RP

1.1s Preserving and Restoring Healthy Vision

CEVR Centre for Eye and Vision Research 眼視覺研究中心

The Hong Kong Polytechnic University 香港理工大學 | University of Waterloo

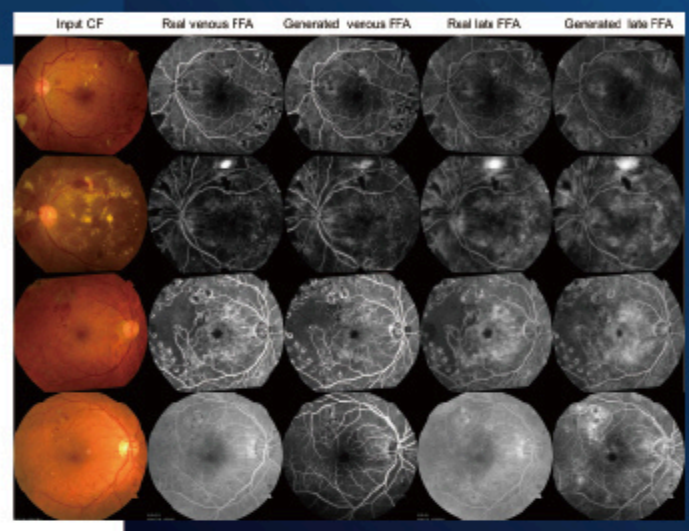
Development and Clinical Validation of AI-Based Software as a Medical Device for Non-Invasive Ophthalmic Imaging and Automated Reporting

Principal Investigators

PolyU : Mingguang He

UW : Stanley Woo

Co-I : Chea-su Kee, Danli Shi, Yanxian Chen, Xianwen Shang



Multi-stage generation of FFA from colour fundus photographs

Aims

This project develops AI software that transforms fundus photos into angiography images using GANs and generates automated reports via LLMs, enabling precise, non-invasive diagnosis of retinal diseases while improving clinical efficiency.

Background

Current retinal diagnostics rely on invasive angiograms requiring dye injections. Our team's breakthrough GAN technology converts standard fundus photos into equivalent angiograms, non-invasively detecting conditions like neovascularization, while our LLM system generates instant diagnostic reports.

Work to be Done

The project will integrate AI models for commercialization by developing Software as a Medical Device (SaMD). This involves refining and integrating GAN-based and LLM-based models into a user-friendly platform that meets regulatory standards. Rigorous clinical trials will be conducted to validate the AI's accuracy and efficacy in diagnosing retinal conditions like diabetic retinopathy and age-related macular degeneration.

Benefits

The AI-powered ophthalmic imaging system delivers three key advantages: (1) enhanced diagnostic accuracy through non-invasive analysis enabling earlier disease detection, (2) expanded healthcare access to underserved regions through portable implementation, and (3) significant cost reductions (up to 60%) by replacing invasive procedures with automated diagnostics. Additionally, the technology streamlines clinical workflows through integrated reporting features while creating new commercialization opportunities in medical AI.

Impact

This innovation is transforming global eye care by establishing a new standard for retinal disease diagnosis. Its scalable AI platform promises to benefit millions of patients worldwide, particularly in resource-limited settings.

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Anti-Myopia Electronic Displays: Making Screens Eye-Safe for Children

Principal Investigators

PolyU : Yan-yin Dennis Tse, Ka-man Rachel Chun

UW : Benjamin Thompson, Debbie Jones

Co-I : Vivian Choh, Chi-ho To, Elie de Lestrange-Anginieur

Making screens eye-safe for children

Aims

RP1.2s aims to make digital-device screens that are eye-safe for children by counteracting the screen-based signals that contribute to the onset and progression of myopia.

Background

The project foundation lies in the groundbreaking design of anti-myopia lenses that were developed within the PolyU School of Optometry. These lenses blur peripheral (side) vision in a way that significantly reduces the progression of myopia. Specifically, the lenses focus peripheral images in front of the retina causing what is called myopic blur. The patented technology is now being used in over 20 countries, benefiting over 2 million children worldwide.

Work to be Done

Develop two novel, parallel, and complementary technologies that will produce myopic blur when children use digital screens. One technology, simulated myopic defocus, utilizes eye tracking and image processing to therapeutically blur images in real time using only software. This approach will enable anti-myopia algorithms to be switched on and off through software on any device and will be marketed to the general public.

Benefits

Eye-safe screens will reduce myopia risk factors, directly benefiting children in dense urban environments with high digital screen use. Individuals will experience an enhanced quality of life due to the reduced severity of myopia, which not only improves personal well-being but also prevents high myopia-related ocular complications.

Impact

Anti-myopia screens can significantly reduce the public health burden by decreasing the prevalence of high myopia and its associated ocular diseases, such as glaucoma and retinal detachment. This leads to a healthier, visually capable, and productive community, as individuals benefit from lifelong prevention of visual loss and maintain a good quality of life. Additionally, the economic burden from reduced work productivity and long-term healthcare costs is lowered, while the public health care system experiences less strain from myopia-related vision impairments.

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Advanced Technologies for Prediction of Myopia Progression

Principal Investigators

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UW : Daphne Lynne McCulloch, Benjamin Thompson

Co-I : Vivian Choh, Vivek Maheshwari, Stanley Woo, Kai-yip Choi, Elizabeth Irving, Mingguang He, Tsz-wing Jeffrey Leung, Jeremy Kang, Elie de Lestrange

AI and novel imaging tools to enhance myopia treatment

Aims

Myopia is a major vision health concern. Accurate prediction of which patients will progress to high myopia would enable early and targeted treatment to preserve sight. AI algorithms have significant potential to enable the prediction of high myopia prediction. This project will utilize AI for high myopia prediction and will simultaneously develop novel technologies to assess eye structure and function that will enable even greater predictive accuracy. In addition, we will adopt structured light technology for the early detection and monitoring of myopia.

Background

Myopia is a significant vision health issue, with an estimated 50% of the global population expected to be affected by 2025. About 20% of those with myopia will develop high myopia. By 2050, high myopia is projected to affect 1 billion people, placing major stress on economies and healthcare systems. Early and accurate prediction of high myopia progression could enable targeted treatments to preserve sight.

Work to be Done

The first phase focuses on the development and clinical validation of a Digital Myopia Control (d.MC™) platform that incorporates patented predictive algorithms based on ocular biometrics for monitoring eye growth, offering a novel approach to managing myopia. The d.MC™ platform aims to provide personalized treatment plans to slow down the progression of myopia, thereby reducing the risk of severe ocular complications. 3. In parallel to the embodiment of the predictive algorithm, the project team will develop and evaluate the potential of structured light technology as a tool for predicting and monitoring myopia progression. During the first five years, the team conducted extensive research on the interaction between structured light and the human eye. While the original findings were primarily aimed at advancing the understanding of age-related macular degeneration (AMD), there are significant opportunities to apply the same underlying principles to other ocular diseases, such as myopia.

Benefits

The potential beneficiaries encompass all children at risk of developing myopia. The potential beneficiaries encompass all children at risk of developing myopia. Present clinical protocols rely only on age and refractive error, lacking objective clinical information derived from the neural system of the eye. The addition of structured light technology offers a unique and valuable alternative to the limited number of technologies currently available for the management of myopia. The new technologies developed in this project, which combine AI and structured light, will provide a more comprehensive approach to examining myopia progression and evaluating the effectiveness of novel treatment strategies.

Impact

Identify individuals at risk of high myopia-related retinal degeneration, allowing appropriate early intervention to halt or slow myopia progression. This approach will allow comprehensive myopia management to offer a personalized approach to treatment. Consequently, to prevent the onset of severe ocular complications, such as retinal detachment, macular degeneration, cataracts, and glaucoma, preserving the vision of individuals with myopia and enhancing their quality of life.

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Targeting Higher Level Brain Functions for Amblyopia Rehabilitation

Principal Investigators

PolyU : Tsz-wing Jeffrey Leung, Ming-yan Allen Cheong

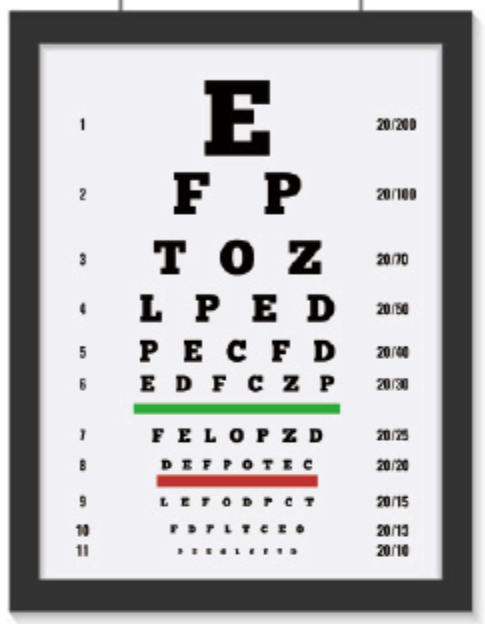
UW : Benjamin Thompson, Krista Kelly

Aims

Develop a novel approach for recovering vision in children and adults with amblyopia, by targeting higher-level brain mechanisms underpinning visual attention.

Background

Amblyopia is a neurodevelopmental disorder characterised by reduced visual acuity in one or both eyes, significantly impairing visual acuity and 3D vision (stereopsis). Adult amblyopia has been labelled untreatable because neuroplasticity (the brain's capacity for rewiring and recovery) wanes with age. However, our research group has demonstrated that visual areas of the adult brain retain neuroplasticity, suggesting potential for vision recovery in amblyopia. While visual acuity can be improved, other visual deficits, in particular impaired 3D vision, persist. This project will focus on improving visual attention in amblyopia to recover 3D vision.



Restore vision in patients with amblyopia at any age

Work to be Done

The project will develop a novel training framework focused on visual attention to recover 3D vision. The framework will include a home-based component, allowing patients to complete their training on personal devices via a web-based training algorithm, commercialized through a subscription model. Additionally, both clinic-based and home-based neuromodulation devices will be developed and patented to augment neuroplasticity and accelerate training effects for adult patients.

Benefits

This project offers several key benefits: Patients, particularly adults with amblyopia, will experience improved visual function, especially binocular vision, with potential extension to treating children. Healthcare providers gain new treatment options leading to better patient outcomes for amblyopia, fundamentally changing its management across the lifespan. Public health systems will see reduced burdens through effective amblyopia management, alleviating long-term impacts. The healthcare industry will benefit from opportunities for innovation and commercialization in digital therapeutics and augmentative neuromodulation technologies. Finally, the general public will benefit from the enhanced quality of life for individuals with amblyopia, reducing the societal impacts of visual impairment.

Impact

The project is expected to lead to healthier populations by improving vision recovery in amblyopia, thereby significantly enhancing individuals' quality of life and independence. This scalable solution aims to change the management of amblyopia across the lifespan, benefiting millions globally. Furthermore, the project will advance the understanding of neuroplasticity within the adult brain, potentially paving the way for new rehabilitation techniques that are applicable to a broad range of vision and neurological disorders.

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Novel Neuromodulation Approaches for Vision Enhancement in Adults

Principal Investigators

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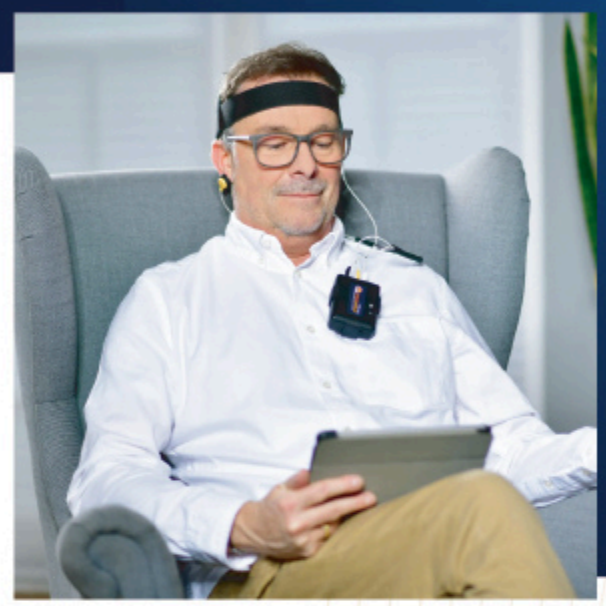
UW : Benjamin Thompson, Tao Chen

Co-I : Tsz-wing Jeffrey Leung



Enhance neural processing to restore functional vision

Aims

Develop next generation of non-invasive brain stimulation (NIBS) technologies and protocols for optimal vision rehabilitation across various eye and brain disorders.

Background

NIBS is a powerful tool in neurorehabilitation, that modulates excitability and neurotransmitter expression in targeted brain areas. This technique typically uses magnetic fields to induce weak electrical currents (transcranial magnetic stimulation, TMS) or employs head-mounted electrodes (transcranial electrical stimulation, TES). Current approaches can provide temporary improvements in visual perception through single- site, once-daily stimulation. Enhancing the magnitude and duration of these effects is crucial for NIBS to become a viable vision rehabilitation tool.

Work to be Done

This project will focus on developing next-generation vision rehabilitation technologies through four key approaches: implementing accelerated protocols involving multiple neuromodulation sessions within a single day, similar to treatments for resistant depression; creating multi-site stimulation protocols that target multiple brain regions involved in visual processing, either simultaneously or sequentially; exploring combination techniques to leverage the potential benefits of combining TMS and TES; and investigating emerging NIBS technologies, such as transcranial ultrasound stimulation (TUS), for their application in vision enhancement.

Benefits

NIBS technologies offer numerous benefits across various sectors. For patients with visual impairments who have exhausted traditional management options, NIBS provides access to innovative treatments that enhance residual visual function. This can improve quality of life, independence, and overall well-being, which can lead to better mental health, educational and career opportunities, and social integration. Healthcare providers gain novel treatment options for improved patient outcomes, especially for adults, expanding their toolkit for managing visual impairments. Public health systems benefit from reduced burden due to widespread NIBS adoption, while the healthcare industry sees opportunities for commercializing specialized brain stimulation devices and protocols. The public at large benefits from increased economic productivity as improved vision may enable individuals to return to work, alleviating the financial strain on social welfare systems.

Impact

This project will develop NIBS technologies that provide significant, lasting improvements in visual function, exceeding conventional NIBS approaches. The findings will advance NIBS protocols in vision rehabilitation, support clinical integration, expand treatment options for individuals with visual impairments. Additionally, this research will enhance our understanding of brain areas involved in visual processing and guiding the development of optimal stimulation protocols. The commercialisation of NIBS technologies will improve accessibility to vision rehabilitation.

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