IET
The Institution of Engineering and Technology

Artificial intelligence and ageing

Machine learning for human health and longevity.

theiet.org/healthcare

Introduction

How can artificial intelligence (AI) help societies with ageing populations to increase levels of health and wellbeing across a longer lifespan?

It is somewhat paradoxical that advances in medicine leading to increasing lifespans create a need for solutions that can ensure that the additional years can be associated with a high quality of life.

As a result, the accelerating growth of elderly populations in the face of near static global healthcare system capacity calls out for solutions that both automate the delivery of healthcare (this is a clear use case for AI techniques such as machine learning) and recognise the need for an integrated approach to both physical and mental wellbeing.

But can the potential of AI challenge us to take this one step further? Can we move from a position of simply mitigating the effects of ageing to one where thriving communities of older people include retired engineers and others who could even contribute directly to research and development (R&D) that promotes healthy ageing?

Dr Peter Bannister CEng FIET
IET Healthcare Sector Executive Chair

Dr Peter Bannister
**CEng FIET**
IET Healthcare Sector Executive Chair

Supporting healthy ageing with AI technology is a growth area. How can innovators identify opportunities for new products?

Data is exploding. We should look at where data can be used to continuously nudge good habits. Innovators can develop new sensors – sweat patches and blood pressure measuring devices are among recent examples.

Social interaction is important to well-being as people get older. AI game players, AI personalities or even matchmaking services linked to lunch clubs, social events and educational talks could all help here. Finally,

AI assistants can provide affordable, 24-hour support with managing an independent life. They could include diet and exercise coaches or even medical screening systems to tell you when to go to the doctor.

Dr Ronjon Nag
Interdisciplinary Distinguished Careers Institute Fellow, Stanford University, and Founder, R42 Institute

Dr Ronjon Nag
Interdisciplinary Distinguished Careers Institute Fellow, Stanford University, and Founder, R42 Institute
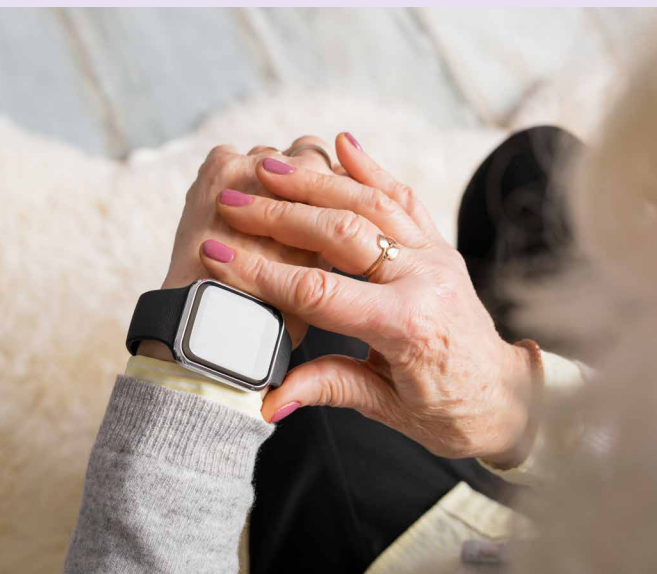
AgeTech is poised for growth

The number of people in the world aged 65 or over will more than double to reach 1.5 billion by 2050, according to the United Nations.[1] The rapidly changing demographic is set to pose acute economic and social challenges and threatens to place a huge burden on health systems. Helping people to live independently and maintain their health and wellbeing across a longer lifespan is widely regarded as a key part of the solution to these challenges. The UK, the US and Japan are among countries that have adopted policies aiming to support healthy ageing through investment in technological innovation. With a plethora of novel devices aimed at improving health and longevity already on the market and hundreds more in development, the segment is poised for rapid growth.

[1] World Population Ageing 2019 (un.org).

Smart solutions for longer lives

Data scientists are taking advantage of the latest AI techniques and advances in genetics to create novel solutions to the health challenges of ageing populations. Here are some of the key questions they are helping to answer.
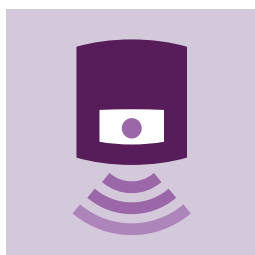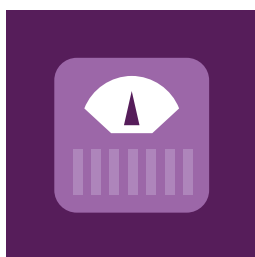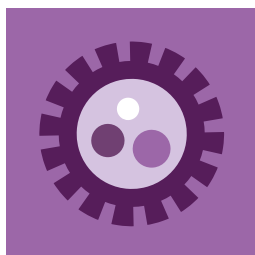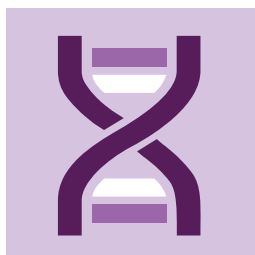
How do we establish a baseline for monitoring individuals' biological age to advance research into healthy ageing?

The economic pressures of ageing populations have prompted a growing body of research into how far the ageing process can be slowed down. Researchers are using AI to measure how an individual's biological age differs from their chronological one, as a first step towards promoting healthy ageing and preventing disease.[2] The hunt is on for a range of accurate biomarkers of ageing, such as the length of telomeres, the end sections of chromosomes, which shorten with age. Such biomarkers are plugged into "deep ageing clocks" and used to predict the individual's biological age and identify what factors may be contributing to the ageing process.

How can AI promote longevity by helping us to eat a healthier diet and exercise more effectively?

A myriad of apps, sensors and wearables are available today to help fitness enthusiasts measure their own vital signs. The devices use algorithms to analyse data on exercise regimes ranging from gym workouts to yoga sessions and provide feedback to improve performance.[3] Dieting apps provide the calorific values of food items for people seeking to lose weight, while smart weighing scales can store bodily measurements in the cloud to plot trends over time.[4] By providing precise information on the impact of diet and exercise on the body, these devices empower individuals to improve their own health and wellbeing.

Can AI help us to tackle the chronic diseases of ageing?

Trials have shown that AI can match or surpass human performance in the detection of cancer from diagnostic images.[5] Deep learning, which quantifies patterns in imaging data, has the potential to improve the detection of lung, breast, brain and prostate cancers. It also provides ways to enhance characterisation and monitoring of tumours and is expected to transform the clinical workflow in cancer treatment. Wearables that use unsupervised machine learning to classify users' susceptibility to glucose dysregulation promise to help in the early identification of type 2 diabetes,[6] while similar techniques are being explored in relation to disorders of the liver, kidney, immune system and metabolic system.[7]

How can AI help us to remain healthy and well as we get older?

Living longer at home is beneficial both for people aged 65 or over and the societies they live in. As well as being the age group's predominant lifestyle preference, it promises to reduce the healthcare burden on wider society.[8] A host of gadgets using AI to help older people who are "ageing in place" to maintain their health and wellbeing has come on stream. Spanning emergency calls, vital signs monitoring, reminder services, fall detection and health assessment, they include sensors, cameras, smartwatches and tablets.[9] Many can be connected to a smart home control system or healthcare and emergency services.

[2] Deep Aging Clocks: The Emergence of AI-Based Biomarkers of Aging and Longevity: Trends in Pharmacological Sciences (cell.com).
[3] Sensoria Home Page (sensoriafitness.com); Nadi X - Smart Yoga Pants that Guide Your Form by Wearable X - Kickstarter; Home – Fitbod; I am sweati - Home; Garmin - Home.
[4] MyFitnesPal.com; HealthWatch 360 - Precision Nutrition as Medicine (gbhealthwatch.com); Fitbit Official Site for Activity Trackers and More.
[5] Artificial intelligence in cancer imaging: Clinical challenges and applications (nih.gov).
[6] Glucotypes reveal new patterns of glucose dysregulation (plos.org).
[7] Personal aging markers and ageotypes revealed by deep longitudinal profiling - PubMed (nih.gov).
[8] Beyond 50.05: A Report to the Nation on Livable Communities: Creating Environments for Successful Aging (aarp.org).
[9] Smart Homes for Elderly Healthcare-Recent Advances and Research Challenges - PubMed (nih.gov).

Artificial intelligence and ageing case studies

Testing time for cells

Cutting-edge DNA test aims to provide a baseline for healthier living

A novel health tracking programme that was cofounded by a Nobel Laureate uses genetic testing to tell customers their biological age – and gives tips for healthy ageing.

The TeloYears programme measures the average length of people's telomeres, the protective caps at the end of chromosomes, to identify what point they have reached in the biological ageing process compared with other people of the same chronological age and gender.[11]

The DNA tests are offered by Telomere Diagnostics, a Silicon Valley company that was founded by a group of scientists including Dr Elizabeth Blackburn, joint winner of the 2009 Nobel Prize in Medicine.

Telomeres shorten slightly every time a cell divides and, once they reach a certain length, cell division stops. Dr Blackburn and her fellow Laureates established the mechanism by which telomeres and the enzyme telomerase protect chromosomes. They also discovered that telomerase can actually lengthen telomeres in cells.[12]

The US firm offers an $89 mail-order testing kit that takes a single pinprick blood sample and sends customers a report giving their biological age. The result is accompanied by advice about healthy ageing and the option of a personalised lifestyle improvement plan based on telomere science.

Avatar leads workout sessions

Start-up takes a novel approach to interactive personal training

A personal trainer avatar is the centrepiece of a smartphone fitness app from Twenty Billion Neurons (TwentyBN), an AI start-up backed by Microsoft's venture arm M12.

The virtual coach interacts in real time with users of Fitness Ally as they work out, deploying the computer vision and natural language processing capabilities of TwentyBN's AI platform.[13]

The on demand fitness app, which was launched in May 2020 on the App Store, is part of a growing trend in fit tech towards interactive personal training services. Thousands of iPhone and iPad owners have downloaded the programme.

Fitness Ally is based on a deep learning platform that was trained on millions of videos showing people working out that were collected from TwentyBN's network of crowdworkers around the world. Users' movements are tracked through the smartphone camera.

The avatar, called Allie, creates a plan based on the user's fitness level and goals, guides them through workouts, and provides verbal feedback on their form, giving encouragement and corrective tips.

Fitness Ally offers a variety of workouts, including high intensity interval training, that can be customised by users, who place the smartphone several metres away while they exercise.[14]

[11] TeloYears fact sheet (teloyears.com).
[12] TeloYears Scientific Overview (teloyears.com).
[13] M12-backed startup launches computer vision based virtual fitness coach that never lets users cheat (prnewswire.com).
[14] Fitness Ally App | Facebook.

Sensor reveals diabetes risk

Stanford research could help advance personalised medicine

Researchers at Stanford University have identified a set of glucotypes that may help to prevent type 2 diabetes after conducting an experiment involving continuous glucose monitoring (CGM).[15]

The team used the DexCom G4 body sensor, which takes continuous readings of glucose levels from a small electrode placed under the skin and transmits them to an Apple iPhone for monitoring.

A total of 57 healthy individuals aged 25 to 76 were monitored for two to four weeks using the sensor, with nearly 500,000 measurements taken. Patterns extracted from the data using spectral clustering revealed three types of glucose variability: low, moderate and severe.

The study found that 25% of individuals considered non-diabetic by standard measures exhibited high glucose variability using CGM, with glucose reaching pre-diabetic levels 15% of the time, and diabetic levels 2% of the time.

A subgroup of 30 participants were monitored separately for raised glucose levels after eating three standardised meals: milk and cereal, bread and peanut butter, and a protein bar. Analysis showed that individuals were sensitive to different foods and by varying amounts.

The researchers concluded that CGM combined with a glucotypes model could be used for earlier identification of pre-diabetic individuals, who could then use CGM to avoid foods that raise their glucose levels.

> Upload your CGM readings at **glucotype.stanford.edu** to identify your glucotype.

Smart home support network

AI based system for monitoring the elderly preserves privacy

A Canadian startup has devised a nonintrusive monitoring system using state of the art wireless and sensor technology to support elderly people who live on their own.

HomeEXCEPT won the Grand Prize in the American Association of Retired Persons' 2017 Innovation Champion Awards for its anonymous home monitoring system, which avoids the use of cameras or listening devices.[16]

The system relies on small sensors placed on objects around the house that collect data related to daily activities such as walking, eating, sleeping, taking medicines and going outdoors.

The environmental sensors track temperature, humidity, and air pressure as well as activity, while a high capacity wireless mesh network links sensors to an internet router. The data is analysed by an algorithm, which "learns" the resident's normal pattern of behaviour over time and notifies their carer through a mobile phone app about any unexpected changes.[17]

As well as avoiding the use of uncomfortable body sensors, the low cost system is designed to protect the privacy of elderly people by keeping all data completely anonymous. Only the subscriber knows the person's name or address.

The sensors can be attached to objects ranging from chairs and beds to pill dispensers and doors. Locations are selected to monitor activities that may show an emerging health issue.
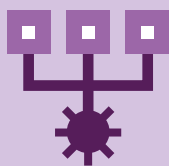
[15] Glucotypes reveal new patterns of glucose dysregulation (plos.org).
[16] AARP Names HomeEXCEPT Inc. Grand Prize Winner of Innovation Champion Awards - June 21, 2017.
[17] HomeEXCEPT Launches New Contactless Remote Monitoring for Independent Senior Living.
       (newsfilecorp.com); Measure Your World - Ruuvi; Wirepas - Very very good IoT - Wirepas.

The next steps

1. Data

– Create an open access data repository for ageing research to support international collaboration.

– Support metadata harmonisation initiatives such as the Maelstrom Catalogue.[18]

– Set up hackathon competitions for the extraction of data from ageing studies.

2. Research

– Prioritise AI and healthy ageing in national research strategies.

– Coordinate national research initiatives and challenges in AI and ageing with counterparts abroad for international synergy.

– Launch academic journals on AI for ageing and longevity.
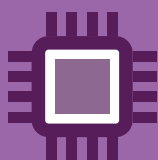
3. Innovation

– Set up incubator and accelerator programmes dedicated to AI and ageing.

– Develop applied ageing research networks involving universities, health services, local authorities and charities to match R&D to regional needs.

– Hold annual tech fairs on smart home sensors and wearable devices for healthy ageing.

4. Engagement

– Set up health and social care AI groups to promote understanding of devices and therapies for healthy ageing, participation in trials, and user feedback.

– Create opportunities for retired data scientists, engineers and healthcare specialists to take part in study programmes, research and innovation related to healthy ageing.

– Build a model smart home showcasing the latest internet of things (IoT) devices to assist healthy ageing.

5. Finance

– Launch public-private matched funding initiatives to encourage investment in R&D of AI based devices for healthy ageing.

– Provide annual post-doctoral fellowships for AI and ageing researchers to support a talent pipeline for future R&D leadership.

– Set up prizes for innovative solutions to key challenges in AI for ageing research.
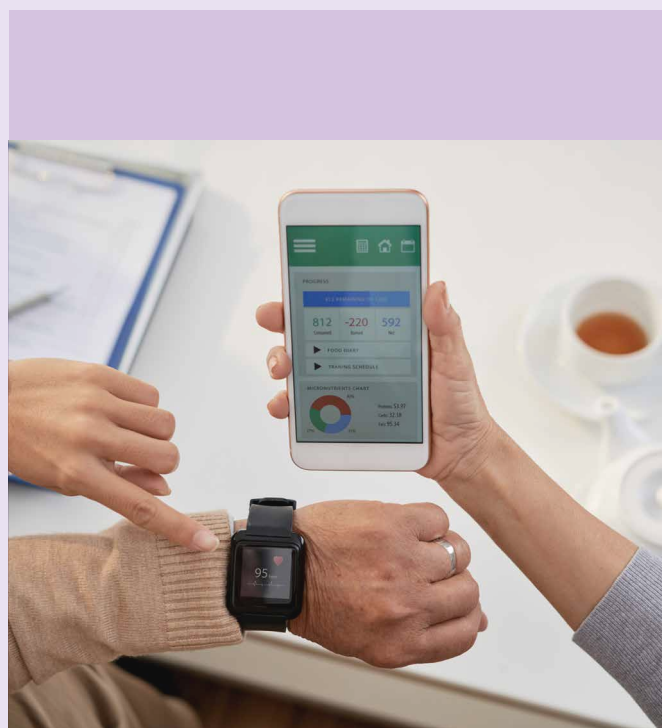
[18]   Maelstrom Research (maelstrom-research.org).

═ We say...

The World Health Organization's Decade of Healthy Ageing began in 2020.[19] Data scientists have a key role to play in its global strategy and action plan. This includes calls for improved data, measurement and research and the remodelling of environments and health and care systems to meet the needs of older people. AI will be crucial to all these efforts.

1. Develop comprehensive, long term national policies aimed at achieving population-wide healthy ageing.

Putting innovation for healthy ageing at the heart of national industrial strategy and setting up targeted challenge funds could kick start the development of environments and health and social care systems suitable for ageing populations.

2. Introduce planning regulations that enable cities, communities and housing to be adapted to the needs of older people using the IoT.

Local authorities that commit to action can join the WHO Global Network for Age friendly Cities and Communities[20] to exchange ideas with counterparts around the world.

3. Develop long term strategies and investment plans for building preventative health systems that address the challenges posed by ageing populations to healthcare services.

Personalised medicine based on smart devices could prevent the onset of chronic diseases through diet, exercise and early intervention, and help older people live independently.

4. Set up a National Institute for AI and Ageing to spearhead R&D across the field and promote interdisciplinary collaboration.

A centre of excellence in basic and applied research could act as a focal point for scientific advancement and knowledge transfer and guide the direction of innovation for healthy ageing.

5. Develop, pilot and roll out a universal system of online e-health records with secure access based on an encrypted database and digital signatures.

The bank would provide regular, subscription-based funding and one-off incentives for pharmaceutical companies, global consortia and regional public-private partnerships to tackle global health threats and neglected diseases.

A poll of more than 1,000 attendees at the IET's AI and Ageing webinar[21] showed that:

– 98% believe AI has the potential to radically improve health and quality of life among people aged 60 and above.
– 78% think health ID cards should be introduced in their country.

19 UN Decade of Healthy Ageing 2021-2030; The World Health Organization (WHO) approach to healthy ageing (nih.gov).
20 The Global Network for Age-friendly Cities and Communities (who.int).
21 Webinar Recap: Artificial Intelligence and Ageing (theiet.org).

We are the Institution of Engineering and Technology (The IET), a charitable engineering institution. Passionate about healthcare? We bring together expert practitioners from the healthcare industry, academia, the public and third sectors. Your specialist healthcare knowledge can inspire others and make a difference.

If you would like to get in touch, please contact us at **sep@theiet.org**.

IET
**The Institution of
Engineering and Technology**

Contact information

London, UK
T +44 (0)20 7344 8460
E faradaycentre@ietvenues.co.uk

Stevenage, UK
T +44 (0)1438 313311
E postmaster@theiet.org

Beijing, China*
T +86 10 6566 4687
E china@theiet.org
W theiet.org.cn

Hong Kong SAR
T +852 2521 2140
E infoAP@theiet.org

Bangalore, India
T +91 80 4089 2222
E india@theiet.in
W theiet.in

New Jersey, USA
T +1 (732) 321 5575
E ietusa@theiet.org
W americas.theiet.org

@TheIET   theiet.org