A Study on Computed Tomography Based Technique for Predicting Prognosis in Patients with Chronic Pulmonary Lung Disease (COPD)

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Abstract

Recently, there has been a gradual increase in research on diaphragm functions fused with computer engineering-related techniques in the medical field. Therefore, this paper proposes a technique for evaluating the function of the diaphragm through chest computed tomography for chronic obstructive pulmonary disease (COPD) substitution. The proposed technique utilizes a patient's chest segmentation algorithm to extract the diaphragm region from 2D slice images, and calculate the dynamic change experienced during breathing by calculating the diaphragm area and volume difference during inhalation and exhalation.

Keywords: Digital image processing, Medical image computing, Computed tomography, Chronic obstructive pulmonary disease, Diaphragm segmentation

1 Introduction

Chronic Obstructive pulmonary disease (COPD) is mainly characterized as progressive irreversible obstruction of airflow to the lungs and has become a severe health problem in some patients leading to a fatal effect on diaphragm function, In COPD patients, the diaphragm is the most important muscle in breathing and is closely related to the patient's dyspnea symptoms and the mobility of the diaphragm. Despite the fact that the analysis of CT images has been actively used to diagnose many lungs disease, only a few research has been conducted to evaluate lung function based on the mobility of the diaphragm.

2 Related Work

COPD is comprised of two main components, which are emphysema and small airway disease. Previous studies show the results of a quantitative CT assessment significantly correlate with the COPD exacerbation frequency independent of the severity of airflow limitation. Also, Automated quantitative analysis techniques have been developed to segment the lung parenchyma and airways from the chest wall and surrounding structures. Furthermore, a high-resolution Computed Tomography-based approach has also been implemented in diagnosing patients with Fibrosing Interstitial Lung Disease.

3 Experimental Design

The figure 1 explains the process in which 2D images (DICOM Images) of the COPD patients are first analyzed and converted the JPEG images and thereafter the segmentation of the diaphragm region is conducted. Finally, the segmented diaphragm region is visualized in 3D image format.

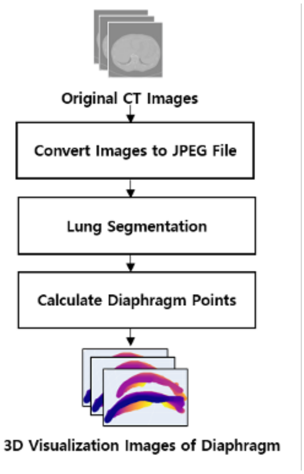

Fig. 1: Flowchart describing the diaphragm segmentation procedure

4 Technique Interpretation

4.1 Background

As shown in figure 2, the position of the diaphragm during inhalation and exhalation is different, hence the algorithm 1 is used to obtain continuous diaphragm points during inhalation or exhalation and merge them for 3D visualization.

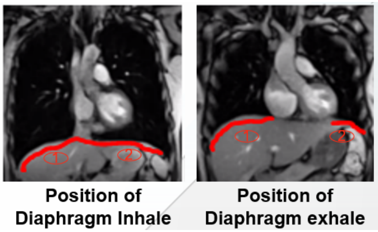

Fig. 2: Flowchart describing the diaphragm segmentation procedure

4.2 Algorithm

To provide a systematic approach on performing the Computed Tomography Based Technique (CTBT) for predicting prognosis in patients with COPD the following steps are implemented.

First, Dicom images are viewed through the Dicom viewer known as Horos. Afterward, the Dicom files are converted to JPEG images. Second, the segmentation of the lungs is conducted first, and then the diaphragm region is segmented using the OpenCV library. Third, the extreme X and Y axis points are determined. In order to determine the exact diaphragm area, calculate the second monotonic change point (SMP) from the point with the largest y value to the extreme point of x (point with the largest x value for the left lung, point with smallest y value for the right lung). If it fails to find the SMP, the point where the first slope is 0.5 is regarded as SMP. Finally, linearly interpolate the resulting array.

5 Result

Figure 3 compares the 3D results obtained after conducting segmentation of a patient with COPD (Patient 1) and another patient with acute exacerbations of COPD (Patient 2).

Table 1 shows the lung capacity of the two patients. The difference in volume between the two 3D images indicates a lung capacity difference.

Algorithm 1 Procedure for extracting diaphragm points from CT images of lungs during inhalation or exhalation

Ensure: One based indexing for the DCM images
Input: m, n represent the start and end index of the manually selected lung slice image with the diaphragm.
Output: PTS represents the array of linearly interpolated diaphragm points.

procedure EXTRACTPOINTS(DCM_k, m, n)
    $PTS \Leftarrow$ new Array
    for $i = m : n$ **do**
        $JPG_i \Leftarrow$ DCM2JPG(DCM$_i$)
        $HSV_i \Leftarrow$ BGR2HSV(JPG$_i$)
        $ROI_i \Leftarrow$ COLOR_SEG(HSV$_i$, *lower_bound*, *upper_bound*)
        $contours_i \Leftarrow$ CV_FIND_CONTOURS(ROI$_i$)
        $x_{extreme}, y_{\max} \Leftarrow$ GET_EXTREME_POINTS(contours$_i$)
        $SMP \Leftarrow$ 2ND_MONOTONIC(x$_{extreme}$, $y_{\max}$, $contours_i$)
        if $SMP = Null$ **then**
            $SMP \Leftarrow$ ONE_HALF_SLOPE_POINT(x$_{extreme}$, $y_{\max}$, $contours_i$)
        end if
        $TMP_{PTS} \Leftarrow$ contours$_i$[IND(y$_{\max}$), IND($x_{extreme}$)]
        $TMP_{PTS} \Leftarrow$ LINEAR_INTERPOLATION(TMP$_{PTS}$)
        PTS.INSERT(TMP_{PTS})
    end for
    return PTS
end procedure

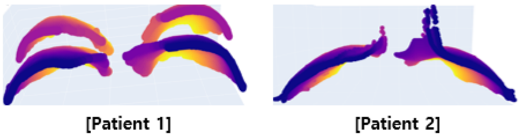

Fig. 3: Comparison Between patients with COPD

6 Conclusion

In this paper, after further research on the proposed tomography-based technique, it can be actively introduced into clinical practice through automatic measurement algorithms, this approach has the tendency to aid in respiratory rehabilitation in patients with chronic obstructive pulmonary disease and can induce the patient's independent function recovery thereby increasing the chances of survival.

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Table 1: Lung Capacity in both patients

Dataset	Lung Capacity (%)
Patient 1	72%
Patient 2	35%

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