CiC 醫療創新中心
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創新專案計畫

老年性黃斑部病變之人工智慧醫學影像應用-治療決策及預後預測模式

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摘要

老年性黃斑部病變(Age related macular degeneration, AMD) 是因老化而使視網膜黃斑部退化的疾病，是目前造成全世界失明人口的第三大主因，僅次於白內障和青光眼，病變患者會有視力喪失或扭曲變形。近年研究顯示，此疾病新生血管的產生與血管生成因子（ VEGF ）有關，因此 anti VEGF 藥物注射成近年主要治療方式。然而，現今臨床上仍無有效方法預測 anti VEGF 治療後之視力預後，長期仰賴藥物治療及預後之不確定性造成病人及醫療系統龐大負擔。

因此，本計畫結合深度學習分析老年性黃斑部病變患者之視網膜光學同調斷層掃描影像(Optical coherence tomography, OCT)，藉由視網膜之分層結構及影像上特殊生物標記，預測藥物治療對患者視力的影響。本團隊透過全新研發之卷積神經網路等，預測藥物治療對患者視力的影響。本團隊透過全新研發之卷積神經網路(Convolutional neural network, CNN)，可同時分析，可同時分析OCT影像及數據資料影像 (baseline visual acuity, gender, age)，達到93.6% (95% confidence interval [CI], 0.889-0.964)之準確率之準確率(accuracy)。

本研究是目前少數能同時分析眼底OCT影像及數據資料之深度學習模型，未來，伴隨精準醫療精準醫療之發展，該研究成果可望能結合病人之影像, 臨床及基因資料，達到更精準之老年性黃斑部病變診斷及預後之預測，以作為個人化(personalized)治療之準則。

Abstract

Age-related macular degeneration (AMD) is a leading cause of irreversible blindness worldwide, and the number of affected population is projected to be 288 million by 2040. It is a debilitating and progressive disease that independence and overall quality of life decline in parallel with visual impairment. Over the past several years, anti-vascular endothelial growth factor (anti VEGF) injection has become the current mainstay of treatment for neovascular AMD. However, high cost and needs for repetitive administration results in substantial healthcare burden. Moreover, the therapeutic response varies widely, and was difficult to predict based on limited clinical information in the past.

To enhance clinical decision-making and provide personalized treatment strategy, we developed a novel deep convolutional neural network which can simultaneously process optical coherence tomography (OCT) images and corresponding numerical values including baseline visual acuity (VA) and patient demographics. The idea of using original OCT image without human processing as well as baseline data input is simulate current clinical decision making. This innovative approach demonstrated high accuracy in predicting individualized treatment outcome and demonstrated an AUC of 0.989 (95% CI, 0.9700.970--0.999), accuracy of 0.936 (95% confidence interval [CI], 0.8890.999), sensitivity of 0.933 (95% CI, 0.841--0.974), and specificity of 0.938 (95% CI, 0.877--0.969). In the attention heatmap, focused locations that contributed most to decision making by HDF-Net showed validity and corresponded well to the clinically relevant features within OCT images.

By simulating the clinical decision process with mixed baseline information from OCT images and non--image data, HDF-Net demonstrated promising performance in predicting individualized treatment outcome. The results highlight the potential of deep learning to simultaneously process a broad range of clinical data to weigh and leverage the complete information of the patient. This novel approach is an important step toward real-world personalized therapeutic strategy for treatment-naïve AMD.