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Toward a vendor agnostic AI assistant system for brain metastasis detection on MRI

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Abstract

Introduction

The majority of deep learning artificial intelligence (AI) models for imaging diagnosis demonstrate diminished model performance on external dataset. We employ multiple steps in model development, refinement, validation and test on MRI from wide-ranging vendors and hospitals to avoid performance diminishing. The works present our development of a clinically applicable vendor agnostic AI assisted system for brain metastasis detection on MRI.

Methods

AI model training based on MRI of 1029 patients with brain metastases from a single institute and single MRI brand was conducted. A benchmark algorithm of 2D Mask R-CNN was used and resulted in an initial model (DeepMets®). Model generalization of DeepMets® was then carried out over a nationwide population-based dataset via deep active learning on 559 patients (randomized from 3125) from National Health Insurance Administration (NHIA) medi-cloud, Taiwan. Iterative refining process using the ResNext50 U-Net architecture with attention mechanisms were undertaken and resulted in a newer version model (DeepMets-Plus®). Final testing of the model was conducted on a dataset of brain metastasis consisted of 152 patients (489 metastases) from 19 hospitals and three MRI vendors. Sizes of the metastases were median 7 (4-40) mm in maximum diameters. The ground truth of the final test was obtained from a consensus of three experienced neuroradiologists, with 30 (25-36) years professional experience in neuroradiology.

Results

The performance of DeepMets® were: sensitivity 96%, precision 86%, and f1 91%. It dropped to sensitivity 76%, precision 45% and f1 48%, initially, on the NHIA dataset. After three active learning rounds with Ensemble & Post, DeepMets-Plus® yielded the final performance of sensitivity 0.86%, precision 0.90%, and f1 0.87%. For DeepMets-Plus®, the intersection over union between ground truth and model inference were 0.718, 0.210-0.904 (median, range). The centroid and Hausdorff distances were, respectively, 0.617, 0.124-2.154 mm and 2.512, 0.469-7.469 mm.

Discussion

The initial model (DeepMets®) has high performance in detecting brain metastases on MRI. However, being stemmed from its high imaging homogeneity training dataset, the high performance of DeepMets® is applicable only on in-house dataset with single vendor and uniform imaging parameters. DeepMets-Plus® gains model generalization while keeps similar model performance with training conducted on MRI of wide-ranging vendors from multiple hospitals.

Conclusion

With the access to a national-scale dataset, we demonstrate significant improvements in performance and model generalization across vendors and imaging parameters for brain metastasis detection. The improved model is developing into a useful clinical tool for assisting diagnosis.

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