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A NEW PROCEDURE FOR AUTOMATIC PATH PLANNING IN BRONCHOSCOPY

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1. Introduction

Lung cancer can be diagnosed using a bronchoscopy procedure together with a biopsy from the affected area, performed using a forceps introduced through the working channel of the bronchoscope in order to obtain a tissue specimen from the prospective tumor location. Virtual bronchoscopy is a very useful tool that can be used for a proper planning of the real bronchoscopy or even to replace it if considered too invasive, for example in case of children [1]. Software applications for virtual bronchoscopy are based on the segmentation of the tracheobronchial tree from the medical image scan which is a difficult operation, both conceptually and from the computer implementation and running time point of view.

In this paper, a method for bronchoscopy procedure planning that does not require such a segmentation is presented.

2. Description of the method

The method is based on the discretization of the 3D reconstructed CT scan in voxels. A Hounsfield unit value corresponding to the gray scale from CT is assessed to each voxel. Airways tubes will be the voxels having the Hounsfield unit values of the air, taken in this research between –1100 and –850. Based on the 3D image volume discretization, two geometric methods are implemented: i. A “line” tool that enumerates the voxels intersected by a certain line segment between two points and ii. A “wave” tool that creates iteratively a certain wave surface centered on a fixed voxel and that enumerates the voxels of a specific wave generation.

In the set of 2D projections of the CT data, the user selects the starting point and the target point which will appear in the 3D image of the medical data. If, according to the Hounsfield value of the voxel containing the target point, this point is not inside the airways, it is projected using the wave tool iterator inside the “nearest” air tube. Then, a path is automatically generated through voxels containing Hounsfield values for air between the starting point and the projected target point using a modified version of the A* algorithm [2]. The user validates the generated path by manual navigation through the lung airways, using the mouse.

3. Skin removal

The view of the lungs in the 3D reconstructed volume may be blocked by other body tissues that have similar Hounsfield value as the lungs. These layers can be removed from each slice considering the cylindrical organization of the chest volume on layers: skin (outside layer) – fat tissue (middle layer) – lungs tissue (inside layer). A view of the slices after skin removal is shown in Fig. 1.

4. Virtual navigation and collision detection

In this method, virtual navigation through the lungs and airways can be undertaken using a computer mouse with three buttons. The 3D visualization camera is rotated around its own axes

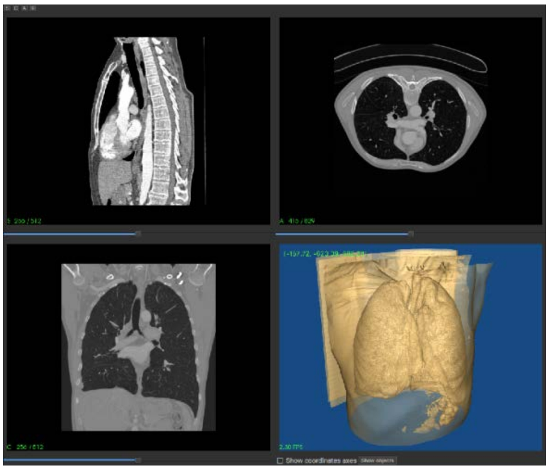

Fig. 1. Axial, sagittal, coronal slices and Lungs 3D view after "skin removal" algorithm is applied

with mouse drag operations, through quaternion computations that implement a method known as “arc ball” rotation. Once a mouse click and drag operation is started, the camera is rotated in such manner that the point in 3D space perceived under the mouse position when the operation is started will remain in the same position during dragging. Translations are done along the 3D axes perpendicular to the screen, and rotations can be performed around the same axes to better simulate the bronchoscope rotations. The camera view angle and other view parameters can be modified from the software application interface.

In order to constrain the visualization camera to remain always inside the airways, an algorithm for collisions detection and resolution is used. The algorithm is adapted from the one presented in [3], with the main improvement that, in the new one, there is no segmentation of the airways. Only the Hounsfield values for the voxels and the “line” tool iterator are used to detect the collision and to find the position where the camera trajectory intersected the lungs tissue. For the collision resolution, the gradient in the collision place is used to move camera back “inside” the airways tube.

5. A* algorithm and automatic path

The A* algorithm tries to find the shortest path from a starting voxel to a destination voxel iterating from one neighbor voxel to another until the destination is reached.

For virtual bronchoscopy, it is important to find the airways tubes that form the path from the trachea to the area of interest. An automatic path and the manual validation are shown in Fig. 2.

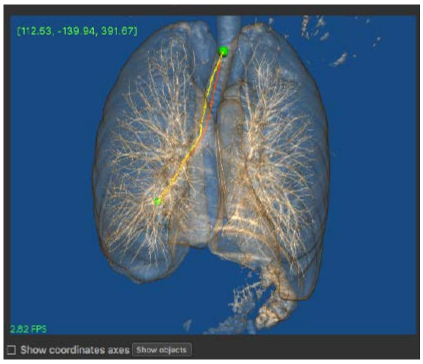

Fig. 2. Automatic generated path, yellow, and manually validation with virtual bronchoscopy, red

6. Conclusions

In this paper, a method for path planning in bronchoscopy interventions is described. The method has the advantage that it does not need segmentation of the tracheobronchial tree from the medical image scan. The procedure is very easy to use and navigation through airways can be performed using only the computer mouse.

Together with a system for tracking the bronchoscope during the real procedure, this method can improve the diagnostic success rate and decrease the discomfort perceived by the patient.

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