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Blockwise Classification of Lung Patterns in Unsegmented CT Images

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Summary

- Introduction
- Related Work
- Materials and Methods
  - Dataset
  - Completed Local Binary Pattern (CLBP)
- Experimental Results
- Discussion
- Conclusion and Future Work

Introduction

- Diagnosis of lung diseases
  - Abnormal characteristics in CT scans
  - Information extracted from visual patterns
  - Techniques of image processing can increase the confidence and consistency of diagnosis

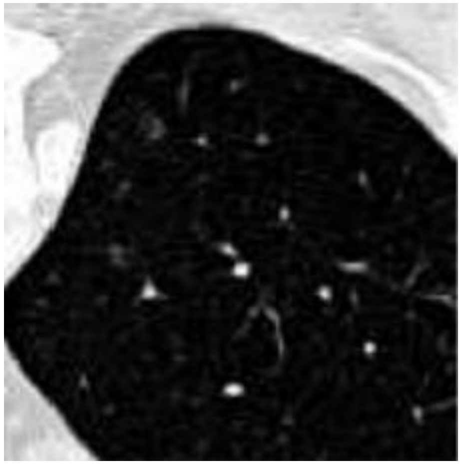
- Image classification
  - Image acquisition
  - Feature extraction
  - Classification

Introduction

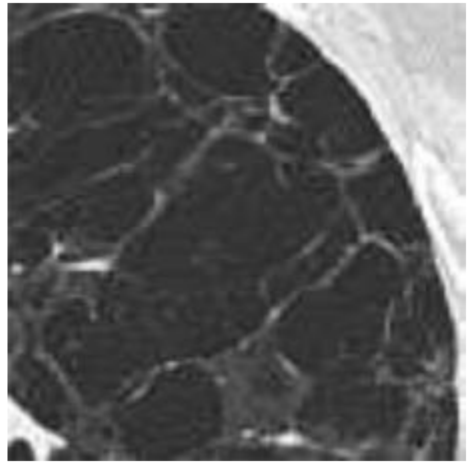
- Main goal
  - To execute an analysis and quantification of lung disease patterns in High-Resolution CT images
  - To perform a coarse lung segmentation by also classifying body areas outside the lungs

- Initial results
  - Classification of image blocks of: non-lung (e.g. bone, tissue and fat), normal lung tissue, emphysema, ground-glass opacity, fibrosis and micronodules.
  - Completed Local Binary Patterns (CLBP) descriptor
  - Support Vector Machine classifier

Pulmonary patterns

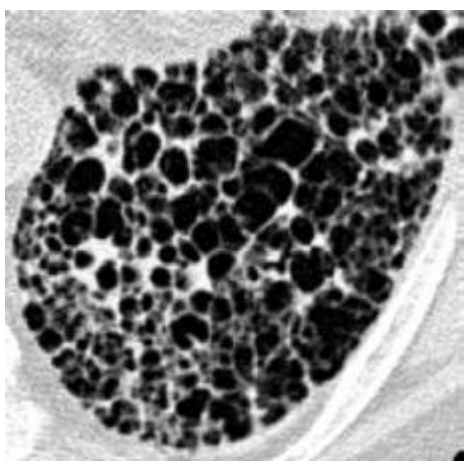


Normal tissue

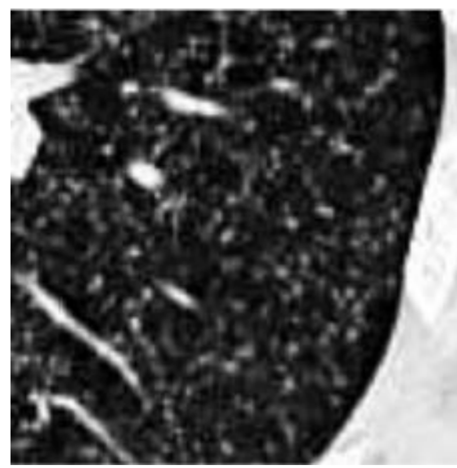


Emphysema

Ground-glass opacity



Fibrosis



Micronodules

Computed Tomography

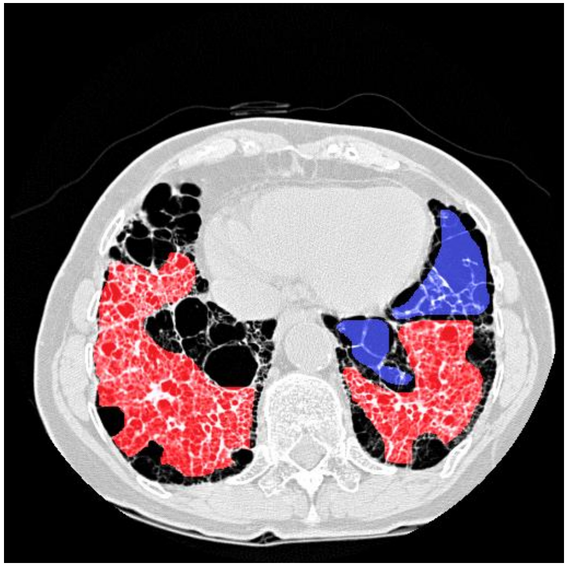
Radiography

High-Resolution CT

Dataset

- Provided by Depeursinge *et al.*[1]
- Multimedia collection of cases with interstitial lung diseases (ILDs)
- High-Resolution CT images in DICOM format

- *Ground truth*
  - Lung masks
  - Annotated ROIs (Regions of Interest) of 17 tissue patterns
    - Normal
    - Emphysema
    - Ground-glass
    - Fibrosis
    - Micronodules

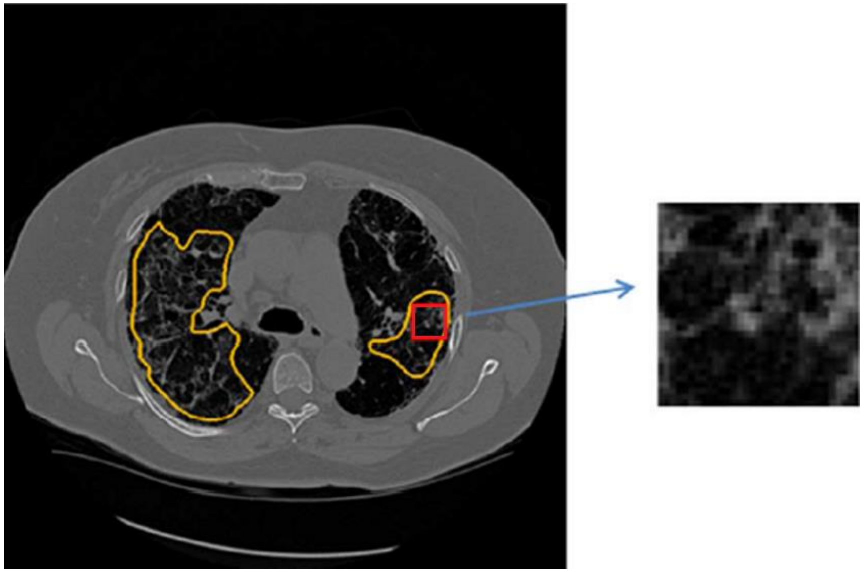


Blue: emphysema
Red: fibrosis

[1] Depeursinge, A., Vargas, A., Platon, A. a. A., Poletti, P.-A., and Muller, H. (2011). Building a Reference Multimedia Database for Interstitial Lung Diseases. *Computerized Medical Imaging and Graphics*.

Dataset

- Extraction of lung tissue blocks
  - Half-overlapping blocks at *x,y* of 32x32 pixels
  - At least 75% of the pixels need to belong the ROI



Example of block extraction from annotated ROI (Song *et al.*[2])

[2] Song, Y., Cai, W., Zhou, Y., and Feng, D. D. (2013). Feature-Based Image Patch Approximation for Lung Tissue Classification. IEEE Trans. Med. Imaging, 32(4):797-808.

Dataset

- Extraction of non-lung blocks
  - Morphology dilation applied in the lung mask
  - The non-lung ROI is the dilated area which does not belong to the lung mask
  - Non-overlapping blocks at *x,y* of 32x32 pixels
  - At least 75% of the pixels need to belong the ROI

Original image

Lung mask

Dilated lung mask

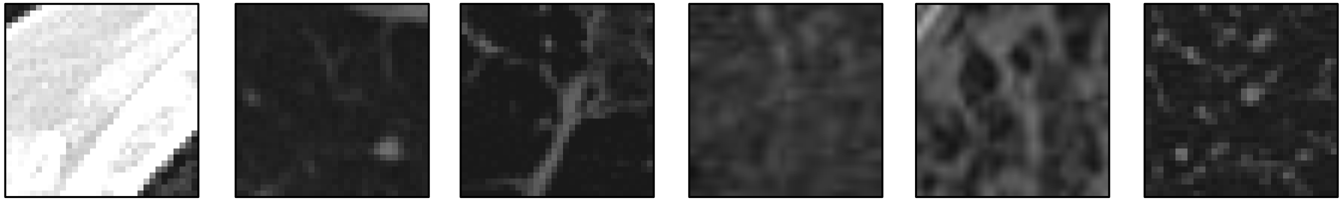
The gray area is the non-lung ROI

Dataset

Summary of the dataset

Pattern	Number of blocks
Non-lung	3000
Normal tissue	5733
Emphysema	1017
Ground-glass	1942
Fibrosis	2736
Micronodules	6112

- Examples of the extracted blocks



Non-lung Normal Emphysema Ground-glass Fibrosis Micronodules

Completed Local Binary Pattern

- Proposed by Guo *et al.*[3]

- It represents a local region by its center pixel g_c and a local difference sign-magnitude transform d_p.
- This difference is decomposed into sign s_p and magnitude m_p:

$$s_p = sign(d_p) \text{ and } m_p = |d_p|$$

- The original image is represented by its center gray level, sign and magnitude

- The combination of these operators forms the CLBP feature map

[3] Z. Guo, D. Zhang, and D. Zhang, "A completed modeling of local binary pattern operator for texture classification," Image Processing, IEEE Transactions on, vol. 19, no. 6, pp. 1657–1663, June 2010.

Experimental Results

- Testing four configurations for CLBP descriptor
  - $CLBP_{(8,1)}^{u2}$
  - $CLBP_{(8,2)}^{u2}$
  - $CLBP_{(8,1)}^{riu2}$
  - $CLBP_{(8,2)}^{riu2}$
  - where *u2* is the uniform pattern and *riu2* is the rotation invariant uniform pattern

- Five-fold cross validation method
  - Splitting folds based on patients

- SVM classifier
  - Gaussian kernel and one-*vs*-one approach

Experimental Results

- Measures:
- $sensitivity = \frac{TP}{TP+FN}$
- $precision = \frac{TP}{TP+FP}$
- $specificity = \frac{TN}{TN+FP}$
- $accuracy = \frac{TP+TN}{TP+FP+FN+TN}$

- TP – true positive
- FP – false positive
- FN – false negative
- TN – true negative

Experimental Results

Overall results for the blockwise classification (in %)

	Sensitivity	Precision	Specificity	Accuracy
$CLBP^{riu2}_{(8,2)}$	**78.99**	**75.95**	**93**	**95.55**
$CLBP^{riu2}_{(8,1)}$	75.29	70.84	91.76	94.82
$CLBP^{u2}_{(8,2)}$	74.18	70.76	91.39	94.51
$CLBP^{u2}_{(8,1)}$	72.06	67.89	90.69	94.12

Confusion matrix for the best CLBP configuration (in %)

	Non-lung	Normal	Emphysema	Ground-glass	Fibrosis	Micronodules
Non-lung	**97.5**	0.7	0.17	1.37	0.23	0.03
Normal	0.68	**79.98**	0.78	7.01	0.72	10.83
Emphysema	2.46	19.96	**57.13**	5.51	10.91	4.03
Ground-glass	3.5	24.46	0.26	**39.8**	23.43	8.55
Fibrosis	0.58	1.1	1.86	15.1	**77.6**	3.76
Micronodules	0.02	9.62	0.44	1.42	2.81	**85.68**

Discussion

- Major confusions:
  - Emphysema and normal
  - Ground-glass and normal
  - Ground glass and fibrosis

- Problems:
  - Small inter-class variation between emphysema and normal, and ground-glass and fibrosis
  - Large intra-class variation for emphysema and fibrosis
  - Healthy tissue does not possess a single uniform texture

- Normal tissue, fibrosis and micronodules achieved similar results to the literature
- Non-lung pattern obtained a high sensitivity

Conclusion and Future Work

- Initial results in classification of texture patterns from HRCT of the lung using the CLBP descriptor with a SVM classifier
- Also classifying body areas outside the lungs

- $CLBP_{(8,2)}^{riu2}$ was shown to be the best CLBP configuration
  - Good classification results for non-lung, normal lung, fibrosis and micronodules
  - Multiple misclassifications involving emphysema and ground-glass

- Future work
  - Analysis and quantification of lung diseases patterns
  - Combination of multiple classifiers using *a posteriori* probabilities
  - Lung segmentation based on non-lung pattern

References

- A. Depeursinge, A. Vargas, A. Platon, A. Geissbuhler, P.-A. Poletti, and H. Mller, “**Building a reference multimedia database for interstitial lung diseases**,” Computerized Medical Imaging and Graphics, vol. 36, no. 3, p. 227238, 2011.

- Z. Guo, D. Zhang, and D. Zhang, “**A completed modeling of local binary pattern operator for texture classification**,” Image Processing, IEEE Transactions on, vol. 19, no. 6, pp. 1657–1663, June 2010.

Thank you!

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