Automatic Identification and Classification of Tuberculosis Findings on Chest Radiographs for Global Surveillance Programs

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Presenter Disclosures/ Disclaimer

- Potentially related
  - Issued patent on CT processing/viewing method
  - Patent Pending on portable imaging inclinometer
  - Books published
    - Chest Imaging: An Algorithmic Approach to Learning
    - Combat Radiology
- Unrelated
  - Research agreement with Carestream Health
  - Patent Pending on CT compression to mp4

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Background

- One third of world population infected with TB*
  - Countries with high TB incidence screen with CXR **
  - Many with disproportionally reduced number of radiologists

Purpose

- Develop automated TB classification algorithm
  - In addition to abnormality detection on chest x-ray
- Evaluate ability to detect and classify (future)
- Help curtail spread of tuberculosis internationally
  - With improved TB mass-screening and surveillance

* CDC Global Tuberculosis Elimination: http://www.cdc.gov/globalhealth/programs/tb.htm

Methods

- Two radiologists identified abnormal findings
  - In 342 CXRs of patients with confirmed TB
    - From The Shenzhen No. 3 People’s Hospital in China
    - Compared to normal CXR
    - Annotated each CXR on Firefly annotation tool*

* firefly.cs.missouri.edu
University of Missouri

CXR Annotating Process

1. Identify and classify each abnormal finding
2. Choose drawing tool that approximates shape
   - Polygon, circle, dot, etc.
3. Outline each abnormality on the CXR

Radiologists applied intentional over-reading
  - Advocated by the WHO Lime book*

Finding Classification, Shape

- Select one of 17 classifications
  - Nodule, infiltrate, cavity, etc.
  - Severities/ extent

* World Health Organization: Tuberculosis prevalence surveys: a handbook
  http://www.who.int/tb/advisory_bodies/impact_measurement_taskforce/resources_documents/thelimebook/en/
Example infiltrate

Few nodules

Segmented infiltrate

Example annotated mild effusion/thickening

Automated Classification

1. Lung fields are segmented (identifies ROI)  
   (image of lung outlined)
2. Features are computed within ROI  
   Histogram analysis (i.e. nodules have peaks)
3. Feature vectors are classified (normal or not)  
   TB or not TB is work in progress..

System Architecture

Detect Lung Fields

Identify anatomical structures (ribs, heart, aorta, etc.)

From the remaining structures extract features that describe TB patterns: nodules, collapsed lungs, ...

2-Class Classifier

Normal Case

Abnormal Case

1. Lung Segmentation

Original image

Lung detection

Rib detection

Methods: 2. Feature Computation

- Compute histogram-based texture features
  - Including histogram of gradients (HOG),
  - Local binary patterns (LBP) and other features
- Features concatenated into a single feature vector
  - i.e. String of numbers for each chest x-ray image
- Resulting strings are used to train and test linear support vector machine (neural network best)
- Classifier assessed by AUC through cross validation
  - Compared with same number of normal CXR's

Results

- Radiologists labeled 1671 abnormal findings in 342 CXRs
- Our system classified CXRs as either normal or abnormal
  - With 95% AUC (area under ROC curve)
  - Sensitivity and specificity is 99.76%
- Abnormalities are classified with variable accuracy;
  - Infiltrates were correctly classified in 90% of cases
  - Severity were correctly graded in 87% of cases
- Degree of similarity (using feature-specific distance function)
  - Between previously annotated regions and suspicious regions
  - In newly presented CXRs for interactive computer-aided diagnostics

Global Deployment Aims

- Prevents losing patients from rural clinics
  - Immediacy, minimizes disease spread, etc.
- Triage: severe patients get images read first
- Reduce radiologist footprint
  - From days to hours (since radiologists are scarce)
- Commonly two scenarios
  1. Patients without prior drug treatment
  2. Avoid drug incompatibilities in HIV infected

Kenya Initial Experience

- Automated system now in place in Africa
  - Associated with mobile/portable x-ray in Kenya*

*[X-ray Truck Visits Rural Kenya. RSNA News. Feb 2015.]

Initial Field Results

- CXR on 40 patients per week
- Initial pilot suggests no false negatives
  - Similar rate of published over-reading**


Significance of Conclusions

- Potential for automated TB identification/classification
  - Based on our pilot radiologist/automation comparison
- Current prototype discerns abnormalities in 95%
- Our resultant statistics provide clues
  - To frequency/common locations of TB manifestations
- Help establish TB/HIV screening in developing regions
  - Per WHO recommendations
• Images now available on line*
• Segmented dataset will soon be available
• Labeling: looking for volunteer radiologists

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4256233/

Thank you….

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References


• TB Screening: