

Eye Disease Diagnosis and Treatment Enabled by Novel Retinal Instrumentation

Principal Investigators

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Aims

To utilize state of the art technology to image and deliver precision treatment to the retina of the eye, using a unique adaptive optics scanning laser ophthalmoscope (AOSLO) to detect the earliest stages of age related retinal degeneration (AMD) and ocular melanoma and using ultrafast laser technology to precisely treat them.

Background

Researchers plan to develop a cellular-scale fluorescence lifetime imaging system for human use, filling a gap in early diagnosis. Once diagnosed, current treatments for AMD require frequent anti-VEGF injections, while ocular cancers often necessitate eye removal. An alternative approach involves closing the main vessel feeding the pathology, but existing single-photon therapy lacks precision. The proposed two-photon photodynamic therapy system aims to improve accuracy and preserve vision by precisely targeting these key retinal blood vessels.

Work to be Done

The AOSLO technology will be used to test two-photon photodynamic therapy (2P-PDT) in rat models for AMD and ocular melanoma by closing feeder blood vessels. Once validated in animal models, the instrument design will be refined and patented with Imagine Eyes for human treatment. Given the unique capabilities of CEVR's AOSLO system, this approach has the potential for global adoption, offering a groundbreaking treatment alternative for retinal diseases. The team will also develop an advanced AOSLO clinical instrument for high-precision imaging of the retinal pigment epithelium at the cellular scale as changes in its structure and function are linked to AMD, allowing early detection and assessment of retinal conditions.

Benefits

Improved early screening for AMD will expand patient access to 2P-PDT treatment and help reduce vision care costs for older adults. This precise AMD treatment will require fewer procedures, reducing costs and benefiting patients, while ocular melanoma treatment is expected to be much less invasive than eye removal. In both cases, vision will be better preserved, recurrence rates will be lowered, and survival outcomes will be improved.

Impact

Investigators will work with industry collaborators, Imagine Eyes and Robotrak, to develop the proposed technology, building on successful past collaborative projects. These strategic partnerships will pave the way for more effective clinical instruments to become a standard tool in ophthalmology clinics worldwide, enhancing diagnosis, monitoring and treatment of these sight and life-threatening diseases. Key indicators of success include higher early AMD detection rates, increased patient access to these new treatments, reduced eye removal rates, and overall decreased healthcare costs of treating AMD and eye cancers.



A two-photon ultrafast laser for ocular imaging and treatment

Non-Invasive Tear-Based Diagnostic System

Principal Investigators

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Aims

To establish the metabolomic and proteomic profiles of tear fluid as a tool for non-invasive diagnosis and monitoring of ocular disease. The project will develop non-invasive in vitro diagnostics and point-of-care tear analysis tests.

Background

The human tear fluid is rich in molecules, including proteins, lipids, electrolytes, and metabolites, making its metabolomic profile a valuable indicator of overall health. Since tear collection is quick, safe, and non-invasive, it could serve as an effective alternative to blood plasma for diagnosing and monitoring various diseases. The team has been extensively studying tear proteomic and metabolomic profiles linked to over 20 ocular and systemic diseases, identifying promising biomarkers for diagnosis and monitoring. They are advancing machine learning (ML) methods to analyse proteomic and metabolomic data, offering key insights for diagnostic and therapeutic development.

Work to be Done

Platform 1: Multi-omics tear biomarker discovery and validation platform

Liquid chromatography-tandem mass spectrometry (LC-MS/MS) for high-resolution analysis of the tear proteome and metabolome, leveraging bioinformatics and machine learning to identify clinical biomarkers. Key R&D activities include developing a reliable tear collection device, a mass spectrometry-based "Tear Analyzer" for precise biomarker measurement, and machine learning models to create a new diagnostic tool for clinicians.

Platform 2: Development of tear-based point of care tests

Validating tear biomarkers using mass spectrometry and clinical cohorts, which will lead to optimized point-of-care test prototypes. Key R&D activities include developing a tear test kit for dry eye detection, a biomarker panel for detecting retinopathy of prematurity, a biomarker for glaucoma diagnosis and treatment monitoring, and identifying biomarkers linked to contact lens discomfort to improve diagnosis and treatment.

Benefits

These processes will enhance early detection, diagnostic accuracy, and disease management for conditions that include glaucoma, retinopathy of prematurity, dry eye disease, and contact lens discomfort. These non-invasive screening tools will be particularly valuable in high-prevalence regions such as Asia.

Impact

Integration of these concepts into diagnostics, prognostics, and monitoring will improve healthcare efficiency, reduce costs, and transform disease management. Tear proteomics and metabolomics will drive advancements in personalized medicine, leading to better patient outcomes, lower treatment costs, and continue innovation in eye and systemic disease management.



Inexpensive and non-invasive detection of disease

Development of New-Generation Contact Lenses Using Novel Materials and Additive Manufacturing

Principal Investigators

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Aims

To combine advanced material design with state-of-the-art 3D printing technology to enable the affordable production of personalized and/or specialized contact lenses with a sustained ocular drug delivery feature through on-demand manufacturing.

Background

Traditional hydrogel contact lenses, although widely used, often lack advanced capabilities for effective drug delivery and long-term durability, limiting their utility beyond basic vision correction. Silicone hydrogel contact lenses were developed to improve oxygen permeability, flexibility, and durability, making them more suitable for extended wear. However, integrating reliable drug delivery systems into these lenses remains challenging. The emergence of 3D printing technology has introduced new possibilities for creating customized hydrogel structures for medical applications.

Work to be Done

To overcome current limitations, 3D-Printable Hydrophilic Silicone Elastomers will be designed to enhance the durability, comfort, and drug delivery capabilities of contact lenses. Our approach utilizes a single-step ink formulation and in situ gelation for rapid photopolymerization, enabling high-resolution (10-micron) 3D printing with mechanical stiffness ranging from 100 kPa to 10 MPa. By integrating silicone with hydrophilic side chains and acrylate monomers within a semi-interpenetrating polymer network, we aim to create a material with high water content, mechanical resilience, and long-term stability—essential for both vision correction and ocular drug delivery.

Benefits

The breakthrough in elastic and durable hydrogel polymers for ocular drug delivery and vision correction will revolutionize eye care, providing immediate benefits for individuals with refractive error. These advanced specialty contact lenses, designed for personalized fitting and superior oxygen permeability, will offer an unparalleled combination of comfort, precision, and convenience—surpassing traditional corrective lenses. By integrating cutting-edge materials and technology, this innovation will redefine vision enhancement, ensuring healthier eyes and improved quality of life for millions worldwide.

Impact

These innovations will significantly enhance the quality of life for individuals with visual disabilities, such as glaucoma, macular degeneration, and diabetic retinopathy, through sustained drug-release contact lenses. This advancement is expected to reduce the number of eye operations while increasing the availability of drug-delivery lenses, benefiting both patients and the healthcare industry. Additionally, the commercialization of these novel materials will drive economic growth and sustainability by establishing a new industry.



3D printed contact lenses

Detection of Macular Degeneration and Myopia-Induced Retinal Damage Using Structured Light Technology: A Novel Approach Supporting Early Intervention for Vision Preservation

Principal Investigators

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Aims

To develop objective macular polarity imaging for detecting age-related macular degeneration and structured light vision testing to identify retinal degeneration caused by myopia.

Background

Structured light beams have led to groundbreaking optical applications. The team discovered that structured light interacts with macular nerve fibres in the retina, creating an entoptic image—an internal visual phenomenon shaped by the retina's natural radial polarizer. Changes in these fibres, such as those from retinal degeneration, alter the image, making structured light a powerful tool for early retinal disease detection and intervention.

Work to be Done

Platform 1 will create an advanced retinal polarity imaging tool that objectively analyses structured light interactions with the retina, eliminating the need for patient perception-based assessments. The system will generate a retinal polarization profile to detect early signs of retinal disease. The prototype imaging system will undergo clinical trials to evaluate its effectiveness in detecting macular degeneration.

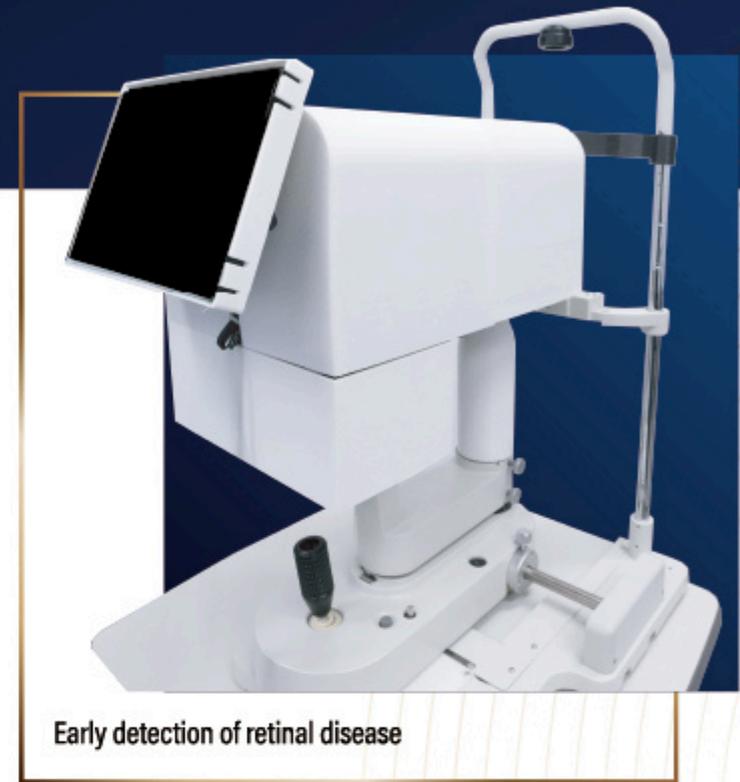
Platform 2 will adapt the team's existing structured light system to detect myopic macular degeneration, that can result in excessive eyeball elongation, stressing ocular structures and deforming the retina. Early detection is crucial to slowing or preventing disease progression. R&D efforts will refine structured light stimuli and perceptual tasks to identify localized retinal distortions and damage. Proof-of-concept research will guide clinical studies to evaluate the system's accuracy in detecting early-stage myopic macular degeneration.

Benefits

Advanced diagnostic tools for AMD and pathologic myopia will enable ophthalmologists and optometrists to provide more accurate and timely diagnoses, improving early intervention for patients and preventing disease progression. Widespread adoption of these tools will enhance public health and lower healthcare costs. The society will experience increased productivity and economic contributions leading to a more sustainable healthcare system and improved overall quality of life.

Impact

The outcome will pioneer a breakthrough in structured light technology to transform early detection and monitoring of eye diseases. By fusing quantum information science and structured light quantum techniques with vision science, this cutting-edge approach redefines how retinal neurodegeneration is understood. The innovation will combine psychophysical testing of structured light perception with advanced retinal imaging, creating a powerful diagnostic tool.



Early detection of retinal disease

3.5s *Advanced Optometric Technologies*

Extended Reality Visual Intelligence System (XRVIS) for Tele-Visual Assessment and Safety Enhancement for People with Visual Impairment

Principal Investigators

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Aims

Our goal is to develop and commercialize XRVIS devices that enhance visual and perceptual assessment and empowering visually impaired individuals with greater environmental awareness. By reducing dependence on traditional navigation aids, XRVIS will improve mobility, independence, and overall quality of life.

Background

Visual impairment significantly impacts daily life, increasing injury risks and affecting physical and mental health. Urban environments further complicate mobility for the visually impaired. Building on the success of ObstAR, we aim to elevate the potential of virtual, extended reality and artificial intelligence for the visually impaired. Our innovative technology will enable personalized augmented reality solutions tailored to everyone's unique visual needs, transforming accessibility and enhancing daily life.

Work to be Done

The XRVIS project focuses on developing proprietary algorithms for precise functional vision assessment, object recognition, and obstacle detection, leveraging new visual function data from visually impaired adults to refine AI-driven enhancements. Advanced vision assessment technologies will be translated into a VR format and integrating electroencephalography for objective evaluation. Continuous software refinement will ensure ease of use, personalization, and accessibility, with iterative user testing optimizing functionality. Additionally, a comprehensive training curriculum will be designed to help users navigate XR technology effectively, supporting the adaptation of AR tools for improved mobility and independence. These innovations will enhance vision testing, improve navigation for the visually impaired, and set a new benchmark in extended reality solutions.

Benefits

The XRVIS technology will empower visually impaired individuals with greater navigation. This will enhance mobility, productivity, and safety while reducing navigation-related accidents. Specialized training programs and user experience enhancements will improve accessibility and inform AR/VR/XR developers, with measurable outcomes including device adoption rates. The expanded software capabilities-including functional vision assessment technologies with EEG integration will enable vision evaluation and treatment referrals benefiting healthcare facilities, rehabilitation centres, and community programs. The XRVIS will extend its impact to individuals with cognitive impairments, contributing to early detection and intervention for neurodegenerative conditions.

Impact

To transform the mobility and independence of individuals with visual impairment, fostering greater inclusion and enhancing their overall quality of life. In addition, the development of tele-visual (remote) functional assessments has the potential to enhance eye care services for the community at large by enhancing access to eye care for the public. This scalable solution will benefit millions globally, create jobs, and position Hong Kong as a leader in ophthalmic research and XR technology.



Illustration of the VR vision assessment suite