Artificial intelligence analysis of chest X-ray and computed tomographic images for COVID-19 patient management: abridged secondary publication

J Cai *, M Ying, WC Chan, MF Wong, HC Tsang, FM Kong, YX Wang, J Qin, G Ren

KEY MESSAGES

1. The artificial intelligence (AI)-enhanced chest X-ray (CXR) model increased lung signal and suppressed rib signal, enabling more accurate classification of COVID-19 conditions.
2. The AI-based segmentation model delineated lung contours and infected regions in computed tomographic and CXR images with high Dice scores.
3. The multi-view approach significantly improved the area under the curve compared with the use of a single feature type.
4. The developed computer programme supports COVID-19 diagnosis and patient management.

Hong Kong Med J 2025;31(Suppl 4):S37-8
HMRF project number: COVID190211

[1] J Cai, [1] M Ying, [1] WC Chan, [2] MF Wong, [3] HC Tsang, [4] FM Kong, [5] YX Wang, [6] J Qin, [1] G Ren

[1] *Department of Health Technology and Informatics, The Hong Kong Polytechnic University, Hong Kong SAR, China*
[2] *Department of Radiology, Pamela Youde Nethersole Eastern Hospital, Hong Kong SAR, China*
[3] *Department of Radiology and Imaging, Queen Elizabeth Hospital, Hong Kong SAR, China*
[4] *Department of Clinical Oncology, The University of Hong Kong, Hong Kong SAR, China*
[5] *Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong SAR, China*
[6] *School of Nursing, The Hong Kong Polytechnic University, Hong Kong SAR, China*

Introduction

Chest X-ray (CXR) and computed tomography (CT) are essential for diagnosing, assessing, and monitoring patients with COVID-19.[1] Artificial intelligence (AI) and big-data analytics facilitate early detection and diagnosis of COVID-19.[2] This study aimed to evaluate the application of AI and big-data analytics in the detection, diagnosis, surveillance, and management of COVID-19.

Methods

In total, 1818 CXR or CT images were retrospectively collected from Queen Elizabeth Hospital and Pamela Youde Nethersole Eastern Hospital, as were >3000 images from public datasets. The AI-enhanced CXR model was developed using a multi-strategy framework comprising lung segmentation, bone suppression, and super-resolution. Robust, self-adaptive AI-based segmentation frameworks were developed with an image pre-processing pipeline, residual learning, and data augmentation. A multiple kernel combination method was applied within our existing multi-view framework[3] and incorporated into conventional classifiers, including support vector machines and kernel ridge regression. The computer programme was integrated with the developed models and compiled using 3D Slicer.

Results

The AI-enhanced CXR images achieved a peak signal-to-noise ratio of 43.21±3.14 and a root mean square error of 0.0074±0.0029. Average Dice scores for infected regions based on the AI-based segmentation model were 0.93 for CT and 0.85 for CXR. The proposed multi-view analysis model substantially improved the area under the curve when combining radiomics and clinical features. The area under the curve for assessing COVID-19 pneumonia severity using the multi-view analysis was 0.98, considerably greater than that based on image features alone (0.60). The developed computer programme incorporated CXR image enhancement, CT and CXR image segmentation, and multi-view analysis, enabling automatic processing and analysis of input CT and CXR images for COVID-19.

Discussion

We developed a multi-strategy model comprising AI-enhanced CXR, AI-based segmentation, multi-view analysis, and an integrated image analysis programme to support auxiliary diagnosis for patients with COVID-19. The results of the multi-view analysis confirmed that the integration of feature types improved classification performance. The introduction of radiomics features also enhanced the interpretability of the classification model; this is essential for clinical adoption of AI technologies. Future studies should incorporate larger and more diverse datasets, evaluate model performance across varied settings and populations, and investigate the added value of other imaging features or patient information.

Conclusions

Our AI techniques offer safer, more accurate, and more efficient imaging solutions for managing COVID-19, providing actionable insights for clinical assessment and personalised treatment. Our models can predict patients at risk of developing severe symptoms, facilitating hospital resource planning. The AI-empowered CXR technique is highly accessible and demonstrates robust diagnostic and monitoring accuracy for COVID-19. It is suitable for implementation across hospitals at all levels.

Funding

This study was supported by the Health and Medical Research Fund Commissioned Research on the Novel Coronavirus Disease, Health Bureau, Hong Kong SAR Government (#COVID190211). The full report is available from the Health and Medical Research Fund website (https://rfs1.healthbureau.gov.hk).

Disclosure

The results of this research have been previously published in:

1. Ren G, Xiao H, Lam SK, et al. Deep learning-based bone suppression in chest radiographs using CT-derived features: a feasibility study. Quant Imaging Med Surg 2021;11:4807-19.
2. Lam NFD, Sun H, Song L, et al. Development and validation of bone-suppressed deep learning classification of COVID-19 presentation in chest radiographs. Quant Imaging Med Surg 2022;12:3917-31.
3. Sun H, Ren G, Teng X, et al. Artificial intelligence-assisted multistrategy image enhancement of chest X-rays for COVID-19 classification. Quant Imaging Med Surg 2023;13:394-416.
4. Zhang Y, Yang D, Lam SK, et al. Radiomics-based detection of COVID-19 from chest X-ray using interpretable soft label-driven TSK fuzzy classifier. Diagnostics 2022;12:2613.
5. Yang D, Ren G, Ni R, et al. Deep learning attention-guided radiomics for COVID-19 chest radiograph classification. Quant Imaging Med Surg 2023;13:572-5.

Acknowledgements

We thank Dr Daniel Lam, Dr Shaohua Zhi, Dr Alex Wong, Dr Ta Zhou, Dr Hongfei Sun, Mr Dongrong Yang, Mr Bosco Chan, Mr Liming Song, Mr Howard Lin, Ms Carol Liu, Mr Mayang Zhao, Mr Yiming Ni, Mr Jin Cao, Ms Yinghui Wang, Mr Kang Li, Ms Yuyao Wu, Mr Yunsong Tang, Ms Xinyu Zhang, Dr Yuanpeng Zhang, Dr Sai-Kit Lam, Mr Jiang Zhang, Mr Zongrui Ma, and Ms Jiamin Chen for their help with data collection and analysis.

References

1. Rodrigues JCL, Hare SS, Edey A, et al. An update on COVID-19 for the radiologist: a British Society of Thoracic Imaging statement. Clin Radiol 2020;75:323-5.
2. Shi F, Wang J, Shi J, et al. Review of artificial intelligence techniques in imaging data acquisition, segmentation, and diagnosis for COVID-19. IEEE Rev Biomed Eng 2021;14:4-15.
3. Zhang Y, Chung FL, Wang S. A multiview and multiexemplar fuzzy clustering approach: theoretical analysis and experimental studies. IEEE Trans Fuzzy Syst 2019;27:1543-57.