Computer Aided Diagnosis System for Early Detection of Lung Cancer Using Chest Computer Tomography Images - Summary

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Presented by

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In this paper, we present an automatic computer-aided diagnosis (CAD) system for early detection of lung cancer by analyzing chest 3D computed tomography (CT) images.

The proposed CAD system is capable of detecting lung nodules with diameter ≥ 2 mm.

Steps followed by the CAD:

1- Lung regions are extracted automatically.
2- The extracted lung regions in each slice are segmented. These regions (structures or objects) forming the segmented lung may include true lung nodules and normal structures consisting mainly of blood vessels.
3- A set of diagnostic rules has been formulated based on the extracted features, which aims at eliminating (as much as possible) non-cancerous candidate nodules or false positives (FP's) without sacrificing cancerous candidates or true positives (TP's).

Some statistics:

The mortality rate of lung cancer is the highest among all other types of cancer. Lung cancer is one of the most serious cancers in the world, with the smallest survival rate after the diagnosis, with a gradual increase in the number of deaths every year. The earlier the detection is, the higher the chances of successful treatment are.
An estimated 85% of lung cancer cases in males and 75% in females are caused by cigarette smoking.
In 2005, approximately 1,372,910 new cancer cases are expected and about 570,280 cancer deaths are expected to occur in the United States. It is estimated that there will be 163,510 deaths from lung cancer, which forms 29% of all cancer deaths. The overall survival rate for all types of cancer is 63%. Although surgery, radiation therapy, and chemotherapy have been used in the treatment of lung cancer, the five-year survival rate for all stages combined is only 14%. This has not changed in the past three decades.
In the current clinical practice, hundreds of thin-sectional CT images (300-600) are generated for each patient and are evaluated by a radiologist in the traditional sense of looking at each image in the axial mode, something very difficult to interpret and very time consuming to radiologists, which may cause high false-negative rates for detecting small lung nodules, and thus potentially miss a cancer. The underlying idea of developing *A CAD system is not to delegate the diagnosis to a machine, but rather that a machine algorithm acts as a support to*

<u>the radiologist and points out locations of suspicious objects, so that the overall sensitivity (detection rate) is raised</u>.

<u>CAD systems meet four main objectives, which are:</u>

- Improving the quality and accuracy of diagnosis.
- Increasing therapy success by early detection of cancer.
- Avoiding unnecessary biopsies.
- Reducing radiologist interpretation time.

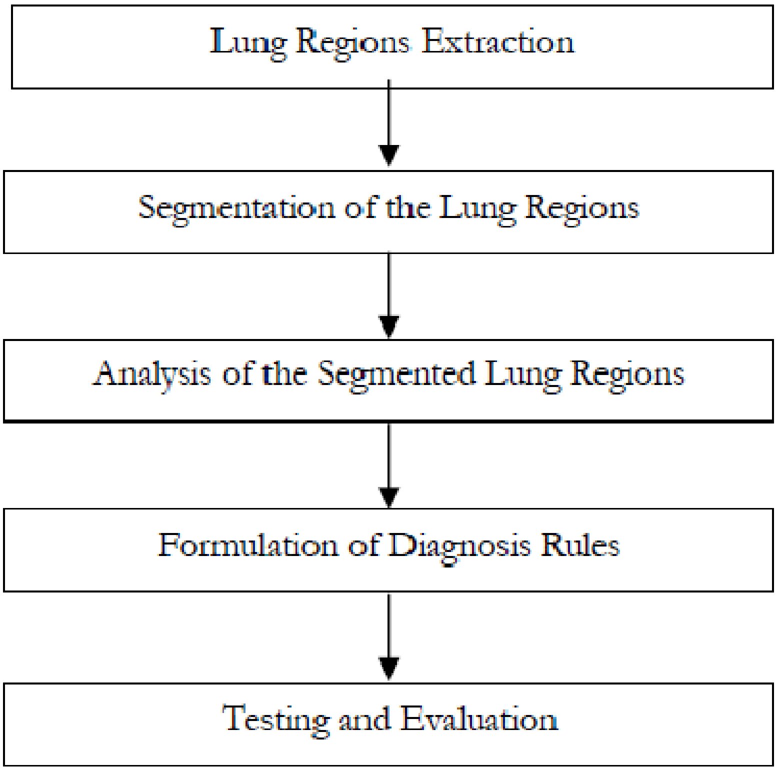


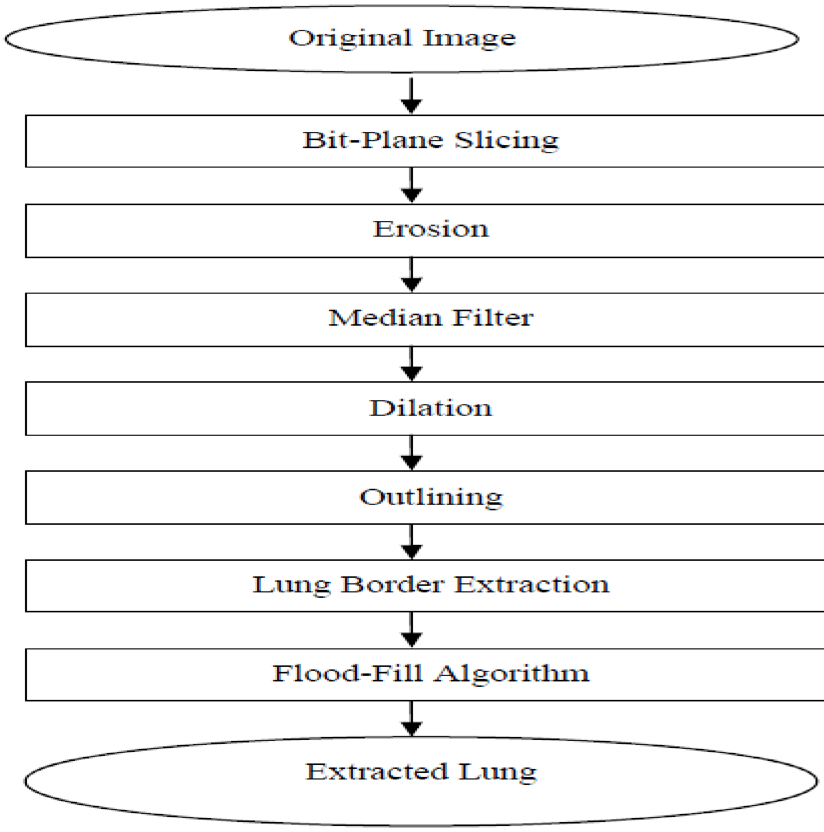
Figure 1. The Lung Cancer Detection System.

<u>System steps in more details:</u>

1- <u>Lung region extraction:</u>

A CT image of chest consists of different regions such as the background, lung, heart, liver and other organs' areas. The goal of lung region extraction step is to separate the lung regions, our regions of interest (ROIs), from the surrounding anatomy structures.

A figure that summarize the extraction steps



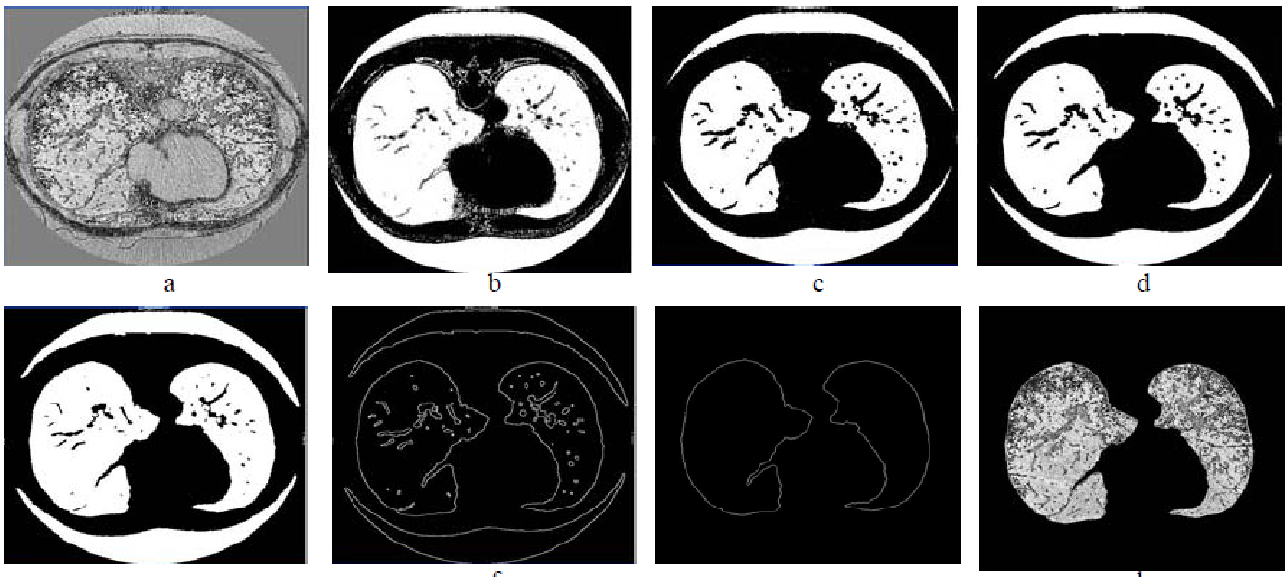


Figure 4. Lung regions extraction algorithm: a. original CT image, b. bit-plane-2, c. erosion, d. median filter, e. dilation, f. outlining, g. lung region borders, and h. extracted lung.

2- <u>Lung regions segmentation:</u>

- This step aims to segment the extracted lung regions searching for cancerous cells candidates –our new region of interests (ROIs)-.
- ***Hopfield Artificial Neural Network (HANN)*** is used in the proposed system for the segmentation of the extracted lung regions.
- The HANN segmentation results are accurate and homogeneous. In addition to that, HANN takes short time to achieve the desired

segmentation results. By experiment, HANN needs less than 120 iterations to reach the desired segmentation results (i.e. about 9 seconds on average).

"For more details about HANN and segmentation review the paper."

3- Feature extraction and formulation of diagnostic rules:

A. Feature Extraction

In the literature we found among the features used in the diagnostic rules:

- Area of the candidate region.
- The maximum drawable circle (MDC) inside the candidate region.
- Mean intensity value of the candidate region.

B. Formulation of Diagnostic Rules

Rule 1: For each candidate object, if the area of the object is less than a threshold value T1 delete it from the candidate list. Applying this filter has the effect of decreasing the number of false positives that richly exist in the initial candidate objects. This decision may reduce the computation time needed in the following diagnostic rules.

Rule 2: For each candidate object, if the value of maximum drawable circle (MDC) of this object is less than a threshold value T2 delete it from the candidate list. We chose T2 to be 2-pixels radius size, which means that any candidate objects with
MDC less than 2-pixels radius size should be eliminated since it is away from being a nodule, and very close from being blood vessel. This rule is based on the medical fact that says that true lung nodules exhibit some circularity especially small lung nodules. ***Applying this filter has the effect of eliminating large number of vessels, which in general have a thin oblong, or line shape.***

Rule 3: For each candidate object, if the value of the mean intensity value of this object lies outside a specified range, i.e. between T3 and T4, delete it from the candidate list. Medical information and experimentation lead as to choose the right values for both thresholds T3 and T4. The values we used are -9000 CT-intensity value for the threshold T3 and -12500 CT-intensity value for the threshold T4. Applying this filter has the effect of eliminating further more false positives.

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After applying all the filters we stay with no or very small number of cancerous candidate objects. The CAD system marks all the remaining candidates as possible cancerous regions. Then the images concerned with these regions should be reported and displayed to radiologists to take their final decision about the candidate, either malignant cancer, benign tumor or not at all.

This implies that the proposed ***CAD system is not aimed to replace radiologists; it is aimed to assist radiologists and provide them with a tool that may help them*** in detecting lung cancer at early stages by alerting them to possible abnormalities. Improving the accuracy of detection and reducing the time spent by radiologists in analyzing huge number of slices per patient (more than 300) is also one of the main objectives of the proposed CAD system.

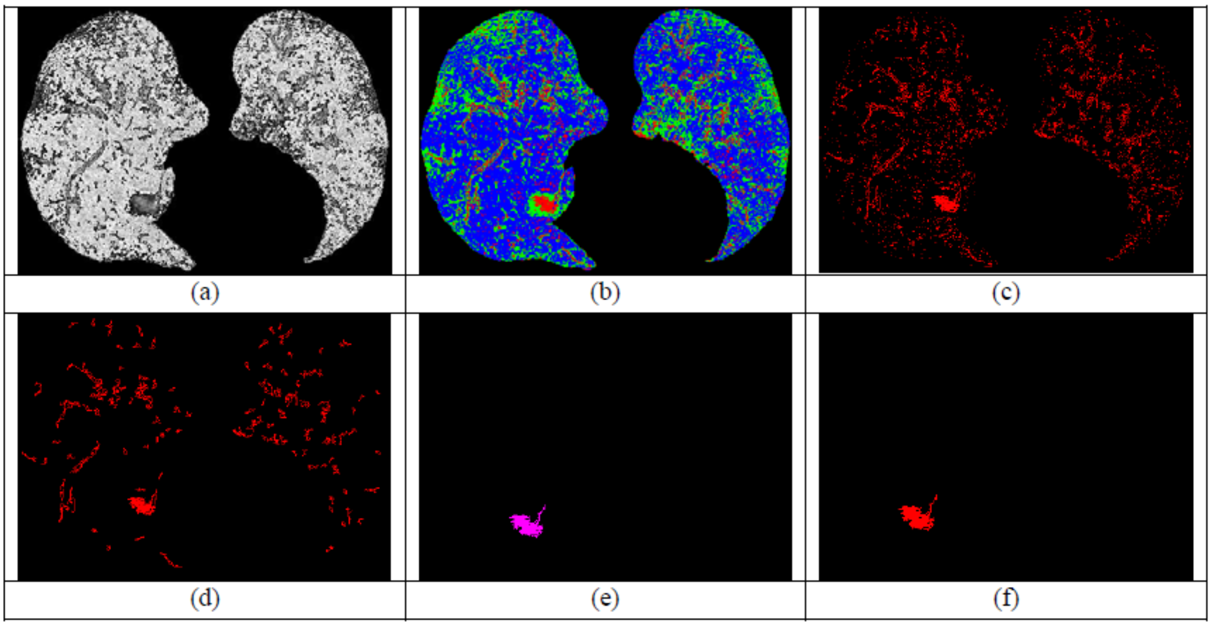

Figure 5. Applying the diagnostic rules: (a) extracted lung regions, (b) HANN segmentation results, (c) initial cancerous candidates, (d) the remaining candidate after applying filter 1, (e) the remaining candidates after applying filter 2, and (f) the final candidates after applying filter 3.