Erasmus University Rotterdam, the Netherlands
CSC PhD 2015 Project Description

School/Department:

Biomedical Imaging Group Rotterdam (BIGR), Departments of Radiology and Medical Informatics, Erasmus MC
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Project Title:

Computer aided diagnosis of lung disease from CT imaging

Abstract:

Accurate and reproducible quantification of abnormalities in lung images is crucial to improve our understanding of how lung diseases develop and evolve, to assess the effect of novel drugs, and to recognize problems as early as possible and determine the best treatment in individual patients. For this, automated image analysis is required, which is especially challenging in lung images because of the large deformations that occur in the lungs during breathing.

In this PhD project you will develop novel computer algorithms to analyze CT and MR images and image sequences of the chest.

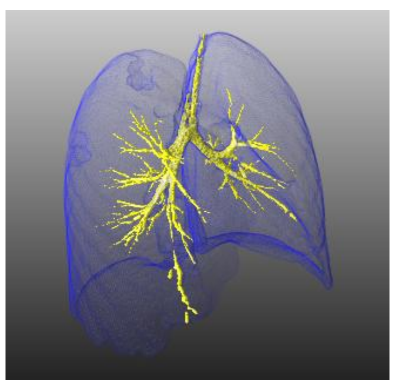

Fig1. Airway segmentation.

Fig2. Trapped air is visible as darker regions in the lung tissue.

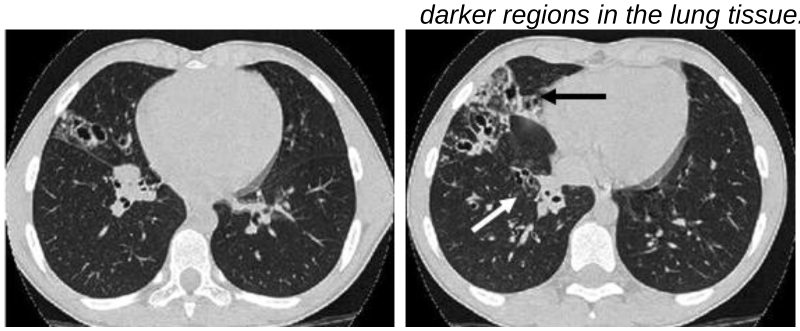

Fig 3. A CT scan of a patient with cystic fibrosis (left). Two years later, the disease has progressed and more abnormalities are visible (right)

	We suggest the following topics to work on within this PhD project, but you may also define related topics yourself. **1. Segmentation of the airways and arteries** Untreated lung disease can lead to irreversible damage to the airways, which can be seen e.g. as a widening of the airway lumen or thickening of the wall. To detect this in an early stage, segmentation (outlining) of the airways and of the neighboring arteries is needed. Some approaches already exist, but current methods are not able to segment the smaller airways or airways with severe abnormalities and should therefore be improved (Fig 1). **2. Geometrical analysis of the airways and arteries** Based on the segmentations obtained above, the airway and vessel diameters, wall thickness, etc can be measured at hundreds of locations throughout the lungs. Common practice is to average these measures to obtain an indicator of airway disease, but we expect that high-dimensional machine learning techniques, exploiting the entire distribution of measures and/or taking the tree structure into account, will provide much stronger cues for diagnosis. **3. Texture classification** Different lung abnormalities show a distinctive texture in the image (Fig 2, 3). Classifying the different textures can help detect and quantify lung disease. For this purpose, popular texture segmentation techniques from Computer Vision such as the \`bag of words' or \`deep learning' approaches can be used. 4. **Quantifying changes over time** To detect the onset or progression of lung disease, we should be able to measure local changes in airways, trapped air, and lung texture. To this end, the methods developed above will be combined with techniques for robust, deformable image registration. Registration methods need to be able to both cope with appearance changes caused by disease and compensate for large deformations caused by breathing. **5. Dynamic image analysis** In some cases, 4D (3D +time) dynamic image sequences of the chest are acquired to study the motion of the lungs, diaphragm and chest muscles during breathing or coughing. We will develop techniques based on image registration to quantify the different motion patterns in such sequences. **Techniques used in this project: Image segmentation, texture analysis, machine learning, image registration.**

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Requirements of candidate:	Background: You should have a Master's degree in physics, electrical engineering, mathematics, biomedical engineering, computer science, or a related field. Experience with biomedical image analysis and/or machine learning is an advantage. You should be familiar with programming. Strong theoretical skills and affinity with experimental work are required. Master degree: Yes IELTS Grade: 7.0 *(minimal 6.0 per component)* *or* TOEFL: *100 (minimal 20 per component)*
Supervisor information:	Associate Professor Marleen de Bruijne marleen.debruijne@erasmusmc.nl http://bigr.nl/people/MarleendeBruijne Marleen de Bruijne is associate professor of medical image analysis at Erasmus MC, The Netherlands, and at the University of Copenhagen, Denmark. She received an MSc degree in physics (1997) and a PhD degree in medical imaging (2003), both from Utrecht University. Before joining the University of Copenhagen (2007) and Erasmus MC (2008) she was assistant professor and later associate professor at the IT University of Copenhagen. Marleen currently supervises 7 PhD students and has supervised 9 PhD students who successfully defended their theses in the past few years. She has (co-)authored over 140 peer-reviewed full papers in international conferences and journals and 18 patent applications. She was a member of the program committee of many international conferences in medical imaging and computer vision, associate editor for Image and Vision Computing and Medical Physics, and is a member of the editorial board of Medical Image Analysis. Her research interests are model based and quantitative analysis of medical images with applications a.o. in lung, brain, cardiac, and vascular imaging. Below a selection of papers published in 2014 is given, a full publication list is available from http://bigr.nl/people/MarleendeBruijne • H. C. Achterberg; F. van der Lijn; T. den Heijer; M. W. Vernooij; M. A. Ikram; W. J. Niessen & M. de Bruijne, Hippocampal shape is predictive for the development of dementia in a normal, elderly population., Human Brain Mapping, 2014

	• N. Baka; B. Kaptein; J. Giphart; M. Staring; M. de Bruijne; B. Lelieveldt & E. R. Valstar, Evaluation of automated statistical shape model based knee kinematics from biplane fluoroscopy, Journal of Biomechanics, 2014 • V. Cheplygina; L. Sorensen; D. M. Tax; J. H. Pedersen; M. Loog & M. de Bruijne, Classification of COPD with Multiple Instance Learning, 22nd International Conference on Pattern Recognition (ICPR) 2014 • P. Ciet; P. Wielopolski; R. Manniesing; S. Lever; M. de Bruijne; G. Morana; P. Muzzio; M. Lequin & H. Tiddens, Spirometer controlled cine-magnetic resonance imaging to diagnose tracheobronchomalacia in pediatric patients, European Respiratory Journal,2014 • A. van Engelen; W. Niessen; S. Klein; H. Groen; H. Verhagen; J. Wentzel; A. van der Lugt & M. de Bruijne, Atherosclerotic plaque component segmentation in combined MRI and CTA Data incorporating class label uncertainty, PLoS ONE,2014 • A. van Engelen; T. Wannarong; G. Parraga; W. Niessen; A. Fenster; J. Spence & M. de Bruijne, Three-dimensional carotid ultrasound plaque texture predicts vascular events, Stroke,2014 • J. Petersen; M. Nielsen; P. Lo; L. H. Nordenmark; J. H. Pedersen; M. M. W. Wille; A. Dirksen & M. de Bruijne, Optimal surface segmentation using flow lines to quantify airway abnormalities in chronic obstructive pulmonary disease., Medical Image Analysis,2014 • J. Petersen; M. Wille; L. Raket; A. Feragen; J. Pedersen; M. Nielsen; A. Dirksen & M. de Bruijne, Effect of inspiration on airway dimensions measured in maximal inspiration CT images of subjects without airflow limitation, European Radiology, 2014 • R. Tennakoon; A. Bab-Hadiashar; Z. Cao & M. de Bruijne, Non-rigid Registration of Volumetric Images Using Ranked Order Statistics, IEEE Transactions on Medical Imaging, 2014 • G. van Tulder & M. de Bruijne, Learning Features for Tissue Classification with the Classification Restricted Boltzmann Machine, MICCAI 2014 Workshop on Medical Computer Vision: Algorithms for Big Data,2014