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

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Introduction

• In urban areas of China, air pollution and particulate exposure seriously affect population lung and cardiovascular health.
• The incidence and severity of lung and lung diseases progressively increase each year.
• Chest radiography is the most utilized imaging technique among all modalities because it can provide an overall health conditions 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.

Methods

• 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 conotruncal follow-up images.
• Our system can also assess the risk for potential heart disease, COPD, tubules, and pneumonia based on the carotid-to-thoracic ratio (CTR), carotid-ophthalmic angle and diaphragmatic surface, and analysis of small abnormalities, and appearance of lung markings, as shown in Figure 1.
• These technologies were applied on 2,376 chest radiographs with pathological or follow-up confirmation of various diseases, acquired from hospitals in China and in the U.S. Additionally, over 400 healthy patients with longitudinal chest radiographs and confirmation of disease onsets have also been collected for the evaluation of the performance for risk assessment.
• 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 classification into normal or abnormal using various machine learning algorithms including support vector machine, convolutional neural network, and transfer learning.
• Because a large number of abnormal manifestations are obscured by bones, we further applied a bone suppression method to remove the ribs and clavicles from a chest radiograph in order to reveal the tissue beneath, using rib and clavicle structure detection and deep learning, and profile estimation. We also applied a temporal subtraction method to highlight the pathologic change across serial chest radiographic images using rigid body transformation based on a global alignment criterion, piece-wise image warping under the maximum cross-correlation criterion, and subtraction between the registered previous and current images. Multiparametric analysis across multiple modalities including imaging and patient survey information is also applied to further improve the diagnostic accuracy.
• 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 reinforcement learning Markov decision processing.

Results

• 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

Discussion

• An integrated system based on artificial intelligence, radiomics, advanced image processing to detect abnormalities and to assess the risk for various chest and heart diseases.
• Transfer radiological findings from images to electronic medical records (EMR).
• Health charts provides a summary of the analysis for effective communication and tracking of findings for health management for each individual.
• Use of this system can improve the diagnostic accuracy, shorten the diagnostic time, assess progress of disease, and improve efficiency of health providers.

Conclusions

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