# Intelligent Image-based Lung Nodule Classification

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## Background

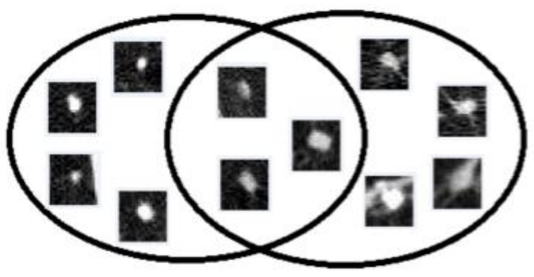
- Lung nodules are small masses of tissue in the lung and typically round in shape; however, they are usually distorted by the surrounding anatomical structures.
- 20% of medical cases with lung nodules represent cancers. Hence, distinguishing malignant nodules from benign ones is essential for early detection of lung cancer.
- Image-based diagnosis computes the quantitative attributes to investigate the correlation between different types of lung nodules.

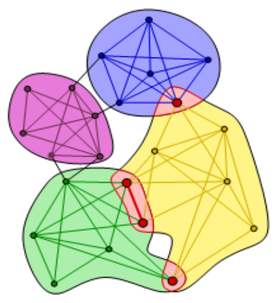
## Dataset

- Early Lung Cancer Action Program (ELCAP) database.
- Provided by the ELCAP and Vision and Image Analysis (VIA) research groups.
- 50 sets of Low-dose computed tomography (LDCT) images.
- 379 lung nodules : W – 57, V – 60, J – 114, P – 148.

## Component 2: Overlapping nodules discovery

**Identify intermediate nodules between different categories**



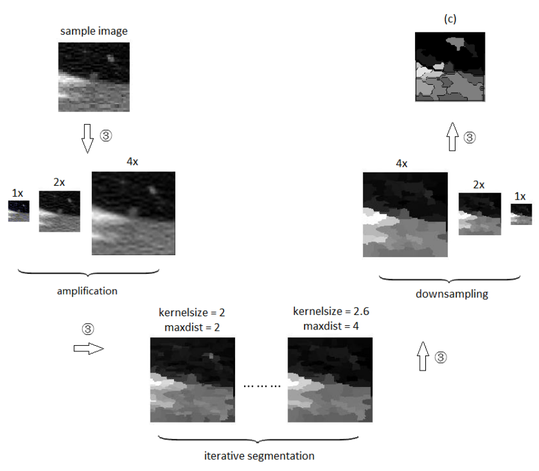


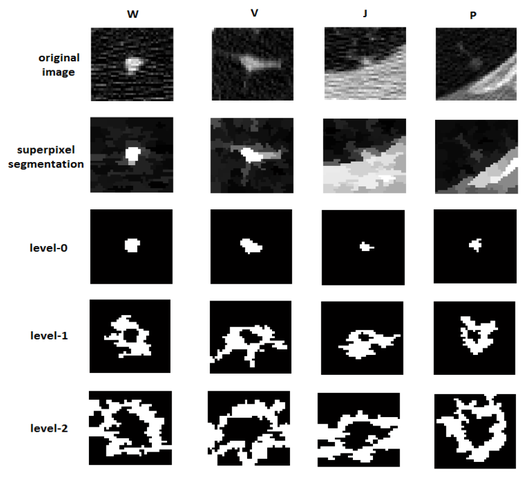
- Descriptor extraction
- SVM classification
- Similarity network construction
- Overlapping nodule identification

## Component 4: Contextual semantic classification

**Contextual analysis : surrounding anatomical structures**

- Concentric level partition
  - Level-nodule and Level-context
- FS3 feature extraction
  - SIFT, MR8+LBP, and HOG
- Latent semantic analysis classification
  - Lung nodule image prediction with contextual voting



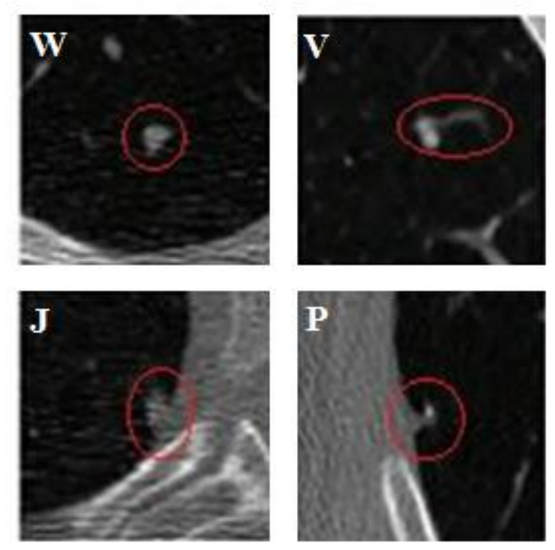




## Lung nodule classification

According to their relative positions to the surrounding structures.

Four categories:

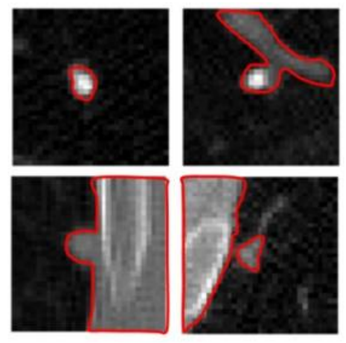
- Well-circumscribed (W)
- Vascularized (V)
- Juxta-pleural (J)
- Pleural-tail (P)

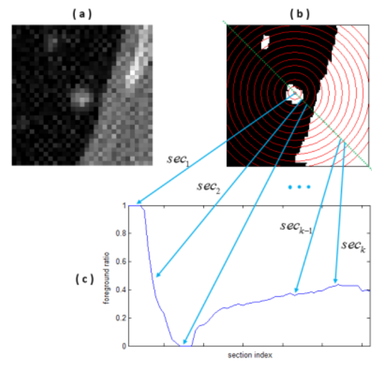



## Component 1: Context curve descriptor

**Feature description including both nodule and surrounding structures**

- Patch division
- Superpixel labeling
- Context curve construction



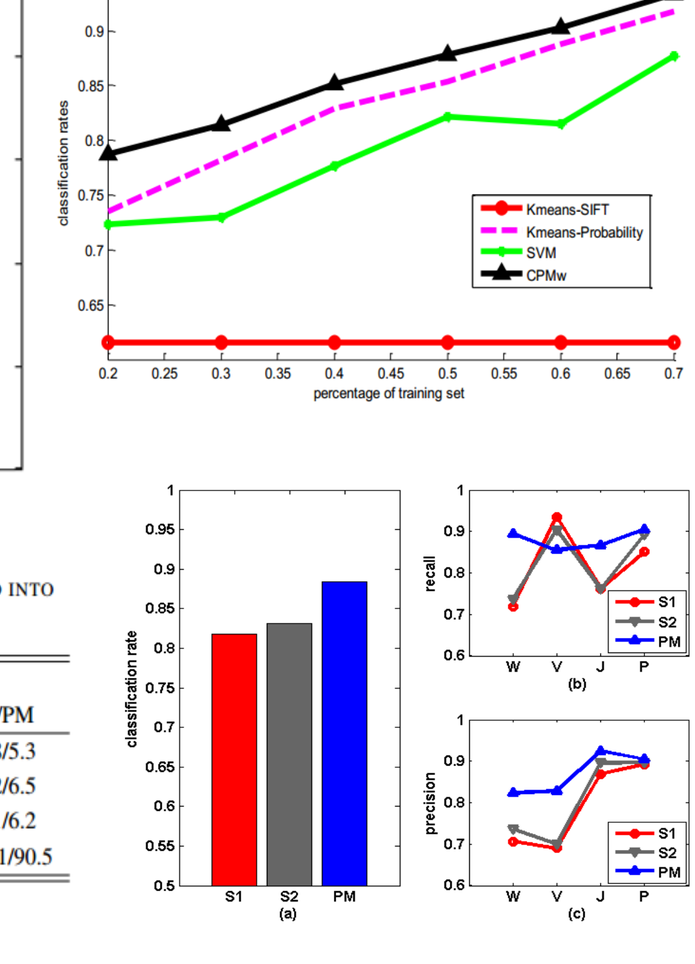



## Component 3: Ranking-based image classification

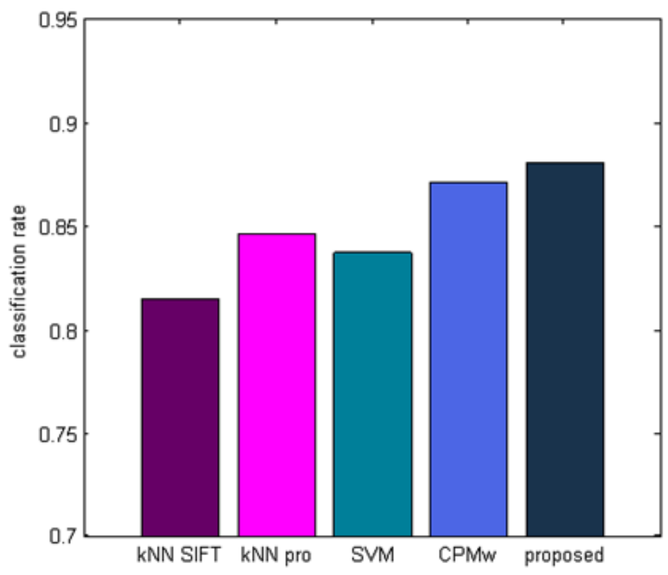
**Semi-supervised method using both labeled and unlabeled images**

- Bipartite graph construction
- Ranking score calculation

**Inputs**: bipartite graph $BG_{Dtr(tp)\text{-}Dte}$, number of iteration $T$
**Outputs**: the ranking score of all testing images $S_{COtp}$
**Steps**:
1. Initializing $Con_0$ with 1 for all training images.
2. for $t = 1{:}T$
   a. Compute $Sco'_t$ using operation 1 with $Con_{t-1}$;
   b. Compute $Con'_t$ using operation 2 with $Sco'_t$;
   c. Obtain $Sco_t$ by normalizing $Sco'_t$;
   d. Obtain $Con_t$ by normalizing $Con'_t$;
   end for
**Return**: $Sco_T$




## Results







CONFUSION MATRIX ON PERCENTAGE OF THE IMAGES CLASSIFIED INTO OTHER TYPES

| | W<br>S1/S2/PM | V<br>S1/S2/PM | J<br>S1/S2/PM | P<br>S1/S2/PM |
|---|---|---|---|---|
| W | 71.9/73.7/89.5 | **14.0/10.5/3.5** | 7.0/7.0/1.8 | 7.0/8.8/5.3 |
| V | 3.2/3.2/4.8 | 93.5/90.3/85.5 | 1.6/3.2/3.2 | 1.6/3.2/6.5 |
| J | 7.1/7.1/2.7 | **9.7/9.7/4.4** | 76.1/76.1/86.7 | 8.8/7.1/6.2 |
| P | 4.8/3.4/3.4 | 4.8/4.8/2.7 | 5.4/2.7/3.4 | 85.0/89.1/90.5 |







## Conclusions:

- Better classification performance compared to the state-of-the-art methods.
- Beneficial for early detection of lung cancer.
- Potentials for large scale imaging data analysis.

## Acknowledgements:

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## Related research publications:

- F. Zhang, Y. Song, W. Cai, M.Z. Lee, Y. Zhou, H. Huang, S. Shan, M. Fulham, D. Feng, "Lung Nodule Classification with Multi-Level Patch-based Context Analysis", *IEEE Transactions on Biomedical Engineering*, Vol.61, No.4, pp1155-1166, 2014.
- F. Zhang, Y. Song, W. Cai, Y. Zhou, M. Fulham, S. Eberl, S. Shan, D. Feng, "A Ranking-based Lung Nodule Image Classification Method using Unlabeled Image Knowledge", *IEEE 11th International Symposium on Biomedical Imaging* (*ISBI* 2014), pp1356-1359.
- F. Zhang, W. Cai, Y. Song, M.. Lee, S. Shan, D. Feng, "Overlapping Node Discovery for Improving Classification of Lung Nodules", *The 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (*EMBC* 2013), pp5461-5464.
- F. Zhang, Y. Song, W. Cai, Y. Zhou, S. Shan, D. Feng, "Context Curves for Classification of Lung Nodule Images", *The International Conference on Digital Image Computing: Techniques and Applications* (*DICTA* 2013), pp185–191 .