Diagnostic Image Analysis of Chest Computed Tomography Scans

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CS585
Project Team

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Clinical Motivation

- Emphysema
- Asthma
- Metastasis of breast, prostate, colon cancer, melanoma, etc
- Lung cancer
Metastatic Disease

8.2 million people with a history of cancer in the US.

Chest Computed Tomography (CT):
- Diagnose pulmonary metastasis of oncology patients.
- Evaluate response to treatment regimens.

Repeated CT studies:
Determine growth rates of pulmonary nodules.
“New” low-dose helical CT scan technology: Screen patients at high risk for primary lung cancer?

Lung cancer kills 160,000 people in the US per year.

5-year survival rate of lung cancer patients: 15%

Early detection and resection at Stage I: 5-year survival rate: 70%
Partial Volume Effect
Long-term Research Goal

- Automated, quantitative, and efficient image analysis system to support radiologists in evaluating chest CT scans.

- System may improve patients' prognosis.
Research in my group

1. Chest landmark detection
2. Thorax, lung, fissure, trachea, and nodule segmentation
3. Nodule shape analysis
4. Registration of lung surfaces, nodules, vessels
5. Nodule detection and classification
6. Phantom studies for validation purposes
Landmark Detection

- Trachea, Carina
- Sternum
- Spine

Detect landmarks using correlation of online templates

$$\sum (I - E[I])(q - E[q]) / (\sigma_I \sigma_q)$$
Lung Segmentation
Contour Smoothing
3D Connectivity
3D Lung Surfaces
3D Lung Surfaces
Anterior Junction Line Problem
Solution to Anterior Junction Line Problem
Find Structures within Lung

- Convert to binary image
- Find connected components
- Label connected components
Classification of Lung Structures

pink: nodule
blue: vessel
Circularity Measure
Shape: Round or Elongated?

Axis of least inertia:
Direction of elongation =
Line for which sum of square of distance to points in object is a minimum

\[ E = \sum \sum r^2 \quad 0 \leq E_{\text{min}}/E_{\text{max}} \leq 1 \]

\[ E = \frac{1}{2} (a+b) - \frac{1}{2} (a-c) \cos 2\theta - \frac{1}{2} \sin 2\theta \]

\[ \sin 2\theta = \pm \frac{b}{\sqrt{b^2 + (a-c)^2}} \]

\[ \cos 2\theta = \pm \frac{a-c}{\sqrt{b^2 + (a-c)^2}} \]
Classification via Horizontal Regions
Classification Rules

- 2D axial area
- Distance to lung centroids
- Distance to lung border
- Shape:
  - Elongated: vessels, round: nodules
- Evaluate shape by computing
  - Ratio of axes of second moments
  - Percentage of pixels within circumscribing circle
Nodule Detection Results

Detected Nodules: 86%

Small Nodules Missed: 10%
Medium Nodules Missed: 3%
Large Nodules Missed: 1%

318 / 370

Radiology January 2001
Data Science Bowl 2017: Can you improve lung cancer detection?

Data: > 1,000 CT scans

Ground truth: Will this patient be diagnosed with lung cancer within one year of the date of the scan? Yes or No?

Competition 1st stage: training and testing data, 2nd stage: additional test data

BU team from AI class: ranked in 300s