AI Driven Model for Automatic Emphysema Detection in Low Dose Computed Tomography Using Disease-Specific Augmentation

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Introduction

Emphysema is a component of chronic obstructive pulmonary disease (COPD) characterised by lung parenchyma destruction. Not only in people undergoing lung cancer screening but also in the general population, there is a high burden of underdiagnosed COPD. As emphysema is itself an independent risk factor for lung cancer, detection is important. Low Dose CT (LDCT) can be leveraged by using AI. The inherent image noise in LDCT impedes detection of emphysema since emphysema CT features may be subtle. Clinically, minIP is used to visualise low-density structures which are representative of emphysema in CT, e.g., lowest tissue density, that is, density equal to or closest to air.

Hypothesis

In this study, a potential disease-specific augmentation such as minIP is used for AI-model development to detect emphysema automatically in LDCT.

Methods

Retrospectively collected data from a general population-based study in the Netherlands (ImaLife) was used to train (n=160) and validate (n=80) the model. For external validation, to mimic the real-case scenario, we choose a class imbalance dataset from a cohort of high-risk patients (National Lung Cancer Screening Trial-NLST) in the United States (n=125). Each scan from both populations included dichotomous emphysema diagnosis by board certified radiologists. The proposed AI-model is based on unsupervised anomaly detection with adversarial autoencoders framework (Figure-1). By using an unsupervised model, the tedious location-based annotation process was eliminated. Experiments were conducted using the scans pre-processed with different minIP slab-thickness varying from 1 to 11mm. The validation findings for each slab-thickness were analysed using the model's area under the receiver operating characteristics (AUC) curve and sensitivity. Bootstrapping with 1000 iterations was performed on AUC to find the confidence interval (CI).

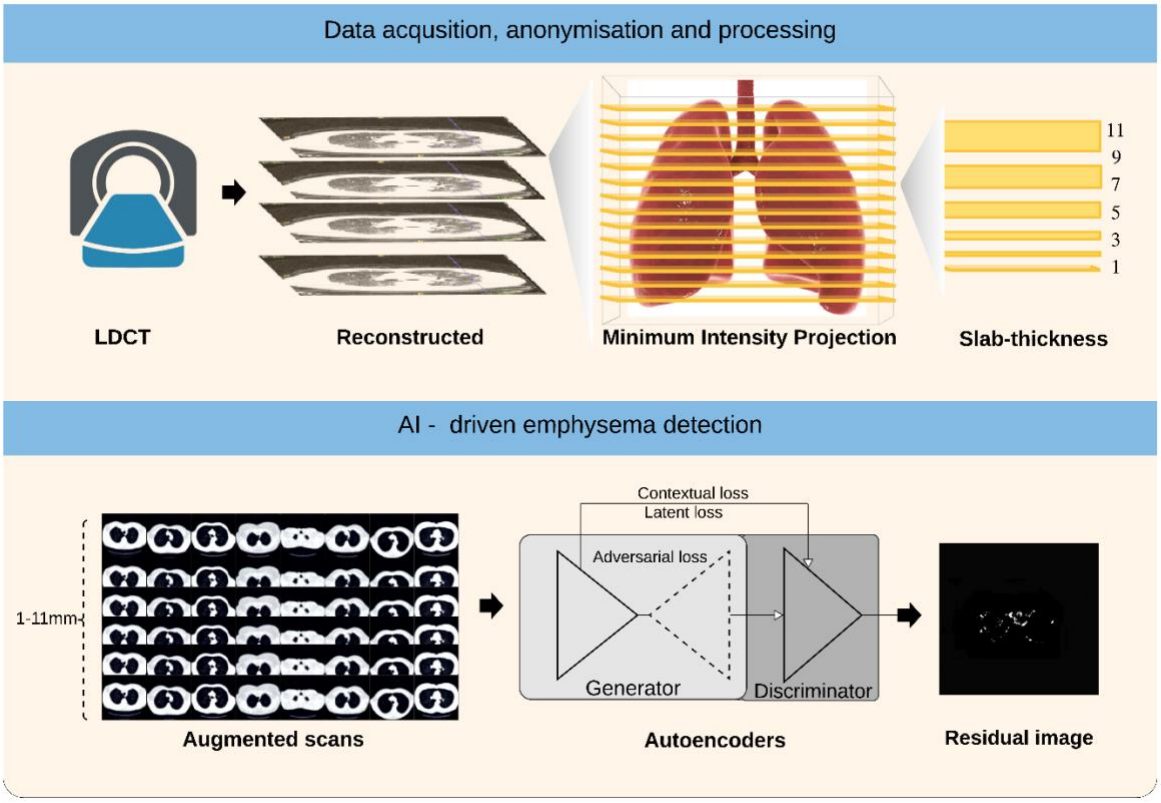
Results

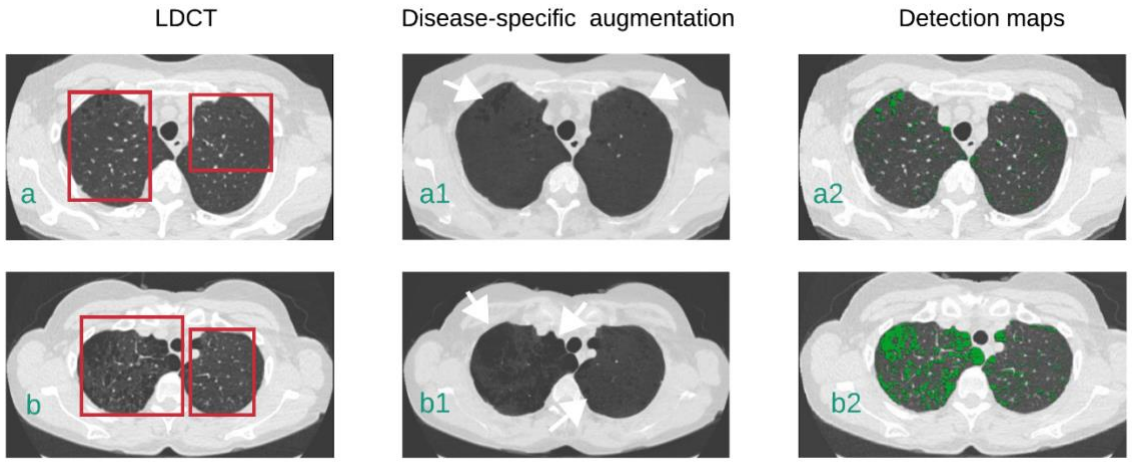
The internal validation showed an AUC of 90±0.05 and the external validation AUC was 0.77±0.06. The AI-model for slab-thickness varying from 1 to 11mm increased sensitivity from 75% to 88%, and the number of false-negative predictions decreased from 10 to 5. The proposed AI-model showed the highest AUC for 11mm slab-thickness with 1mm slice thickness for internal and external validation.

Conclusion

The minIP based disease-specific AI-model can automatically detect emphysema in LDCT. Visualisation of model predictions using residual images enhanced the model interpretability (Figure-2). Large-scale validation using scans from multiple demographics is required to establish the proposed AI-model as a potential tool for emphysema detection in LDCT.

Figure(s)





Keywords

Artificial Intelligence; Imaging Research