Abstract

Artificial intelligence (AI) is transforming many fields, including entertainment, daily life, and industry. It is also becoming an important tool in medicine. Modern healthcare faces challenges such as high workloads and staff shortages, leading to long waiting times for test results. AI can help by pre-analyzing medical data, making diagnostics more efficient. It can guide doctors in their analysis and highlight important medical information, improving patient care.

Computed Tomography (CT) is an advanced imaging technique that creates detailed three-dimensional images of tissues. It has greatly improved diagnostics in various medical fields. In pulmonology, CT is especially valuable, as it allows the detection of lung lesions in areas that cannot be directly examined by doctors.

Chronic obstructive pulmonary disease (COPD) is a growing health concern linked to rising air pollution and tobacco smoking. It is characterized by emphysema, a condition in which parts of the lung tissue are permanently damaged and destroyed, reducing lung function.

The dissertation examined the potential of artificial intelligence (AI) for detecting and quantifying emphysema. The study used CT images from the COPDGene database and the MOLTEST bis project. It provided a detailed analysis of the biological background of emphysema and the methods used for its segmentation. Based on it, a processing pipeline was developed, including lung segmentation, airway segmentation, lesion segmentation, and their quantification and differential analysis. A novel airway segmentation method was introduced, using iterative propagation from landmarks based on two dominant features. To ensure explainability and alignment with medical practices, an automatic thresholding method based on Gaussian mixtures was proposed for emphysema segmentation. For qualitative and quantitative assessment of emphysema, a set of features has been calculated which can be compared with other similar cases based on the created two-dimensional embedding.

The analysis demonstrates the potential of the proposed methods for practical use. However, further validation and expansion of the database with additional data are needed before application in an industrial setting.