Applying Artificial Intelligence and Radiomics for Computer Aided Diagnosis and Risk Assessment in Chest Radiographs

Introducing

- In areas of urban China, air pollution and particulate exposure seriously affect population lung and cardiovascular health.
- The incidence and severity of lung and cancer diseases progressively increase each year.
- Chest radiography is the most utilized imaging technique among all modalities because it provide an overall health condition aiding diagnosis for the thoracic region.
- In China, chest radiography is also a standard procedure for the annual physical health exam and for job entry.
- Over 800 million chest radiographs annually are interpreted in China for multiple diseases by wide varieties of radiologists ranging from small amount of highly experienced to large amount of less or little experienced radiologists, who may have inadequate formalized training.
- For these reasons timeliness of accurate interpretation can be poor.
- Excluding infection and trauma, most chest diseases are not acute. By the time symptoms become obvious or severe, the condition is already advanced.
- Salient signs in “normal” chest radiographs can be used to analyze the disease risk for diseases and image examinations which need further, urgent review.
- Further development of computational decision support tools should improve diagnosing multiple diseases earlier and analyzing risks for clinically asymptomatic patients from chest radiographs; and thus will improve the quality of healthcare.

We developed multiple machine learning and artificial intelligence technologies for radiomics on chest radiographs as an integrated automatic system to assist radiologists in detecting TB, tumors, pneumonia, and heart diseases as well as in analyzing scoliosis, chest region, and contrastive follow-up images. Our system can also assess the risk for potential heart disease, COPD, tuberculosis, and pneumonia based on the costophrenic angle (CTR), costophrenic angle, and diaphragmatic surface evaluation, analysis of small abnormalities, and appearance of lung markings, as shown in Figure 1.

We have applied a graph-cut based segmentation of the lung region, a partitioning of the lung into different zones, a set of texture and shape features, and a transfer learning. Our system can also assess the risk for potential heart disease, COPD, tuberculosis, and pneumonia based on the costophrenic angle (CTR), costophrenic angle, and diaphragmatic surface evaluation, analysis of small abnormalities, and appearance of lung markings, as shown in Figure 1.

A diagnostic report, such as the example shown in Figure 2, is generated for each disease to associate image findings with clinical diagnoses based on a temporal subtraction method to highlight the pathologic change across serial chest radiographic images using rigid body transformation based on its findings, measurements, explanation and advice for a patient.

Figure 1: Overall system schematic diagram showing detection of diseases, assessment of risk, and analyze of abnormalities on chest radiograph.

Figure 2: An example of diagnostic report including image, its findings, measurements, explanation and advice for a patient.

Methods

- One of the first automatic systems in a hospital for diagnosis of more than one lung abnormality on chest radiographs
- The first one to automatically assess risks for various diseases in chest radiographs of asymptomatic individuals
- Automatically associate image findings with diagnostic reports
- Stored in electronic health/medical records (EHR/EMR)
- Provide health management capability

Figure 3: CTR distribution diagram from 399 femal and 388 man. The average, value is 431.35(femal), 445.35(male).

Figure 4: Lung area distribution diagram from 347 femal and 296 man. The average value is 438.2 cm² (femal), 442.5 cm² (male).

Figure 5: Temporal Subtraction of two CXR taken from same patient. Dark areas in the subtracted image shows the internal changes of the symptom.

Figure 6: An example of follow up health chart for a patient showing the changes of lung area, thorax, diaphragmatic surfaces, costophrenic angle, and CTR with a list of possible abnormalities over a period of time.

No
Clinical Application
1. Identification of the lung region
2. Chest x-ray screening during annual physical exam
3. Identification of TB-suspectious cases
4. Thresholds between high-risk and low-risk
5. Changes of lung area, thorax, diaphragmatic surfaces, costophrenic angle, and CTR with a list of possible abnormalities over a period of time

Performance
- 20% of individuals selected to be read by doctors
- False positive rate: 7%
- Sensitivity: 99.3%
- False positive rate: 7%
- CTR: 0.43
- Costophrenic angle: 45-degree
- Lung markings distribution in the peripheral region: 20%