ARTIFICIAL INTELLIGENCE AS GOOD AS TOP EXPERTS AT DETECTING EYE DISEASES

EMBARGOED UNTIL 16:00 MONDAY 13 AUGUST

- **Ground-breaking research by Moorfields Eye Hospital, DeepMind Health and UCL uses artificial intelligence (AI) to help identify potentially blinding eye diseases.**
- **AI system can recommend the correct referral decision for over 50 eye diseases with 94% accuracy – matching world-leading eye experts.**
- **System could help doctors and other eye health professionals spot serious conditions earlier and prioritise patients who urgently need treatment.**

An artificial intelligence (AI) system that can recommend the correct referral decision for over 50 eye diseases as accurately as world-leading experts has been developed by researchers at Moorfields Eye Hospital NHS Foundation Trust, DeepMind Health and University College London (UCL) Institute of Ophthalmology.

The breakthrough research, published online by *Nature Medicine*, describes how machine learning technology has been successfully trained on thousands of historic de-personalised eye scans to identify features of eye disease and recommend how patients should be referred for care. It is hoped that the technology could one day transform the way professionals carry out eye tests, allowing them to spot conditions earlier and prioritise patients with the most serious eye diseases before irreversible damage sets in.

More than 285 million people worldwide live with some form of sight loss, including more than two million people in the UK. Eye diseases remain one of the biggest causes of sight loss, and many can be prevented with early detection and treatment.

Dr Pearse Keane, consultant ophthalmologist at Moorfields Eye Hospital NHS Foundation Trust and NIHR Clinician Scientist at the UCL Institute of Ophthalmology said:
"The number of eye scans we're performing is growing at a pace much faster than human experts are able to interpret them. There is a risk that this may cause delays in the diagnosis and treatment of sight-threatening diseases, which can be devastating for patients.

"The AI technology we're developing is designed to prioritise patients who need to be seen and treated urgently by a doctor or eye care professional. If we can diagnose and treat eye conditions early, it gives us the best chance of saving people's sight. With further research it could lead to greater consistency and quality of care for patients with eye problems in the future."

The study, which was launched in 2016, brought together leading NHS eye health professionals and scientists from the National Institute for Health Research (NIHR) and UCL with some of the UK's top technologists at DeepMind to investigate whether AI technology could help improve the care of patients with sight-threatening diseases, such as age-related macular degeneration and diabetic eye disease.

Using two types of neural network – mathematical systems for identifying patterns in images or data – the AI system quickly learnt to identify ten features of eye disease from highly complex optical coherence tomography (OCT) scans. The system was then able to recommend a referral decision based on the most urgent conditions detected.

To establish whether the AI system was making correct referrals, clinicians also viewed the same OCT scans and made their own referral decisions. The study concluded that AI was

able to make the right referral recommendation more than 94% of the time, matching the performance of expert clinicians.

The AI has been developed with two unique features which maximise its potential use in eye care. Firstly, the system can provide information that helps explain to eye care professionals how it arrives at its recommendations. This information includes visuals of the features of eye disease it has identified on the OCT scan and the level of confidence the system has in its recommendations, in the form of a percentage. This functionality is crucial in helping clinicians scrutinise the technology's recommendations and check its accuracy before deciding the type of care and treatment a patient receives.

Secondly, the AI system can be easily applied to different types of eye scanner, not just the specific model on which it was trained. This could significantly increase the number of people who benefit from this technology and future-proof it, so it can still be used even as OCT scanners are upgraded or replaced over time.

The next step is for the research to go through clinical trials to explore how this technology might improve patient care in practice, and regulatory approval before it can be used in hospitals and other clinical settings.

If clinical trials are successful in demonstrating that the technology can be used safely and effectively, Moorfields will be able to use an eventual, regulatory-approved product for free across all 30 of their UK hospitals and community clinics, for an initial period of five years.

The work which has gone into this project will also help accelerate wider NHS research for many years to come. For example, DeepMind has invested significant resources to clean, curate and label Moorfields' de-identified research dataset to create one of the most advanced eye research databases in the world.

Moorfields owns this database as a non-commercial public asset, which is already forming the basis of nine separate medical research studies. In addition, Moorfields can also use DeepMind's trained AI model for future non-commercial research efforts, which could help advance medical research even further.

Mustafa Suleyman, Co-founder and Head of Applied AI at DeepMind Health, said:
"We set up DeepMind Health because we believe artificial intelligence can help solve some of society's biggest health challenges, like avoidable sight loss, which affects millions of people across the globe. These incredibly exciting results take us one step closer to that goal and could, in time, transform the diagnosis, treatment and management of patients with sight threatening eye conditions, not just at Moorfields, but around the world.

"We're immensely proud of this work, which once again demonstrates what is possible when world-leading clinicians and technologists collaborate to improve patient care".

Professor Sir Peng Tee Khaw, director of the NIHR Biomedical Research Centre at Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology said:
"The results of this pioneering research with DeepMind are very exciting and demonstrate the potential sight-saving impact AI could have for patients. I am in no doubt that AI has a vital role to play in the future of healthcare, particularly when it comes to training and helping medical professionals so that patients benefit from vital treatment earlier than might previously have been possible. This shows the transformative research than can be carried out in the UK combining world leading industry and NIHR/NHS hospital/university partnerships."

Elaine Manna, 71, from north London and mother of three, went blind in her left eye from wet age-related macular degeneration (AMD). She is now being treated at Moorfields Eye Hospital to save the remaining sight in her right eye. She said:
"I lost the sight in my left eye in the year 2000 after noticing a sudden blurring of my vision. A few weeks went by and I was starting to get really worried. A doctor then told me I had a bleed at the back of my eye that needed to be treated urgently but it proved too late to save my sight.

"AMD has had a major impact on my life. I love going to the theatre but I find it difficult to see people's faces and I struggle to find my way around dimly lit rooms. I really hope that technology can help people like me in the future."

Matt Hancock, Health and Social Care Secretary, said:
"The UK leads the world in ground-breaking research and artificial intelligence has the potential to revolutionise the way we spot eye disease, and could be genuinely transformative for the NHS in the future.

"This is hugely exciting and exactly the type of technology which will benefit the NHS in the long term and improve patient care - that's why we fund over a billion pounds a year in health research as part of our long term plan for the NHS."

Robert Dufton, chief executive at Moorfields Eye Charity, said:
"The need for treatment for eye diseases is forecast to grow, in part because people are living longer, far beyond our ability to meet the demand using current practice. Artificial intelligence is showing the potential to transform the speed at which diseases can be diagnosed and treatments suggested, making the best use of the limited time of clinicians. AI will also help our understanding of sight loss. Moorfields Eye Charity is proud to have funded equipment which underpins Dr Pearse Keane's work as part of our programme of philanthropic support in pioneering researchers."

Cathy Yelf, chief executive of the Macular Society, said:
"Macular disease is the biggest cause of sight loss in the UK, affecting 600,000 people. It is extremely debilitating and timely treatment for patients with wet AMD, such as Elaine, is vital. Pressure on eye clinics has resulted in delays for many patients, which has tragically led to unnecessary sight loss. We're excited by this latest development and hope in time this technology will alleviate the pressure on clinics and mean patients will get the urgent treatment they need."

Martin Cordiner, Head of Research at the College of Optometrists said:
"As optometrists are often the first port of call for people with the symptoms of eye disease, we are very excited about the potential that AI has to assist them in helping patients. Further support in prioritising the referral of the patients with the greatest need is in the interests of both practitioners and patients, and we look forward to the results of clinical trials of this technology."

Michele Acton, Chief Executive at Fight for Sight, said:
"Artificial intelligence has the potential to help us address so many challenging health issues. We're delighted that it is being used to help those patients most at need to receive timely access to ophthalmologists and appropriate treatments. This is a great step forward and we believe that the use of artificial intelligence will have an increasing role in addressing eye diseases in the future."

Professor Andrew Lotery, Chair Scientific Committee, The Royal College of Ophthalmologists, said:

"This paper shows the power of utilizing artificial intelligence in ophthalmology. Innovative research such as this could help hospital eye services manage their clinics more effectively in the future."

ENDS

NOTES TO EDITOR

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'Clinically applicable deep learning for diagnosis and referral in retinal optical coherence tomography' will be published online on *Nature Medicine's* website and is under strict embargo until 16:00 Monday 13 August 2018.

The paper will have a digital object identifier (DOI) number. The DOI for this paper will be 10.1038/s41591-018-0107-6.

Once the paper is published electronically, the DOI can be used to retrieve the abstract and full text by adding it to the following url: http://dx.doi.org/

Optical Coherence Tomography (OCT) is a non-invasive imaging test that uses light waves to take cross-sectional pictures of the retina. Moorfields carry out more than 5,000 optical coherence tomography (OCT) scans every week and they are now one of the most common medical imaging procedures in the world. These scans require highly trained expert analysis in order to interpret the result, which can cause delays in getting to diagnosis and treatment.

Fundus images are photographs of the back of the eye (the retina).

How the AI works
Medical professionals need to know how and why an AI system reached its recommendation so they can take this information into consideration when planning a patient's treatment.

Our system does this by combining two different neural networks with an easily interpretable representation between them. The first neural network, known as the segmentation network, analyses the OCT scan to provide a map of the different types of eye tissue and features of disease it sees. This map allows eye care professionals to gain insight into the system's "thinking."

The second network, known as the classification network, analyses this map and correctly identifies symptoms of eye disease, such as haemorrhages, lesions or irregular fluid, to present clinicians with diagnoses and a referral recommendation. Crucially, the network

expresses this recommendation as a percentage, allowing clinicians to assess the system's confidence in its analysis.

This functionality is critically important, since eye care professionals are always going to play a key role in deciding the type of care and treatment a patient receives. Helping them to scrutinise the technology's recommendations and check its accuracy will therefore be key to ensuring patients get the best care.

Evaluating the system's performance
Eight clinical experts were recruited for the study to assess the performance of the artificial intelligence system. Participants included four consultant ophthalmologists at Moorfields Eye Hospital with extensive clinical experience and four optometrists at Moorfields with specialist training in OCT interpretation and retinal diseases. The experts were given additional information including fundus scans, age, gender, ethnicity, and visual acuity results – as would be available in real-life triage situations.

Sight loss statistics
● More than 285 million people worldwide live with some form of sight loss (World Health Organisation)
● An ageing and growing world population coupled with the dramatic increase in the prevalence of eye diseases could lead to a threefold increase in blindness by 2050 (International Agency for the Prevention of Blindness Vision Atlas)
● Two million people in the UK are living with sight loss with this number expected to rise to 2.7 million by 2030 (RNIB). This figure includes people who are registered as blind or partially sighted and those whose sight is just better than the levels which qualify for registration.
● The leading causes of sight loss in the UK are uncorrected refractive error, age-related macular degeneration, cataract, glaucoma and diabetic retinopathy.

Data
DeepMind had access to over one million historic, de-identified OCT scans along with some related anonymous information about eye condition and disease management provided by Moorfields Eye Hospital NHS Foundation Trust. All of this data has been stripped of any information which could be used to identify patients. They are also historic, meaning that while the results of our research may be used to improve future care, they won't affect the care any patient receives today. When research is working with such data, which is anonymous with no way for researchers to identify individual patients, explicit consent from patients for their data to be used in this way is not required. For more information please refer to the ICO code of conduct.

Elaine Manna biography
Elaine Manna, 71, was diagnosed with severe wet AMD in her left eye in 2000 and her right eye in 2013. She has been a patient at Moorfields since 2013 and of Dr Pearse Keane since 2015.

In 2000, Elaine noticed deterioration of vision in her left eye and visited her GP, who referred her to King's College Hospital, where she was diagnosed with severe wet AMD. The only treatment option at the time was to have the bleed lasered and unfortunately she lost sight in her left eye. In 2013 Elaine noticed similar symptoms in her right eye and her GP made an urgent referral to Moorfields Eye Hospital. Elaine has been treated for her condition using regular injections of anti-VEGF (anti vascular endothelial growth factor), a group of medicines which reduce new blood vessel growth or swelling under the macula area of your retina, to slow down and stabilise the symptoms.

Elaine is a retired charity manager and mother of three from north London.

Moorfields Eye Hospital NHS Foundation Trust is a world-leading provider of eye care services in the UK. We provide a wide range of clinical services, caring for patients in over 30 locations in and around London to provide expert treatment closer to patients' homes. We also operate commercial divisions that provide care to private patients in both London and the Middle East. With our academic partner, the UCL Institute of Ophthalmology, we are recognised as a leading centre of excellence in eye research and education. To find out more go to: www.moorfields.nhs.uk

DeepMind is a neuroscience-inspired AI company which develops general-purpose learning algorithms and uses them to help tackle some of the world's most pressing challenges. Since its founding in London in 2010, DeepMind has published over 200 peer-reviewed papers, five of them in the scientific journal Nature, which is an unprecedented track record for a computer science lab. It was acquired by Google in their largest ever European acquisition in 2014. DeepMind's groundbreaking work includes the development of deep reinforcement learning, combining the domains of deep learning and reinforcement learning. This technique underpinned AlphaGo, a computer program that defeated Go world champion Lee Sedol in 2016—a breakthrough experts proclaimed to have arrived a decade ahead of its time. DeepMind is now applying its technical expertise to complex real-world areas like health, including several partnerships with hospitals to make advanced technology work for patients and physicians. For further information please visit https://deepmind.com/health

UCL Institute of Ophthalmology is one of a number of specialised institutes within UCL focusing on vision research and education. It was named the best place in the world to study ophthalmology by the 2017 Centre for World University Rankings and is one of the leading centres for vision and eye research worldwide. The most recent Research Assessment Exercise confirmed the outstanding quality of research carried out at the Institute, with 70 per cent of investigators ranked world leading or internationally excellent. For further information, please visit www.ucl.ac.uk/ioo

The NIHR Biomedical Research Centre at Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology was established in April 2007 and awarded its third five-year term by the NIHR in April 2017. Alongside the NIHR Moorfields Clinical Research Facility (CRF) for Experimental Medicine, our main purpose is to accelerate the progress of biomedical research from the laboratory into early phase safety trials so that scientific breakthroughs that hold promise for patients can proceed along the clinical testing pathway more quickly. Our BRC is one of 20 Biomedical Research Centres awarded to NHS/university partnerships with an outstanding international reputation for research. As a partnership between Moorfields Eye Hospital and UCL Institute of Ophthalmology we are at the centre of one of the largest ophthalmic research sites in the world. For more information go to: www.brcophthalmology.org

The National Institute for Health Research (NIHR): improving the health and wealth of the nation through research. Established by the Department of Health and Social Care, the NIHR:

- funds high quality research to improve health
- trains and supports health researchers
- provides world-class research facilities
- works with the life sciences industry and charities to benefit all
- involves patients and the public at every step

For further information go to: www.nihr.ac.uk

Moorfields Eye Charity supports the work of Moorfields Eye Hospital and its research partner, the UCL Institute of Ophthalmology, making a difference for patients at the hospital and for people with sight problems around the world. It provides grants and raises money to help the hospital provide the best possible care for its patients, educate the researchers and clinicians of tomorrow and support leading-edge research that aims to develop new treatments for blinding diseases. To find out more go to: www.moorfieldseyecharity.org.uk

The Macular Society is the leading charity fighting to end sight loss caused by macular disease. Every day over 200 people in the UK face the shock of a diagnosis of macular disease. This sight loss can rob people of their independence, leaving them unable to drive, read or recognise their family. We help people adapt to life with sight loss, regain their confidence and independence, and take back control of their lives. We fund the research that will one day find a cure. Our work is solely funded by your generous donations.

The **College of Optometrists** is the professional body for optometry. It qualifies the profession and delivers the guidance and training to ensure optometrists provide the best possible care. We promote excellence through the College's affixes, by building the evidence base for optometry, and raising awareness of the profession with the public, commissioners, and health care professionals.

The Royal College of Ophthalmologists champions excellence in the practice of ophthalmology. It is the only professional membership body for medically qualified ophthalmologists and for those who are undergoing specialist training to become ophthalmologists.

Fight for Sight
Fight for Sight is the leading UK charity dedicated to funding pioneering research to prevent sight loss and treat eye disease. Fight for Sight's overall research commitments currently amount to £8m for over 160 research projects at 49 different universities and hospitals across the UK. Over the course of its history the charity's research has resulted in breakthroughs that include new treatments to save the sight of premature babies, the world's first clinical trials to test gene therapies for inherited eye conditions and the creation of a corneal transplant service. The charity currently supports AI research including a project led by Dr Pearse Keane which involves using a machine learning algorithm for early detection of dementia using retinal scan data.