Title: Prediction of lung cancer incidence on the low-dose computed tomography arm of the National Lung Screening Trial: A dynamic Bayesian network

Author: Panayiotis Petousis Simon X. Han Denise Aberle Alex A.T. Bui

PII: S0933-3657(16)30106-3
DOI: http://dx.doi.org/doi:10.1016/j.artmed.2016.07.001
Reference: ARTMED 1470

To appear in: *ARTMED*

Received date: 24-3-2016
Accepted date: 25-7-2016

Please cite this article as: Panayiotis Petousis, Simon X. Han, Denise Aberle, Alex A.T. Bui, Prediction of lung cancer incidence on the low-dose computed tomography arm of the National Lung Screening Trial: A dynamic Bayesian network, *<![CDATA[Artificial Intelligence In Medicine]]>* (2016), http://dx.doi.org/10.1016/j.artmed.2016.07.001

Prediction of lung cancer incidence on the low-dose computed tomography arm of the National Lung Screening Trial: A dynamic Bayesian network

Panayiotis Petousis[1,2], Simon X. Han[1,2], Denise Aberle[1,2] MD, Alex A.T. Bui[1,2] PhD

[1] *Department of Bioengineering, University of California, Los Angeles, CA, USA*

[2] *Medical Imaging Informatics (MII) Group, Department of Radiological Sciences, University of California, Los Angeles, CA, USA*

[*] *Correspondence to: UCLA Medical Imaging Informatics, 924 Westwood Boulevard, Suite 420, Los Angeles, CA 90024, USA*

Email: pp89@ucla.edu

Abstract

Introduction: Identifying high-risk lung cancer individuals at an early disease stage is the most effective way of improving survival. The landmark National Lung Screening Trial (NLST) demonstrated the utility of low-dose computed tomography (LDCT) imaging to reduce mortality (relative to x-ray screening). As a result of the NLST and other studies, imaging-based lung cancer screening programs are now being implemented. However, LDCT interpretation results in a high number of false positives. A set of dynamic Bayesian networks (DBN) were designed and evaluated to provide insight into how longitudinal data can be used to help inform lung cancer screening decisions.

Methods: The LDCT arm of the NLST dataset was used to build and explore five DBNs for high-risk individuals. Three of these DBNs were built using a backward construction process, and two using structure learning methods. All models employ demographic, smoking status, cancer history, family lung cancer history, exposure risk factors, comorbidities related to lung cancer, and LDCT screening outcome information. Given the uncertainty arising from lung cancer screening, a cancer state-space model based on lung cancer staging was utilized to characterize the cancer status of an individual over time. The models were evaluated on balanced training and test sets of cancer and non-cancer cases to deal with data imbalance and overfitting.

Results: Results were comparable to expert decisions. The average area under the curve (AUC) of the receiver operating characteristic (ROC) for the three intervention points of the NLST trial was higher than 0.75 for all models. Evaluation of the models on the complete LDCT arm of the NLST dataset (N = 25,486) demonstrated satisfactory generalization. Consensus of predictions over similar cases is reported in concordance statistics between the models' and the physicians' predictions. The models' predictive ability with respect to missing data was also evaluated with the sample of cases that missed the second screening exam of the trial (N = 417). The DBNs outperformed comparison models such as logistic regression and naïve Bayes.

Conclusion: The lung cancer screening DBNs demonstrated high discrimination and predictive power with the majority of cancer and non-cancer cases.