Growing the national institute for data science and artificial intelligence

The Alan Turing Institute

There has never been a more significant time to work in data science and AI. There is recognition of the importance of these technologies to our economic and social future: the so-called fourth industrial revolution, underpinned by the Government's Industrial Strategy. The technical challenge of keeping our data secure and private has grown in its urgency and importance. At the same time, voices from academia, industry, and government are coming together to debate how these technologies should be governed and managed.

Here at The Alan Turing Institute we are focused on driving forward our research and growing the Institute so that the benefits of data science and AI can be felt across the UK and internationally. This document maps our priorities and presents eight ambitious challenges which we will use to focus and direct our research activities. The challenges have been developed in consultation with researchers and partners, and outline what we consider to be the game-changing areas of data science and AI in which the Turing can have the most impact. They represent a snapshot of a living picture of the Turing's priorities and regular updates will be made to the turing.ac.uk website.

Who we are and what we do

1

We are the national institute for data science and artificial intelligence.

We undertake research which tackles some of the biggest challenges in science, society and the economy.

We collaborate with universities, businesses and public and third sector organisations to apply this research to real-world problems, with lasting effects for science, the economy, and the world we live in.

We are here to help to make the UK the best place in the world for data science and AI research, collaboration, and business.

1

We have three ambitious goals:

Advance world-class research
Innovate and develop world-class research in data science and artificial intelligence that supports next generation theoretical developments and is applied to real-world problems, generating the creation of new businesses, services, and jobs.

Train the leaders of the future
Train new generations of data science and AI leaders with the necessary breadth and depth of technical and ethical skills to match the UK's growing industrial and societal needs.

Lead the public conversation
Through agenda-setting research, public engagement, and expert technical advice, drive new and innovative ideas which have a significant influence on industry, government, regulation, or societal views, or which have an impact on how data science and artificial intelligence research is undertaken.

1

A national institute

Being a national institute enables us to deliver benefits that a single university could not deliver alone. We break down disciplinary boundaries; at the Turing, computer scientists, engineers, statisticians, mathematicians, and social scientists work together under one shared goal, with no departmental boundaries. We are a collaborative hub, with roots in universities and centres of research excellence across the UK, and strong links to a growing network of industry, public sector, and third sector partners. Crucially, we are a convening power, bringing together the best talent in the data science and AI community to speak to industry, policy-makers, and the public.

Our global ambitions

While our first two years have been focused on making the Turing a national success, we recognise that engaging internationally will be critical to ensuring that the UK's strengths in data and AI have global impact. Looking ahead, we will develop a strategy for international engagement which supports our remit and goals and which champions UK talent on the global stage.

2 Research
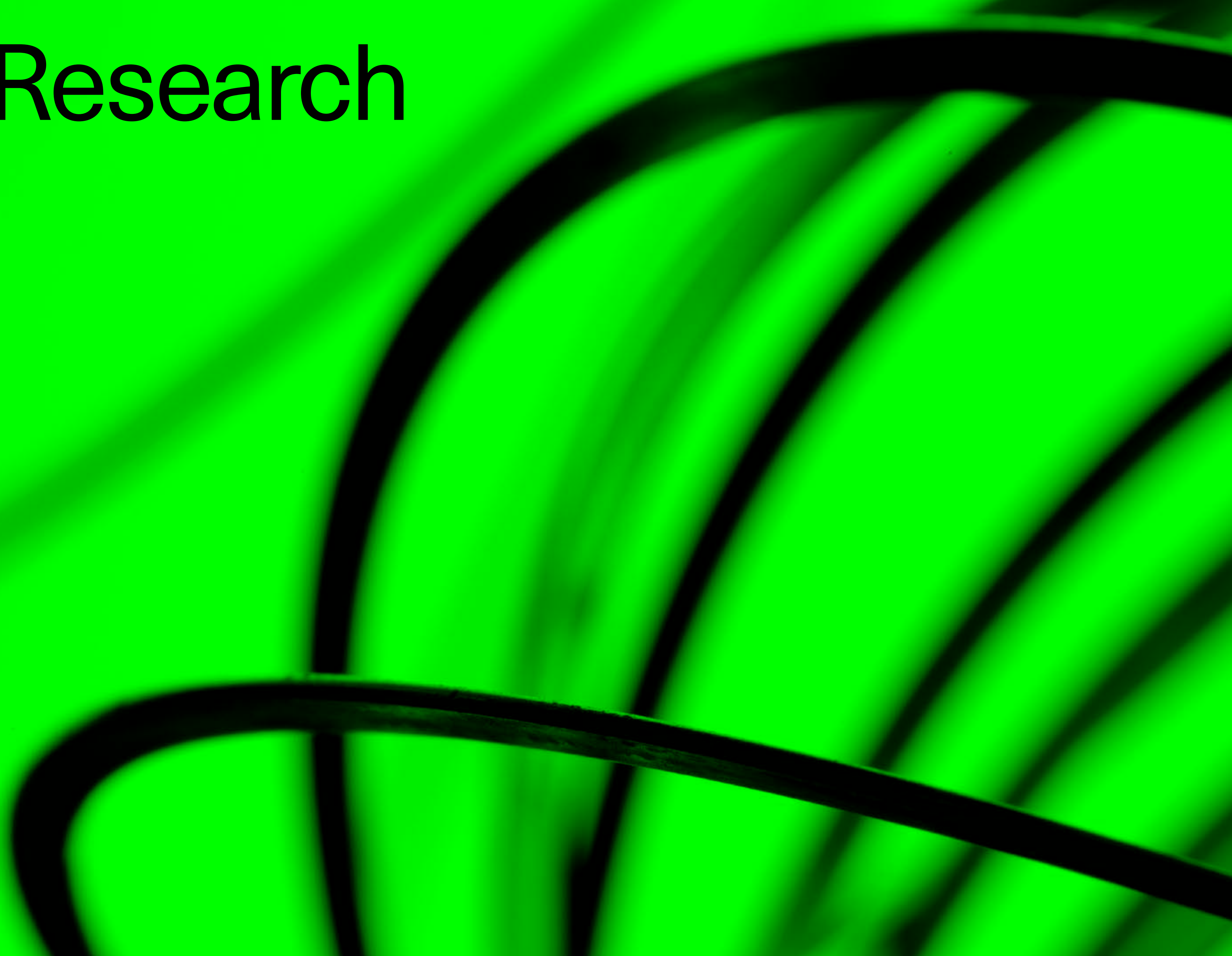
2

The fundamental goal behind all our research is to build a data and AI enriched world for the benefit of all.
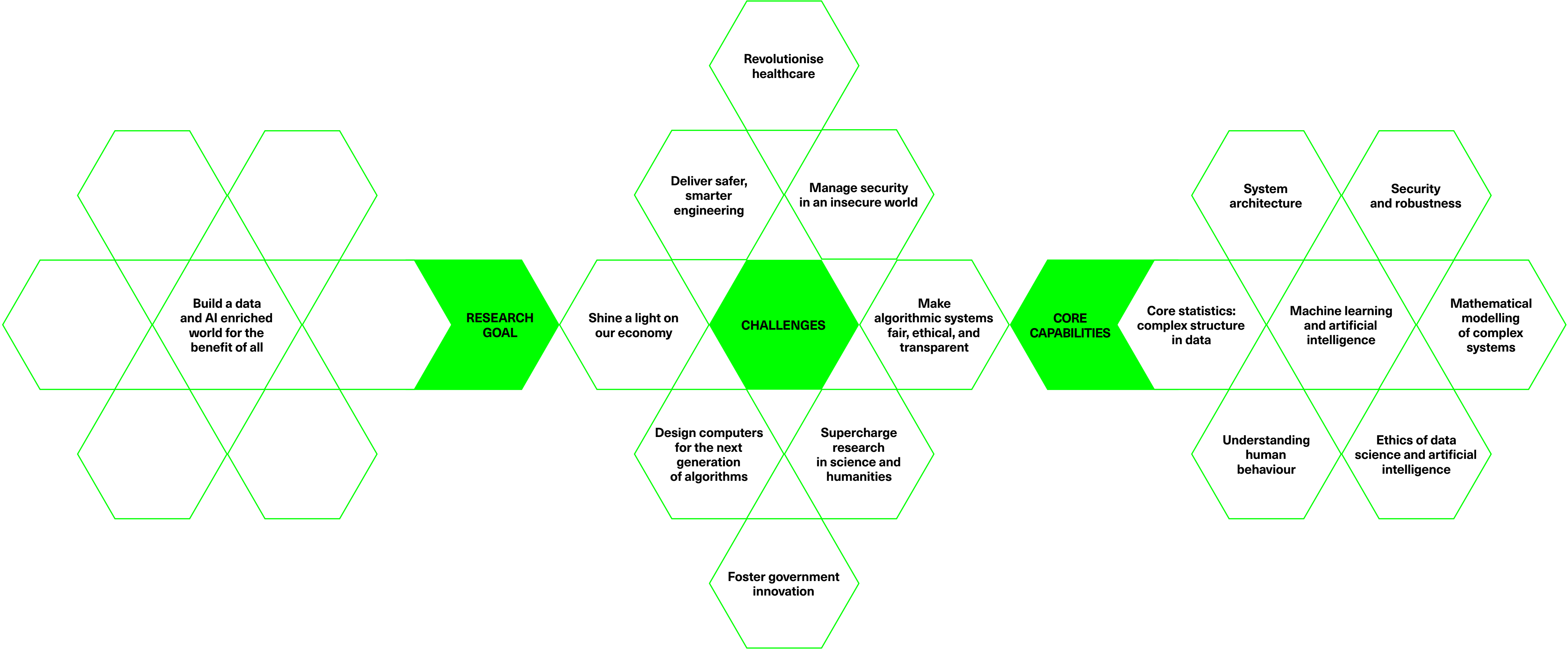
The last decade has seen a dramatic rise in computer power, an explosion in data, and scientific break-throughs, as in deep learning and neural networks. Together, these advances have led to the emergence of data science and the resurgence of artificial intelligence — 'machines that think', as imagined in Alan Turing's landmark research paper published in 1950.

The role of the Turing is to foster these sciences and grow them in order to change the world for the better. We will do this both through basic research into theoretical scientific problems, and through applying our cutting-edge science to real-world problems, and with recognition of the important legal, ethical and societal implications of these technologies.

We will channel our research around a number of ambitious challenges which represent areas in which AI and data science can have a game-changing impact for science, society, and the economy. These challenges are representative of broader areas of applied science which the Turing works in, and will not be led by the Turing alone, but depend on significant collaboration and partnerships.

New challenges, for example in cities and environmental science, will be considered as progress is made and new priorities and technologies emerge.

Our research goal, challenges and core capabilities

RESEARCH GOAL

Build a data and AI enriched world for the benefit of all

CHALLENGES

Revolutionise healthcare

Deliver safer, smarter engineering

Manage security in an insecure world

Shine a light on our economy

Make algorithmic systems fair, ethical, and transparent

Design computers for the next generation of algorithms

Supercharge research in science and humanities

Foster government innovation

CORE CAPABILITIES

System architecture

Security and robustness

Core statistics: complex structure in data

Machine learning and artificial intelligence

Mathematical modelling of complex systems

Understanding human behaviour

Ethics of data science and artificial intelligence

Challenge 1

Revolutionise healthcare
AI and data science will improve the detection, diagnosis, and treatment of illness. It will optimise the provision of services, and support health service providers to anticipate demand and deliver improved patient care.

With cross-sector collaboration, and respect for privacy and patient trust, we can transform healthcare.

What can data science and AI do?
– Enable earlier, more precise detection, diagnosis, and treatment of illnesses
– Predict or prevent diseases before they arise for those at highest risk
– Model the outbreak and transmission of infectious disease
– Model the consequences of medical interventions
– Maximise the information in patient data (while recognising the legal, computational, and privacy hurdles)
– Forecast demand on, and improve, health services

What are the benefits for science, society, and the economy?
– Supporting medical research, e.g. in genetics and genomics, to advance faster
– Personalising healthcare: targeting the right treatments to the right patients at the right times
– Understanding the impact of environmental and lifestyle factors on health
– Efficiency savings from government and the NHS
– Increased collaboration between data scientists and medical researchers
– Lives saved and lives improved

2

Deliver safer, smarter engineering
We are on the cusp of a major step-change
in engineering. Instead of waiting for regular
maintenance cycles, bridges, power plants,
and transport systems can now tell us what they
require and when, all through data. Data science
can also inform how we design and build structures,
enabling exciting and radical new possibilities
to innovate and improve design, performance,
and safety.

Through spearheading new skills, standards,
and education, we will deliver a safer, smarter era
of data-centric engineering.

What can data science and AI do?
– Design and deliver systems that recover
  themselves using their own data
– Enable data-driven maintenance
– Enable real-time monitoring, testing, and resilience
  of complex systems
– Allow engineers to make interventions before
  systems go wrong
– Link major datasets between engineering systems
– Model complex structures in 'digital twins'
– Enable smarter decision-making

**What are the benefits for science, society, and
the economy?**
– Better engineering design in the presence
  of uncertainty
– Improving the resilience, efficiency, and
  environment of cities
– Improved infrastructure systems
– Introduction of new industry standards
  to match innovation
– Changes in engineering education
– Attracting new and different students to work
  in engineering

2

Manage security in an insecure world

From the internet of things, to social messaging and wearable technologies, the ways in which we communicate and interact with each other presents government, organisations and individuals with a set of dynamic and challenging tasks for security, privacy and trust.

We will develop new analytic technology and tools that can help us to manage security in an insecure world, and ensure that skills, methodologies, and expertise in this space remain at the cutting edge of data science and AI research.

What can data science and AI do?

– Develop algorithms to protect individuals' and organisations' privacy
– Integrate information systems to improve cyber security
– Predict and prevent online and offline security risks before they arise
– Perform micro and macro modelling of urban systems to improve public safety
– Enable time-sensitive decisions to be reached using a data-driven approach

– Analyse security risks associated with technological developments in AI
– Promote human-machine interactions in a secure and efficient manner
– Support the reliability, security, and performance of complex systems-of-systems as they handle ever bigger and more complex datasets

What are the benefits for science, society, and the economy?

– Make the UK a safe and secure environment in which to work and live, in an increasingly online world
– Improve skills, training and knowledge to individuals, organisations and authorities for all aspects of cyber security and data
– Build privacy and trust online and offline
– Create safe and efficient transport infrastructures

Challenge 4

Shine a light on our economy
From international trade flows to everyday spending decisions, the economy involves complex networks of financial relationships that drive the economic well-being of individuals, the performance of businesses, and the policy options open to government.

Applying data science and AI techniques to understand the economy will enable us to measure activity faster and at a more granular level than had ever previously been imagined, and to monitor the real-world impact of business and policy decisions. It will also enable us to detect fraudulent activity in financial transactions and tax declarations, with major benefits for the UK economy and society.

What can data science and AI do?
– Measure the geographical relationships in economic activity and trade and how shocks in one region or sector may be transmitted across the economy over time
– Establish what factors drive productivity variation across the country and develop strategies to improve productivity across the UK
– Analyse the jobs of the future and how this will impact well-being and policy decisions
– Combat financial fraud and tax evasion through the implementation of advanced network detection algorithms
– Develop methods to disentangle cause and effect, using new forms of data
– Investigate how certain factors affect outcomes using new analytical approaches

What are the benefits for science, society, and the economy?
– A better understanding of how the economy functions in terms of networks, linkages, and the propagation of shocks
– A better understanding of how work is changing and what that means for individuals, businesses, and the government
– Individual, business, and government decisions can be based on a much more complete and up-to-date picture of what is going on in the economy
– Greater fairness and fewer wasted resources in combatting financial fraud

Challenge 5

Make algorithmic systems fair, transparent, and ethical

Algorithms shape the way we see the world and are being used to make decisions about increasingly sensitive parts of our lives, from our eligibility for a loan to the length of our sentence if we commit a serious crime.

But how do they work? How do we know how the decision was made and if it is fair? And what can we do if decisions made by machines contain prejudice or bias?

Innovation brings with it moral responsibilities which must be addressed if we want to create a data and AI enriched future for the benefit of all. We aim to design and deliver fair and ethical algorithms by bringing together cutting edge technical skills with expertise in ethics, law and policy.

What can data science and AI do?
– Detect and remove bias in machine decisions
– Develop practical approaches to providing appropriate transparency
– Understand human behaviour to help identify bias
– Understand human psychology to help to provide helpful explanations of algorithms
– Protect personal and corporate privacy
– Examine not just algorithms themselves, but how they are used in society
– Tackle asymmetries of power and knowledge

What are the benefits for science, society, and the economy?
– Instilling an ethically engaged approach to the development and use of data science and AI in society
– New standards in government and private sector use of algorithms
– Consideration of appropriate auditing of algorithms
– Improving users' understanding of how and why a machine decision has been made
– Improving users' understanding of and trust in how and why an algorithmic decision has been made
– Updates to the governance or legal framework around algorithmic decision-making
– Systems which provide needed ethical features from the outset

Challenge 6

Design computers for the next generation of algorithms
The explosion of data science and AI wouldn't have been possible without advances in computer power and specialist hardware and software. We need to continue to adapt and refine computer technology in order to meet the needs of the next generation of algorithms and data scientists.

Improved computing performance will also enable data scientists to design more complex and powerful algorithms, creating a virtuous circle of technology supporting and informing innovation.

What can data science and AI do?
– Extract valuable information from increasingly complex and heterogeneous datasets, such as networks of sensors
– Enable the use of sophisticated computational methods for protecting private data
– Facilitate larger scale classification tasks, such as in healthcare (e.g. tumour detection, grading in digital pathology, etc.)
– Produce machine translation of text and speech

What are the benefits for science, society, and the economy?
– Hardware able to deliver quicker, more accurate analysis for academia and industry
– Reduced compute time
– Reduced energy usage
– Novel co-designed algorithms that are tailored to emerging hardware
– Industry products keep pace with research innovation

Challenge 7

Supercharge research in science and humanities
From electron microscope images to thousands of digitised manuscripts, laboratories and research institutes generate colossal amounts of data. As a result, they face considerable challenges in processing and analysing this data.

There is a major opportunity to use data science and AI to advance knowledge across the science and humanities, helping to supercharge research and ensuring that the UK's centres of excellence keep pace with cutting edge AI and data-driven tools.

What can data science and AI do?
– Help with the 'wrangling' process of huge datasets
– Accelerate data availability to facilitate theory testing
– Use machine learning to improve the accuracy and efficiency of synchrotron imaging, and identifying potential new drug targets from genomic and health data
– Develop transformative data-science driven approaches to digital humanities that enable the answering of new questions

What are the benefits for science, society, and the economy?
– Supporting the research sector with cutting edge data science and AI techniques
– Turning data generated by science and the humanities into societal impact more efficiently
– Reaching a better understanding of our heritage, our past, and our present

Challenge 8

Foster government innovation
Government has fostered and embraced important advances in technology, from early adoption of large-scale computer systems in the 1960s to critical investment in the iPhone and the internet.

Today, government is a major holder of data, which data science and AI can harness to improve the design and provision of public services as well as to inform policy-making across all levels of government.

The Turing will work with policy makers to explore how data-driven public service provision and policy innovation might solve long running 'wicked' policy problems and restore government's role as a leader in tech innovation.

What can data science and AI do?
– Design personalised public services that are tailored to each person's needs and situation
– Inform a fairer, data-driven allocation of public resources
– Identify policy priorities by modelling complex systems and scenarios
– Track and evaluate hard-to-measure policy impacts
– Make the decision-making process more efficient and transparent

What are the benefits for science, society, and the economy?
– Better targeted provision of public services
– A more equitable distribution of public resources across society
– More effective policy decisions
– Greater government transparency and accountability
– Higher cost effectiveness of government programs

2

The challenges are supported by the broad range of core capabilities in the Institute.

– system architecture;
– security and robustness;
– core statistics: complex structure in data;
– machine learning and artificial intelligence;
– mathematical modelling of complex systems;
– understanding human behaviour;
– ethics of data science and artificial intelligence.

3

Impact through collaboration

3

Our long-term vision is for the Turing to be the centre of a connected network that brings together academic expertise from the UK's world-class university sector with industry, government, and third sector partners to research, catalyse, apply, and drive global impact in data science and AI.

The Turing networks will encourage direct connections between universities, partners and other communities we reach and provide an important benchmark for the success of the Institute in driving the data science and artificial intelligence agenda in the UK.

Working with universities

The Turing's university network represents a powerful coalition of research excellence in data science and artificial intelligence in the UK. The cutting-edge theoretical and applied knowledge contained within our Fellowship is critical to the Institute and are what makes us stand out from the crowd. They give us the research power to help us solve problems of national importance, working with partners in the private, public and third sector.

The role of the Institute is to act as a convening power for this talent and expertise, enabling large-scale collaborations across universities and disciplinary boundaries. Fellows are supported by a team of research software engineers and data scientists ready to turn theoretical research into software and applications.

In the past year we have extended our university network, enabling even more ambitious collaborative research to take place. We will continue to grow the Institute into a national resource and seek ways to collaborate across the UK higher education sector. We will enable more Turing research and impact to take place in universities and industry hubs across the UK.

This national growth will support the UK to accelerate its ambitions in data science and AI on the global stage, ensuring we are at the forefront in research, talent, and impact.

University partners

UNIVERSITY OF BIRMINGHAM   University of BRISTOL   UNIVERSITY OF CAMBRIDGE   THE UNIVERSITY of EDINBURGH   UNIVERSITY OF EXETER   UCL

UNIVERSITY OF LEEDS   MANCHESTER 1824 The University of Manchester   Newcastle University   UNIVERSITY OF OXFORD   Queen Mary University of London   UNIVERSITY OF Southampton   WARWICK THE UNIVERSITY OF WARWICK

3

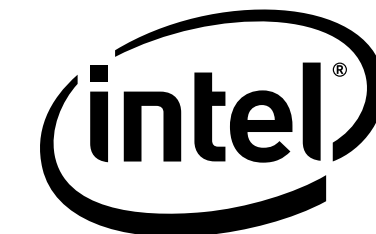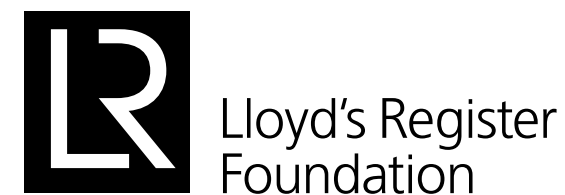## Working with industry, third sector and public sector partners

Academia has a track record of supporting research and development of new products and new techniques. The emergence of data science and AI represent a new frontier in scientific and technological innovation, and there remains great potential impact in many sectors of industry, third sector and government.

The Turing, as the centre of a connected network of world-class academic expertise, has an important role to play as a trusted partner in this rapidly-changing scientific landscape.

We will have a variety of models of engagement, suitable for the largest multi-nationals and the most modest SMEs, built around flexible models of engagement, ranging from one-week Data Study Groups to multi-year research programmes, targeted projects, and a membership programme for organisations and individuals in data science and AI.

Guided by our challenge areas, our engagement with partners will focus on an exchange of talent, skills, and knowledge, with industry and academics learning from each other and sharing best practise.

Strategic partners

Lloyd's Register Foundation   Ministry of Defence   GCHQ   intel   HSBC

**How we will work with industry, third sector and public sector partners**

Partnerships:
– Collaborative research
– Multi-year programmes

Targeted research projects:
– Aligned to research challenges
– 3-24 months

Membership:
– For organisations and individuals
– To launch 2018

Membership

Partnerships

Targeted research projects

The Alan Turing Institute

Tech and infrastructure collaborations
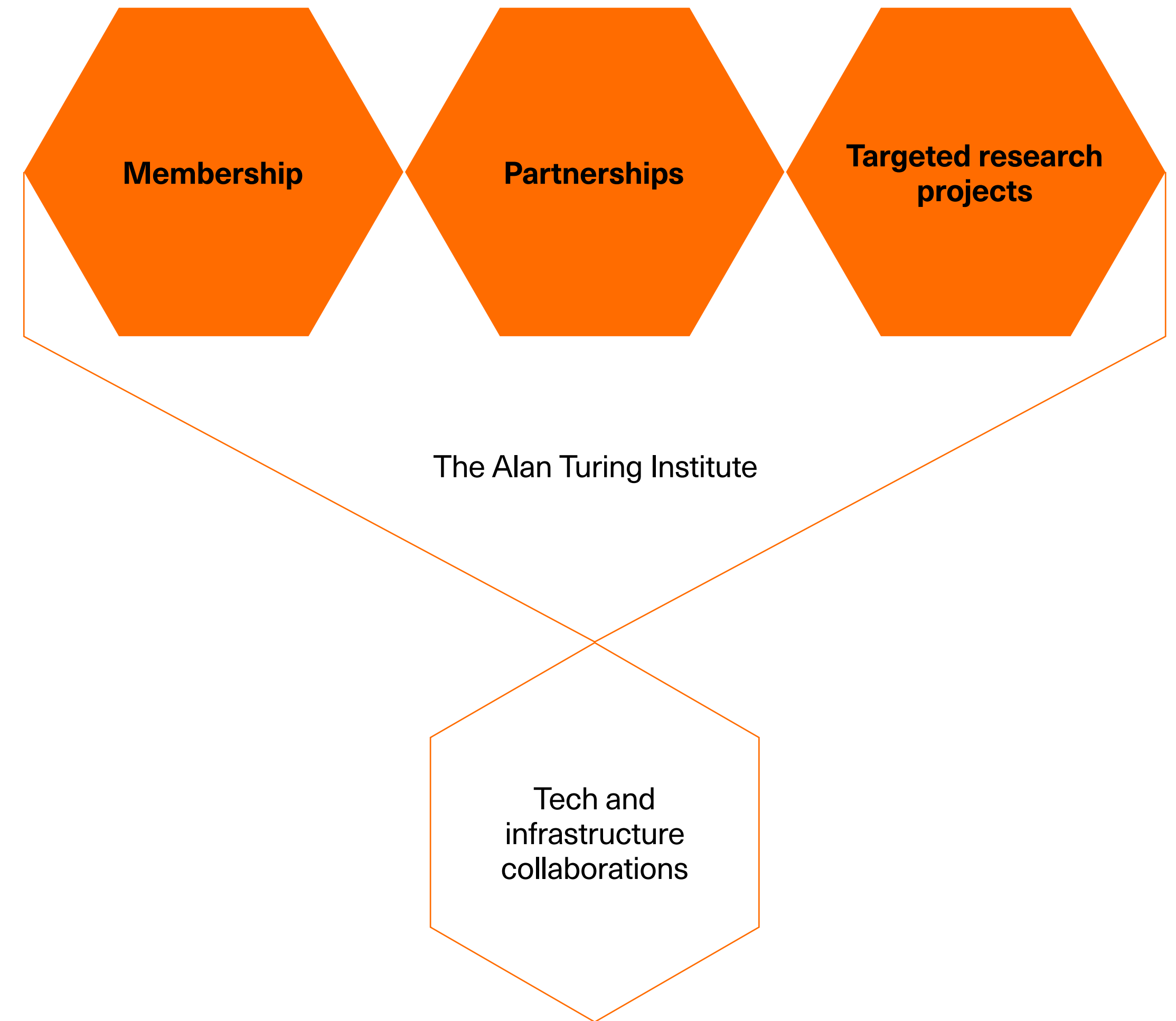
Training a generation

4

Data science and artificial intelligence research relies on a specific set of technical skills and competencies. These include algorithms, systems, mathematical methods and modelling, machine learning and statistics, software engineering, and computer science, as well as engineering, the social sciences, ethics, and design.

The significant industry, government, and academic demand for these skills creates a supply problem, with the UK facing a major skills gap which could inhibit the anticipated potential of data science and AI for our economy and society.

We are committed to taking a leading role in training the next generation of leaders in these sciences, supporting the UK to realise its industrial ambitions. We will also upskill the professional community, developing a programme of executive education and upskilling government and industry through our research programmes and partners.

4

Doctoral training

In our first two years we have recruited more than 70 of the brightest and best students to our doctoral studentship schemes from over 450 applicants.

As well as offering full-time doctoral placements to 30 students, 40 students have joined the Turing through our unique enrichment scheme, which enables those already undertaking PhDs to spend a year or less at the Turing boosting their skills in data science. Turing PhDs are fully-funded and we work with university partners to ensure we can attract the best international students to the UK. We share our data science talks, delivered by experts from our partner and university network, with the world via YouTube, a valued academic resource with more than 133,000 views to date.

We are committed to ensuring that all Turing students go on to successful data science careers in academia, business and government.

Early career researchers

Early career researchers are set to become the next generation of data science leaders, and yet statistically there is a decline in post-doctoral researchers remaining in research roles.

Our Research Fellows each have a mentor in their employing university to guide their academic career development and Fellows are also encouraged to develop relationships through our partners with role models in non-academic organisations.

4

Young learners

In our first two years of operations our internship scheme has seen 40+ post-graduates to date spend their summer at the Turing, working on data science problems.

We have a national responsibility to help to increase the talent pipeline, and to attract more young people to a career in data science and artificial intelligence.

We will do this through a programme of public engagement and events, delivered in collaboration with our university and partner network, as well as learned societies and the broader data science community.

Executive education

There is a demand at a high-level in organisations for training and informing employees in critical skills in data and AI. This falls into two categories; courses for executives providing a strategic perspective of data science across sectors, and state of the art and best practice workshops. Following a series of successful pilots, we will run training sessions for industry, public sector, and third sector participants, in important practical skills and the latest scientific developments in data ethics, machine learning, and artificial intelligence.

5 Advocacy and engagement

5

Innovation cannot thrive unless we manage data and artificial intelligence responsibly in society and industry. Our role is to provide expert technical advice to policy-makers on the wider implications of data science and AI research, the challenges faced by business, public, and third sector organisations, and the governance around these new technologies.

5

Supporting government and industry

Getting policy around data science and artificial intelligence right is critical to the UK achieving its industrial ambitions and to creating a data-rich future people want to live in.

Important areas of focus will be responsible AI and machine learning, data ethics, privacy, data sharing, and data security. Findings will be drawn from our research strategy and be used to drive forward government initiatives. Through our national convening power we will seek to improve ways to enable secure sharing of data assets for research.

Through our work with the Ada Lovelace Institute and its partners, and our own research in data ethics, fairness, transparency and privacy, we will be an active voice in global conversations around building a shared understanding of the ethical questions raised by the application of data, algorithms and artificial intelligence.

Public engagement

The Turing is working in sectors which have major impact on society and the world we live in. Innovation cannot be delivered on a major scale without public support and understanding. We have a responsibility to communicate our research, to listen and to interact with the wider public.

We will do this through a programme of public engagement and events, delivered in collaboration with our university and partner network, as well as learned societies and the broader data science community.

Join us
turing.ac.uk/opportunities

Work with us
turing.ac.uk/partner-with-the-turing

Follow our story
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