NEW METHODS IN CT-BASED COMPUTER-ASSISTED RISK ANALYSIS IN LUNG CANCER SURGERY

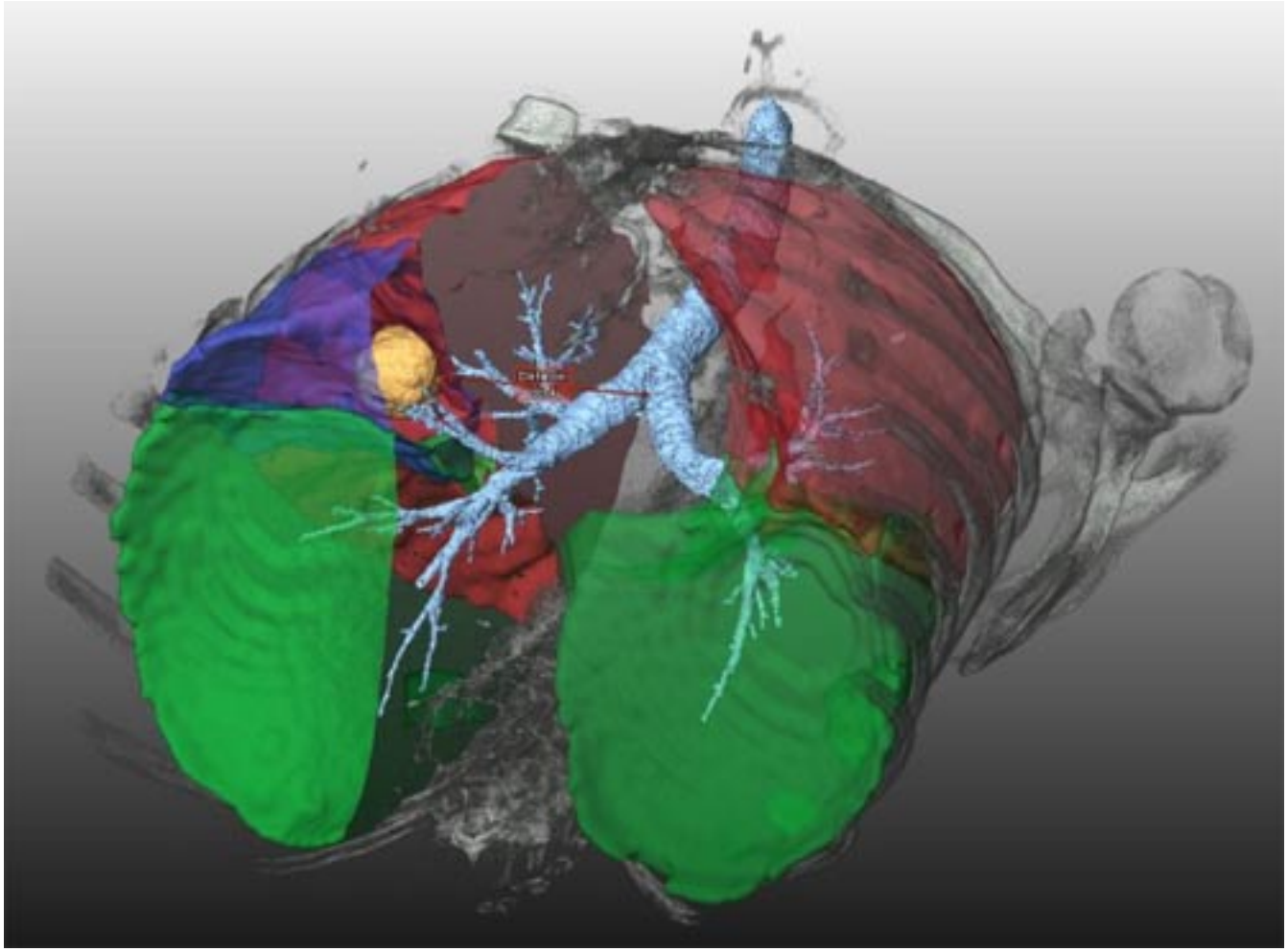
Jan-Martin Kuhnigk (S. Zidowitz, L. Bornemann, V. Dicken, B. Kümmerlen, S. Krass, H.-O. Peitgen)
MeVis-Center for Medical Diagnostic Systems and Visualization, Bremen

Purpose
Resection planning for lung cancer treatment not only requires exact knowledge of the tumor's localization and extent but also a sufficiently accurate prognosis of postoperative lung function. Featuring precise CT-based segmentation of the lungs, the lung lobes, the bronchial tree and the tumor itself as well as a good approximation of the pulmonary segments, the proposed method is able to cover both aspects. Based on the segmentation results, a prognosis for postoperative lung function is given along with qualitative and quantitative information about the nodule's localization with respect to other anatomical structures such as lobar boundaries. Moreover, the entry points of vessels and airways into the lobe(s) or lung to be resected can be displayed in 3d. The acquired information assists the surgeon in assessing risks and benefits of different resection strategies preoperatively and in planning the surgical approach.

Materials & Methods
The risk analysis is based on an exact segmentation of the involved anatomic structures in the CT data. The identified tumor is segmented automatically. Using a combination of morphologic and gradient-based methods, the algorithm is capable of separating tumors from attached high-density structures such as pleura or vessels. The segmentation of the lungs is completely automated and robust in separating the left and the right lung. Due to low contrast and high inter-individual variations, the lobe segmentation does in some cases require an interactive refinement of the results. An estimate of postoperative lung function is calculated by approximating the volume of functional lung parenchyma in each lobe. The algorithm used for the airway segmentation is based on a specialized three-dimensional region growing method which automatically determines an optimal threshold. A tree analysis is performed on the segmented bronchi, allowing to approximate the distance of the tumor to the mediastinal lymph nodes along the lymphatic vessels. Additionally, the bronchi analysis is used to obtain an approximation of the broncho-pulmonary segments and thus, a qualitative description of the tumor location. The described methods are integrated in a prototypical clinical application using the development platform ILAB4.

Results
The nodule segmentation method has been tested on over 500 pulmonary nodules in CT scans of 30 different patients. Lung, lobe, and bronchi segmentation have been successfully applied to over 50 clinical datasets of various CT scanners and protocols. The data included healthy subjects as well as a large number of pathologic findings such as pulmonary nodules, emphysema and atelectasis. A preliminary validation indicates a very low intra- and inter-observer variability of the lung lobe volumes (< 0.5%).

Conclusion
Lung resection surgery is the only curative therapy for early stage non-small cell lung cancer. Based on a fully automated identification of the lungs and a robust, semi-automated decomposition of the lungs into the lobes, the proposed method assesses lobar CT parameters easily and accurately and thus allows a more reliable CT-based prediction of postoperative lung function. Additional assistance in preoperative risk analysis is provided by the quantitative analysis of the tumor localization with respect to safety margins and risk of mediastinal lymphatic metastases.



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