IOCBE 2024 Conference

The 1st International Online Conference on Bioengineering

16–18 October 2024 | Online

MDPI

Optimizing MRI and CT Imaging with AI-Enhanced Signal Processing and Analysis

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INTRODUCTION & AIM

The integration of artificial intelligence (AI) in medical imaging, particularly in MRI and CT, has transformed diagnostic capabilities. AI models, such as Convolutional Neural Networks (CNNs) and Generative Adversarial Networks (GANs), have significantly improved the precision of medical image analysis. These models excel in detecting tumours, lung nodules, and other abnormalities, pushing the boundaries of segmentation, classification, and image enhancement.

This review aims to examine the latest advancements in AI-driven MRI and CT image analysis. Specifically, it highlights the role of CNNs and GANs in improving diagnostic accuracy, minimizing false positives, and improving overall clinical outcomes.

METHOD

A literature review was performed across multiple databases, including PubMed, Web of Science, and IEEE Xplore to find the latest developments in AI signal processing applications in the medical imaging field. Articles from the last 4 years were screened by title and abstract for relevance. Full texts of potentially eligible studies were then reviewed to ensure they met the following criteria: (1) the study used AI algorithms (e.g., CNN, GAN) for MRI or CT image analysis, (2) the study included quantitative measures such as accuracy, sensitivity, specificity, or AUC, and (3) the study focused on medical diagnostic outcomes. Two independent reviewers performed the screening and selection process, resolving any disagreements through discussion.

RESULTS & DISCUSSION

CNNs for Brain Tumor Segmentation:

A study using hybrid CNN models for brain tumor classification achieved a high accuracy rate (up to 99%) [1]. Specifically, CNN-based approaches like LuNetClassifier have demonstrated segmentation accuracy as high as 98% in brain MRI images, significantly improving diagnostic precision for gliomas and meningiomas [2]. Another method reported CNN accuracies reaching 97% when applied to tumor segmentation tasks, underscoring the value of AI in early diagnosis and treatment planning for brain tumors [3].

GANs in Image Processing:

GANs have been used to enhance image resolution and reduce noise, making it easier to detect subtle anomalies in MRI and CT images [4,5]. GAN-driven methods improved the visual quality of medical images, allowing radiologists to make more confident diagnoses, particularly for small or hard-to-detect lesions.

AI in Lung Nodule Detection:

AI algorithms have achieved remarkable accuracy in distinguishing between benign and malignant lung nodules. An ensemble of deep learning models (including ResNet-152, DenseNet-169, and EfficientNet-B7) achieved a detection accuracy of 97.23% in lung cancer detection, which is critical for reducing both false positives and false negatives[4-6].

Impact on False Positives in Cancer Detection:

AI systems have demonstrated the ability to reduce false positives in lung cancer detection through CT and PET-CT by 50%, resulting in fewer unnecessary procedures, such as biopsies, increasing diagnostic confidence among clinicians [5,6].

CONCLUSION

AI-driven advancements in signal processing, particularly with CNNs and GANs, have greatly enhanced the precision and reliability of medical imaging diagnostics. With improved segmentation accuracy, higher image resolution and reduced noise, AI has demonstrated its potential to revolutionize this field. Further advancements in AI research are expected to enhance the effectiveness of these technologies, ultimately leading to improved clinical decision-making and better patient outcomes

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