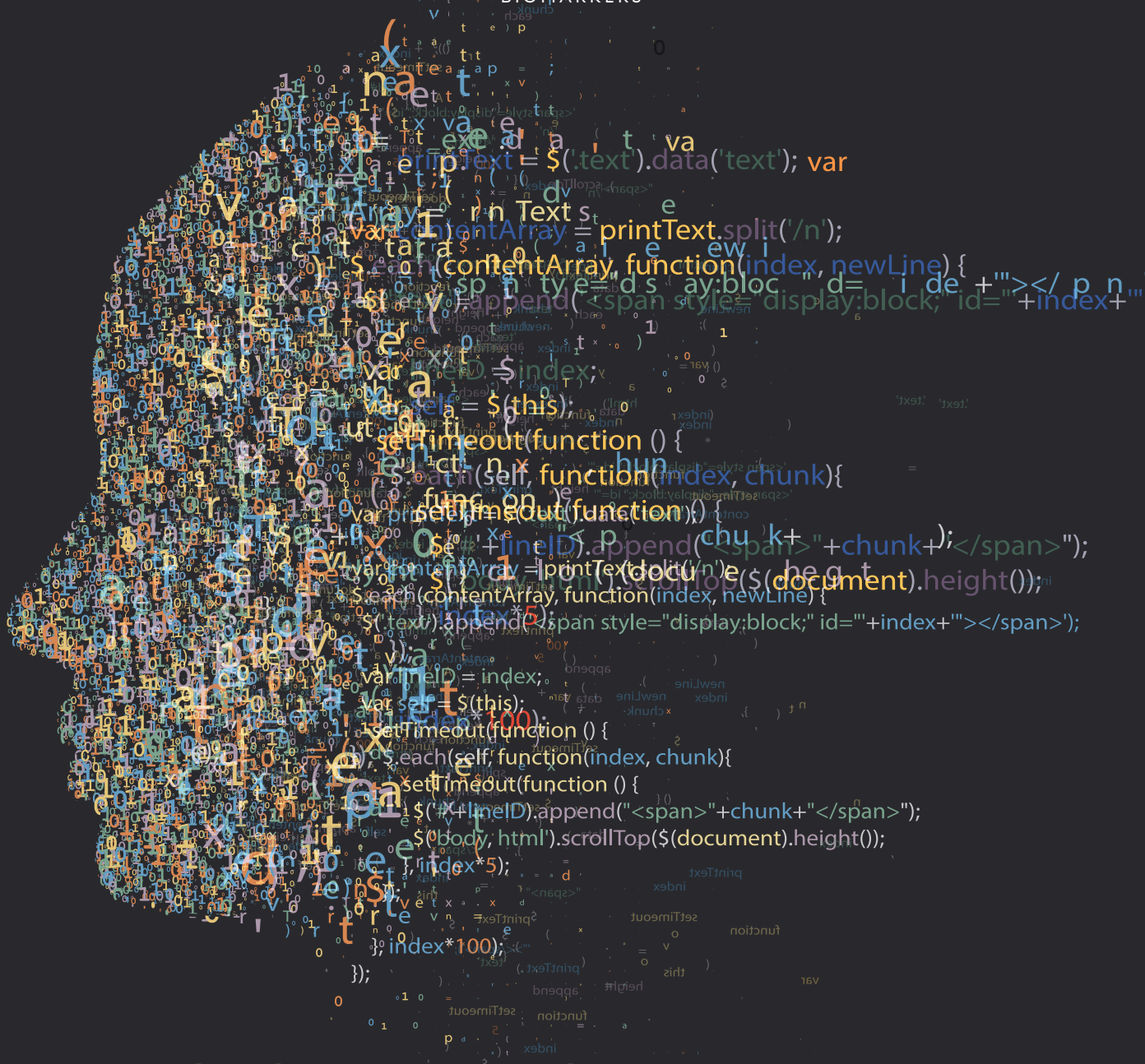


DECODING DISEASE

Following last issue's feature on novel OCT biomarkers, **Helen Bird** examines how AI is transforming eye care by supporting earlier disease detection, clearer tracking and more accurate referrals.

IMAGE: ISTOCK

At the College's AI in Eye Care Summit in March 2025, enthusiasm for artificial intelligence (AI) was clear: 91% of members surveyed believed it would positively impact diagnosis, accuracy and efficiency. Yet 23% expressed concern about AI's effect on patient–practitioner relationships, alongside worries about job security, accuracy and regulation (COptom, 2025).

Yuan Gao MCOptom, optometrist at Imperial College Healthcare NHS Trust and research optometrist at Imperial College Ophthalmology Research Group, says AI is rapidly reshaping clinical practice.

"In eye care, AI has moved from proof-of-concept to targeted clinical use," he says. "It can feel recent, but targeted uses have been around longer than most people realise. In day-to-day practice it's a support tool, not an autonomous decision-maker: it helps with image quality, consistent measurements and triage, while the clinician remains responsible."

WINDOW TO THE BODY

Retinal imaging and OCT, explored previously in *Acuity*, were among the first areas where AI's value became clear, says Yuan. For Anthony Khawaja, Professor of Ophthalmology at University College London (UCL) Institute of Ophthalmology and honorary consultant ophthalmologist at Moorfields Eye Hospital, decision support in diagnosing eye disease is one of two main ways in which AI could transform optometry.

"While optometrists are already experts in this, having support systems can mean reduced false positives and false negatives, which are always present even in the best practices," he says.

The other, he says, is predicting systemic disease risk from eye imaging. "This is currently something no human experts can do alone. Many people see their optometrist but not their GP, and knowing you may be at high risk of heart disease can prompt further testing and then preventative treatments."

> "I don't need AI to replace judgement; I want it to steady my judgement

The name of this emerging field, oculomics, was coined and defined in a seminal paper (Wagner et al, 2020). Senior co-author Pearse Keane, Professor of Artificial Intelligence at UCL and Consultant Ophthalmologist at Moorfields, says: "Within oculomics, we are exploring the centuries-old understanding that the eye reveals clues to the state of our vasculature system, but using machine learning to analyse large-scale datasets of eye images linked to information about systemic diseases," he says.

"In this way we have been able to identify specific biomarkers in the retina associated with types of dementia, the risk of stroke and other conditions. The eye really is a 'window to the body', and AI is the key to decoding the information hidden there."

Population-level health screening through AI-enabled OCT devices could be one of the most powerful applications, Pearse explains. Whereas US regulator-approved systems already exist, UK implementation is still in its early stages.

"Not only would your annual eye exam then become an opportunity to assess your vision, but also identify early signs of sight-threatening conditions, and on top of that whether you are at risk of a heart attack or other systemic condition. So the routine eye check could play a critical role in the healthcare system."

AI can streamline patient care pathways and referrals, says Yuan. It can help optometrists "get cleaner images, more consistent measurements and a better sense of whether something has genuinely changed since the last visit. It could save chair time in areas like contact lens fitting and subjective refraction by reducing variability, and it supports steadier decision-making when clinics are busy. It tidies the flow – fewer unnecessary referrals going out, and better information for those that are necessary.

"Just as importantly, the receiving team can use AI on their side to scan and sort referrals consistently, which makes the whole exchange more clinician- and patient-friendly."

Translating the accuracy of medical AI in lab studies into real-world practice isn't simple. "One challenge is that many datasets that train AI algorithms are biased towards participants of European descent," says Anthony.

Pearse adds: "If a model is trained primarily on data from one ethnic group or a specific type of imaging machine, its accuracy can drop significantly when used on a different, more diverse population or a different device. This lack of generalisability can lead to real-world inaccuracies and potentially exacerbate health inequalities."

AI's strongest potential

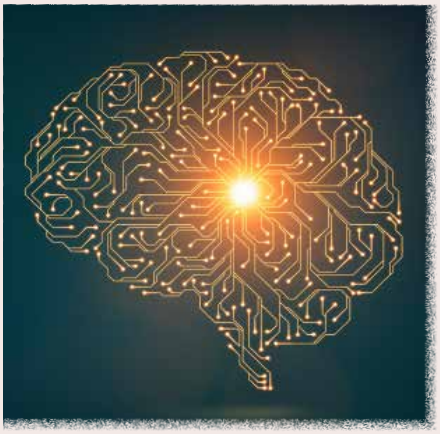
- **Retinal imaging and OCT.** Provides rapid, consistent outputs helping detect genuine change between visits and guide timely action.
- **Risk and progression modelling.** As for glaucoma, AMD conversion risk and diabetic eye disease, integrating structural and functional data across visits can estimate likelihood and timing of progression.
- **Contact lenses (e.g. sclerals).** Corneal shape and scleral profile from 3D scans can suggest first-fit parameters predicting settling, saving chair time and leading to fewer remakes.

Source: Yuan Gao MCOptom

He says some published AI models are validated retrospectively using the same data used for training, another bias source. "To be trusted, an algorithm must undergo rigorous external validation (using data from entirely different patient groups) and prospective validation (testing in a real-world, live clinical setting). In these scenarios, we often see that real-world accuracy is lower than the initial, lab-based results."

Image quality presents further challenges. "In a real-world clinic, images may be taken by different operators, on different machines, and with varying levels of quality," says Pearse. "AI systems must be robust enough to handle the inevitable noise and variability of these images, which can severely impact accuracy if the model isn't trained for it."

Yuan adds that "human–AI interaction errors" are increasingly visible in practice. Examples include automation bias, meaning "over-trusting a green tick and skipping your own review"; anchoring, whereby "seeing the AI label first pulls your grading towards it"; and alert fatigue, when there are "so many pop-ups that the rare critical warning gets ignored".



> Combining genetic data with ophthalmic imaging would facilitate new insights

Beneficial AI applications in optometry

- **DISEASE DETECTION AND ADVANCED IMAGE ANALYSIS**
  AI helps clinicians reach "So what?" quicker, cleaning up images, highlighting subtle changes and maintaining measurement consistency across visits.
- **PREDICTIVE ANALYTICS**
  Predictive tools integrate patient data, presenting forecasts and graphs, making things easier to explain and modifying treatment plans.
- **WORKFLOW AND OPERATIONS**
  AI streamlines admin through standardised reports and letters.
- **TRAINING AND EDUCATION**
  AI supports simulation-based learning with virtual patients using dynamic scenarios.

Source: Yuan Gao MCOptom

FIRM FOUNDATIONS

Pearse led landmark research in collaboration with Google DeepMind, demonstrating AI's exceptional analytical power when applied to "the huge amount of imaging data we had amassed at Moorfields. Our initial collaboration yielded results in less than two years, demonstrating that our algorithm could match the performance of expert clinicians in recommending the correct referral decision for over 50 eye diseases with over 94% accuracy" (De Fauw et al, 2018).

Building on this, Pearse's team are advancing the technology towards regulatory approval, aiming to make AI-powered high-street healthcare a UK reality.

In another breakthrough, the team developed what Pearse calls "one of the most exciting developments to come out of our lab. RETFound, short for Retinal Foundation Model, was released in 2023 as the world's first foundation model for ophthalmology and one of the first in healthcare.

"We made RETFound free to use for non-commercial purposes. This makes the cutting-edge medical AI expertise we have at UCL and Moorfields available to clinicians in low-resource settings," says Pearse.

Two years on, Global RETFound is being trained on data from over 65 countries, building "the first truly representative AI model for eye health".

Yuan says AI is an enhancement of practice, not a replacement. "I don't need AI to replace judgement; I want it to steady my judgement. Give me reliable measurements with certainty, show me if today's scan is comparable to the last, and express risk in a way that naturally drives the next step. That helps me act on time, explain the plan more clearly to patients, and keep the whole pathway moving."

Pearse is exploring "how we can marry oculomics with other -omics. Imagine how much more we can uncover about the link between the eye and the body by combining genetic data with ophthalmic imaging and clinical data. It would facilitate new insights into disease mechanisms, help AI-assisted drug discovery and enable personalised treatments."

The third and final article in the series, in the Spring issue of *Acuity*, will explore multiomics.

IMAGE: ISTOCK

Resources

Scan the QR code to access resources and references