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Enhancing Nodule segmentation Utilizing Attention U-Net: Insights from LUNA-16 Dataset

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Abstract
Lung cancer remains a significant global health challenge, with early detection playing a critical role in improving patient outcomes. Computed Tomography (CT) imaging has become a cornerstone in the early diagnosis and staging of lung cancer, allowing for the detection of pulmonary nodules that may indicate malignancy. However, accurately segmenting and characterizing these nodules from CT scans presents substantial challenges due to variations in size, shape, appearance, and the presence of noise and artifacts. In this study, we propose a comprehensive approach to enhance nodule segmentation in lung CT scans, utilizing the great challenge of Lung Nodule Analysis 2016 (LUNA-16) dataset. We employ a pre-trained U-net based architecture from the Lung Quant (Lizzi et al., 2023) algorithm for robust segmentation of lung regions in CT scans. The pre-trained U-Net model accurately delineates lung boundaries, providing a reliable basis for subsequent nodule segmentation.
Following lung segmentation, we compare the performance of standard U-Net with an attention-enhanced variant, Attention U-Net, for nodule segmentation within the segmented lung regions. Attention mechanisms dynamically highlight informative regions, improving segmentation accuracy, particularly in challenging cases.
Experiments are conducted on the LUNA-16 dataset, comprising CT scans from multiple institutions and acquisition protocols. Quantitative evaluations compare U-Net and Attention U-Net performance using metrics such as Dice coefficient, sensitivity, specificity, and false positive rate. Our results showcase exceptional performance, with a Dice score of 73% for nodule segmentation and 90% for lung segmentation. These findings underscore the superiority of Attention U-Net over conventional U-Net, demonstrating higher accuracy in nodule segmentation and a reduction in false positives. This study presents a comprehensive approach to enhance nodule segmentation in lung CT scans, leveraging deep learning architectures and pre-processing techniques on the LUNA-16 dataset.

Lizzi, F., Postuma, I., Brero, F., Cabini, R. F., Fantacci, M. E., Lascialfari, A., Oliva, P., Rinaldi, L., & Retico, A. (2023). Quantification of pulmonary involvement in COVID-19 pneumonia: an upgrade of the LungQuant software for lung CT segmentation. European Physical Journal Plus, 138(4). https://doi.org/10.1140/epjp/s13360-023-03896-4

Primary authors: ZAFARANCHI, Arman (Istituto Nazionale di Fisica Nucleare); LIZZI, Francesca (Istituto Nazionale di Fisica Nucleare); RETICO, Alessandra (Istituto Nazionale di Fisica Nucleare); SCAPICCHIO, Camilla (Istituto Nazionale di Fisica Nucleare); FANTACCI, Maria Evelina (Istituto Nazionale di Fisica Nucleare)

Presenter: ZAFARANCHI, Arman (Istituto Nazionale di Fisica Nucleare)

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