SINGHEALTH · DUKE-NUS SCIENTIFIC CONGRESS
17 - 18 SEPTEMBER 2021

REVOLUTIONISING MEDICINE - THE NEW FRONTIER

Retinal Photograph-Based Deep Learning Algorithms for Myopia and a Blockchain Platform to Facilitate Artificial Intelligence Medical Research

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Introduction

The global burden of myopia is significant, affecting an estimated 5 billion people by 2050. Of these, 20% are likely to have high myopia, with significant risk of sight-threatening complications, such as myopic macular degeneration (MMD). Early detection of high myopia and MMD through effective screening programs could help to prevent many cases of vision loss. We hypothesized that deep learning (DL) algorithms could be effective for automated detection of MMD and high myopia from retinal photographs.

Despite the proliferation of artificial intelligence (AI) and DL studies in medicine, there are still unresolved challenges in the field, such as a lack of transparency and auditability in the AI development process. We hypothesized that blockchain technology may be able to address some of these challenges in AI medical research.

Aims

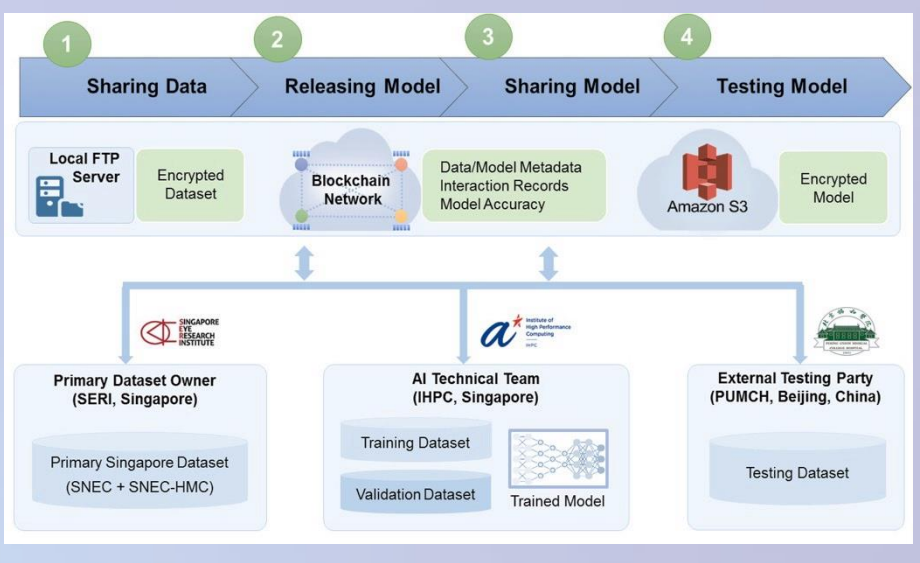
1. To develop DL algorithms for automated detection of MMD and high myopia from retinal photographs.
2. To develop a blockchain-based solution to improve transparency and auditability in AI medical research.

Methodology

We developed and tested DL algorithms for detection of MMD and high myopia using a total of 226,686 retinal images. High myopia was defined as either spherical equivalent (SE) ≤ -6.00D or axial length (AL) ≥ 26.0 mm. We trained and validated the algorithms on datasets from Singapore, and then externally tested them on datasets from China, Taiwan, India, Russia, and the UK. We also compared the performance of the algorithms against 6 human experts on a randomly selected dataset of 400 external dataset images.

As proof of concept, we developed a private permissioned blockchain-based platform (using Hyperledger Fabric) to regulate secure data transfer, model transfer, and model testing across 3 sites in Singapore and China.

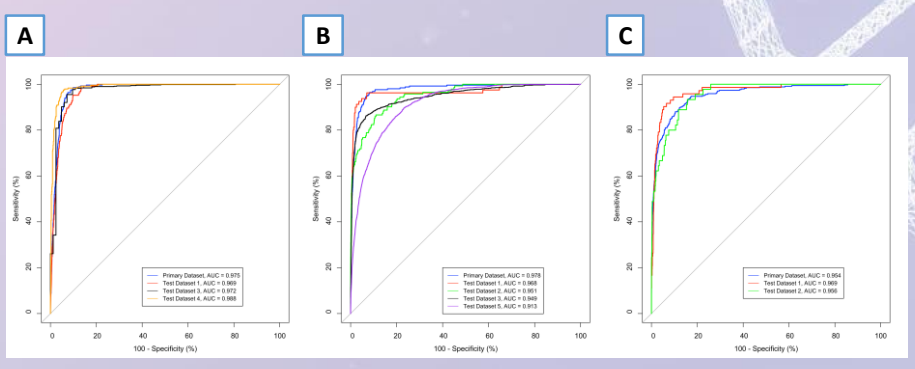
Figure 1. Schematic diagram of blockchain platform.



Results

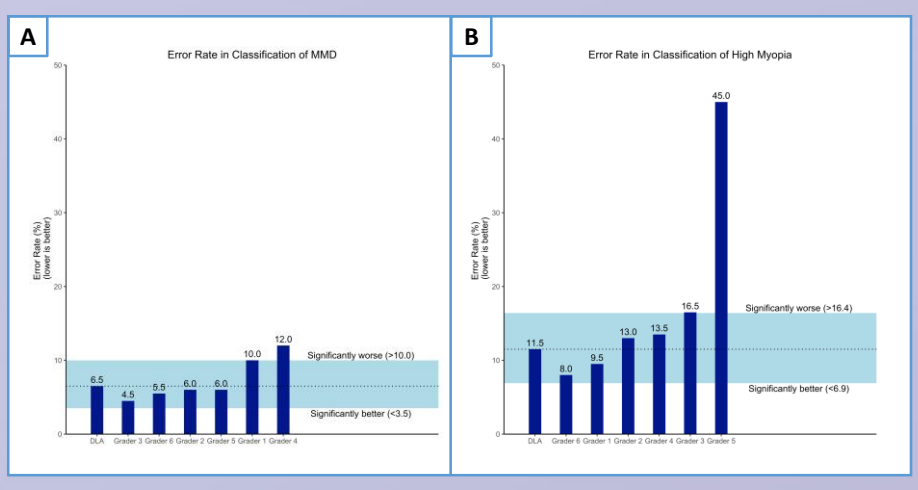
The DL algorithms showed robust diagnostic performance with areas under the receiver operating characteristic (ROC) curves (AUC) of 0.969-0.988, sensitivities of 91.4-98.4%, and specificities of 85.5-95.9% for MMD across all datasets. For high myopia, AUCs ranged from 0.913-0.978 and 0.954-0.969 by SE and AL criteria, respectively.

Figure 2. ROC curves for (A) MMD, (B) high myopia by SE criteria, and (C) high myopia by AL criteria.



In the randomly selected dataset, the algorithms outperformed all six experts in detection of both MMD and high myopia. For MMD, the algorithm achieved an AUC of 0.978 (95% CI: 0.957-0.994) compared to 0.700-0.947 for the six experts. For high myopia by SE criteria, the algorithm achieved an AUC of 0.973 (95% CI: 0.941-0.995) compared to 0.709-0.903 for the six experts.

Figure 3. Comparison of error rate between DL algorithms and human experts for (A) MMD and (B) high myopia by SE criteria.



As proof of concept, the blockchain platform was deployed across 3 sites in Singapore and China. The platform successfully regulated data transfer, model transfer, and model testing between these sites. The blockchain platform also successfully withstood an experimental attempt at malicious data modification.

Conclusions

DL algorithms using retinal photographs can be effective tools for automated risk stratification and screening of MMD and high myopia. Such a strategy is likely to be important in tackling the global burden of myopia.

The blockchain platform developed here could potentially serve as a trusted platform for performance testing of future AI models in medicine.

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