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MULTI-PHASE DUAL-ENCODER MODEL FOR ANOMALY DETECTION IN MEDICAL IMAGING

(Model Berbilang Fasa dengan Dua Pengekod untuk Pengesanan Anomali dalam Pengimejan Perubatan)

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ABSTRACT

An error in medical diagnosis is enough to change a life, and many are suffering from incorrect diagnoses. Deep learning models in healthcare face several challenges due to limited and imbalanced datasets, where anomaly samples often dominated in publicly available data and it is problematic to collect independent data due to strict privacy regulations. Furthermore, current models often perform poorly on small sample datasets and lack robustness across various types of medical imaging. To address these issues, we developed a novel model that capable of detecting anomalies in medical imaging across both small and large datasets. This model features a multiple phase of training and validation, with dual encoders and a shared decoder architecture. Our results demonstrate that this model outperforms established classification methods in medical imaging datasets, including BraTS2021, RESC, and BreastMNIST, by achieving superior accuracy in distinguishing normal and anomalous images based on reconstruction error metrics. Furthermore, the research explores the interpretability of latent space features using explanation methods along with visualization techniques. By automating the diagnostic process, our model aligns with Malaysia's Healthcare Government Plan 2023 to reform the health system over the next 15 years and reduces workload for healthcare professionals. Our model can serve as a foundation for developing reliable diagnostic tools with interpretable latent space to understand the model's decision.

Keywords: diagnostic automation; dual-encoder model; medical data analysis; one-class classification; unsupervised deep learning

ABSTRAK

Kesilapan dalam diagnosis perubatan boleh memberi kesan besar terhadap kehidupan pesakit, dan ramai yang telah menderita akibat salah diagnosis. Model pembelajaran mendalam berdasarkan rangkaian neural dalam bidang kesihatan menghadapi beberapa cabaran disebabkan oleh set data yang terhad dan tidak seimbang, di mana sampel anomali sering mendominasi dalam data yang tersedia secara umum, sementara pengumpulan data baharu menghadapi kekangan kerana peraturan privasi yang ketat. Tambahan pula, model yang sedia ada sering menunjukkan prestasi yang kurang baik pada set data bersaiz kecil dan tidak cukup mantap untuk diaplikasikan pada pelbagai jenis pengimejan perubabatan. Bagi mengatasi isu-isu ini, kami telah membangunkan model baharu yang mampu mengesan anomali dalam pengimejan perubatan merentasi set data bersaiz kecil dan besar. Model ini menampilkan banyak fasa latihan dan penilaian, dengan dua pengekod yang berkongsi penyahkod tunggal. Hasil kajian menunjukkan bahawa model ini mengatasi hasil klasifikasi sedia ada dalam set data pengimejan perubatan, termasuk BraTS2021, RESC, dan BreastMNIST, dengan menunjukkan ketepatan yang lebih tinggi dalam membezakan imej normal dan anomali berdasarkan analisis ralat pembinaan semula. Selain itu, kajian ini meneroka kebolehan mentafsir ciri ruang laten menggunakan kaedah penjelasan bersama teknik visualisasi. Automasi diagnosis yang diperkenalkan oleh model kami selaras dengan Rancangan Kesihatan Kerajaan Malaysia 2023 untuk mereformasi sistem kesihatan dalam tempoh 15 tahun akan datang, selain mengurangkan beban kerja professional kesihatan. Model ini juga berpotensi menjadi asas untuk

membangunkan alat diagnostik yang boleh dipercayai dengan ruang laten yang boleh ditafsirkan bagi memahami hasil klasifikasi model.

Kata kunci: analisis data perubatan; automasi diagnosis; klasifikasi satu kelas; model dua-pengekod; pembelajaran mendalam tanpa pengawasan

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