We developed a hybrid algorithm for the extraction of the vessels of the lung. The main steps of our algorithm are: (1) Preprocessing, (2) Automatic seed generation (3) Extraction of the medial-axes (4) Reconstruction of the vessels, and (5) Post-processing.

In the preprocessing, we multiply an input CT data by its corresponding mask to remove the tissues outside the lung. Finding the ROI of the data that is to be processed is a fundamental task in all step of our algorithm. It reduces the size of the data and increase the runtime of the code. Then, we threshold the data in the range of the intensities of the vessels. This range is found interactively. Except for this step, our algorithm can be considered as an automatic method. To remove non-tubular structures and enhance the vessels, we employ a modified Frangi filter (A. F. Frangi, W. J. Niessen, K. L. Vincken and M. A. Viergever, "Multiscale vessel enhancement filtering," in Proc. 1st MICCAI, 1998, pp. 130-137). To better segment small vessels, the data is interpolated and its size is doubled in each direction. Thus, the size of the data is increased by 8 times. Assuming a typical lung dataset with pixels of float type, it means that we have to deal with a volume of about 1.7 GBytes. Processing such a huge data needs special hardware and processing equipments. To run our code on available hardware, we divided the volume into 8 equal sub-volumes and processed each individually. Later in the post-processing step, the separate results were integrated with each other to form a single volume.

Since we find the medial-axes of the vessels by a tracking approach, we have to generate seeds. Thus, we enhance the medial-axes of the preprocessed vessels by a method of "Multiscale Medialness". We employ a thinning algorithm to find the skeletons of the axes. Then, we use a graph-based analysis to find the branches of the vessels. Pruning of the results removes non-vessel structures in each step. The middle points of the branches are used as the seeds for the tracking approach. The positions of the seeds are adjusted and then the tracking algorithm starts. We also estimate the radius of the vessels in this step. The extracted axes and their estimated radii are used to model the vessels by tubes.

Our algorithm was designed to be applied on both normal and abnormal lung CT datasets. It has no training stage. The major problem with our algorithm is its run-time. The time needed to process a typical data was about 6 hours. The platform on which we ran our code was a MS-Windows® based personal computer (Intel® Core™ – i7 2.2GHz and 8GB-DRAM).