, 5, 10 and at rank equal to the number of instances N_i of the diagnosis using LOPO cross-validation are listed in Table 2.

	$P@1$	$P@5$	$P@10$	$P@N_i$	N_i
Fibrosis	79.2	49.2	45.4	40.3	24
BOOP	40	24	16	24	5
Miliary tuberculosis	71.4	48.6	35.7	42.9	7
PCP	25	20	10	25	4
Hypersensitivity pneumonitis	45.4	38.2	42.7	43.2	11
Acute interstitial pneumonia	77.8	55.6	41.1	40.5	9
Sarcoidosis	100	66.6	52.2	55.6	9
average/total	60.9	40	34.1	34.1	69

Table 2. Mean retrieval precisions based on the diagnostics.

Conclusions

- Image-based diagnosis aid tools for ILDs including a multimedia database, automatic categorization of the lung tissue and retrieval of similar cases are available for evaluation to clinicians at the Emergency Radiology Service of the HUG.
- The recognition rate and retrieval precisions obtained with LOPO cross-validation is faithfully **similar to actual clinical situations**.
- The automatic recognition of abnormal lung tissue provides a draft overview of the image series that constitutes a **second opinion** with reliability assessment.
- Image-based retrieval of similar cases enables **advanced browsing** of large repositories of ILD cases.

Future work

- Reduce false detections of *micronodules* patterns using SVM with asymmetric margins.
- Use low-level texture features for content-based retrieval of similar cases.
- Identify problems and benefits of the CAD in clinical routine at the Emergency Radiology service.

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