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Enhancing Lung Cancer Diagnosis Accuracy through Autoencoder-Based Reconstruction of Computed Tomography (CT) Lung Images

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Abstract

Lung cancer is a major global cause of cancer-related deaths, emphasizing the importance of early detection through chest imaging. Accurate reconstruction of computed tomography (CT) lung images plays a crucial role in the diagnosis and treatment planning of lung cancer patients. However, noise in CT images poses a significant challenge, hindering the precise interpretation of internal tissue structures. Low-dose CT, with reduced radiation risks, has gained popularity. Nonetheless, inherent noise compromises image quality, potentially impacting diagnostic performance. Denoising autoencoder and unsupervised deep learning algorithms offer a promising solution. A dataset of CT images from patients suspected of lung cancer was categorized into four disease groups to evaluate different autoencoder models. Results showed that designed autoencoders effectively reduced noise, enhancing overall image quality. The semi-supervised autoencoder exhibited superior performance, preserving fine details and enhancing diagnostic information. This research underscores autoencoder models' potential in improving lung cancer diagnosis accuracy by reconstructing CT lung images, emphasizing the importance of noise reduction techniques in enhancing image quality and diagnostic performance.

Keywords: Deep Learning, Autoencoder, Computed tomography images reconstruction, Image quality enhancement

1-Introduction

The analysis of medical images about cancer poses significant challenges due to limitations in sample collection, along with various issues such as noise, incomplete annotation, data dispersion, and the high dimensionality of images (characterized by a large number of variables). Consequently, the development of integrated computing approaches to effectively handle such data remains an intricate task. In recent times, numerous machine learning methodologies have been put forth as potential solutions to tackle these complex datasets (Reel et al., 2021). Unsupervised learning techniques play a pivotal role in identifying latent patterns within complex data while effectively overcoming inherent challenges. Notably, among the unsupervised evaluation methods, neural network-based approaches, such as Autoencoders (AEs) and Variational Autoencoders (VAEs) (Kingma & Welling, 2013, Rezende et al., 2014), have demonstrated promising performance across diverse datasets and contexts, including cancer diseases (Simidjievski et al., 2019), bacterial infection (Deng et al., 2019), and the identification of healthy patient tissues (Christopher Heje Grønbech et al., 2020).

The autoencoder is a powerful neural network architecture that learns to extract a concise representation of the input data, gradually reducing the dimensionality through its layers. As the information is processed, it converges to a bottleneck layer, which captures the most intrinsic features of the input data. The reconstruction process then proceeds in the reverse direction to recreate the original data. Through this compression-decompression mechanism, the algorithm gains a more refined data representation, effectively capturing the inherent relationships between the data variables. As a result, downstream analyses can benefit from a more precise and accurate understanding of the data structure (Belkin & Niyogi, 2003).

The primary objective of this research article is to assess and compare the performance of various autoencoder reconstruction models using computed tomography (CT) images from lung cancer patients. The ultimate aim is to offer valuable insights into selecting the most suitable reconstruction technique that can enhance the diagnostic accuracy for lung cancer patients.

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